MARKETS POTENTIALLY AFFECTED BY THE ATP DIGITAL VIDEO PROGRAM

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The Principal Investigator on the project was David Burress, an Associate Scientist and Research Economist at IPPBR, who also was lead author for this report. Additional economic analysis and drafting were provided by Patricia Oslund, Research Economist at IPPBR, and Joshua Rosenbloom, Associate Professor of Economics. Other members of the research team included Susan Mercer, Program Assistant at IPPBR, who served as project manager, assisted with drafting the report, and organized the workshop of experts; John Gauch, Associate Professor of Electrical Engineering and Computer Science, who acted as an in-house resource person on digital video, made a presentation at the workshop, and assisted with editing; Byungsun Cho, a Ph.D. Candidate in Economics and Research Assistant at IPPBR; and Daniel Cardwell, an Undergraduate Research Assistant at IPPBR. Alexander Barket, a Research Associate at IPPBR, provided computer programming and data management. All research was performed under the general direction of Charles Krider, Director of IPPBR and Professor of Business, who also attended the workshop and commented on the draft report.

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The views and interpretations expressed in this report are those of the authors alone, and do not necessarily reflect the opinions of the Institute for Public Policy and Business Research, the University of Kansas, the Advanced Technology Program, the National Institute of Standards and Technology, or any of the consultants engaged on this project.

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EXECUTIVE SUMMARY

- This report provides an outline or roadmap for listing, characterizing and describing the applications of digital video (DV) that may appear in the future marketplace. The report was prepared in conjunction with the Focused Program on Digital Video in Information Systems of the Advanced Technology Program (ATP), an operating unit of the National Institute of Standards and Technology (NIST), US Department of Commerce.

- The ultimate goal of the report is to "identify the markets which are likely to be significantly affected by the Digital Video Program" of ATP. It is planned that these identified markets will be subjects for follow-up studies on the economic benefits of the ATP program.

- This report proceeds in two steps. First, we construct a general map of all DV-related markets that are thought to be possible over the next 15 years. (This map is provided in Chapter 9 and Appendix 5 of the report.) The map implies the existence of some thousands of possible markets, when defined at a very detailed level of disaggregation. Second, we restrict and aggregate the map in various ways to arrive at a condensed list of some hundred markets. We then recommend that these markets be monitored for the economic impacts of the DV Focused Program. (The shorter list is provided in Chapter 10).

- The general mapping structure is based on ideas taken mainly from industrial organization theory. Products are described as points in an abstract space of possible characteristics, as in Lancaster's (1977) model. The space of characteristics is given a hierarchical structure.

- As this particular map was implemented, the top of the structure is driven by types of human activities, which is to say by a generalized description of the demand side of the marketplace for DV-related products. (It would also be possible to drive the structure by technological capabilities, i.e. in terms of a generalized description of the supply side of the marketplace.) Within each type of human activity, a set of individual component products (goods and services) either exist now or could potentially be developed which support that activity. For example, TV program viewing can be supported by components such as monitors, decoders, and play-back units.

- Market forces are then assumed to lead to differentiation or segmentation of these generalized components into distinct markets that do not compete with each other.
  - Component markets may be segmented or differentiated "vertically", i.e. by quality (e.g. picture resolution).
  - Component markets may be also segmented or differentiated "horizontally", i.e. by specialized characteristics appropriate for particular sub-types of applications (e.g. home viewing monitors versus kiosk and wall billboards).

- Empirical data from a variety of sources were used to instantiate the general map. These data

sources were as follows.

- Reviews of literature: we examined scholarly literature, trade and popular journals, and especially electronic literature on the World Wide Web.
- Expert consultants: we sought the oral advice of digital video consultants in individual conversations, both face-to-face and by telephone, and also collectively, at a face-to-face workshop.
- Survey of experts: we performed a mail and website survey of expert users of digital video from a variety of fields.
- Input-output analysis: we analyzed the implications of input-output data which show the quantity and intensity of use by some 500 industries of goods and services that either utilize digital video products, or else utilize products that actually or potentially compete with digital video products.
- Systematic imagination: our student assistants systematically read through the Standard Industrial Classification (SIC) Manual and attempted to imagine new uses for DV in each industry.

Detailed protocols and results are given in the report.

- The general map produced in this way is given in Chapter 9. It includes some two hundred components, which can potentially be segmented into thousands of possible non-intercompetitive markets. Segmentation can occur along roughly a hundred quality scales, and also along roughly fifty ranges of specialized uses, which include some two hundred individual categories of specialized use.

- Perfect market segmentation would consist in separate sets of custom-designed products for each individual use and each individual user. Because of design costs, learning costs, and other sources of economies of scale, the marketplace will not achieve perfect segmentation. In particular, only a small fraction of the segmentation that can be conceived of in theory, will actually ever appear in the marketplace. Consequently, the map of future possibilities includes many more variations than are likely to appear in practice. Unfortunately, however, we can not be sure in advance which of the competing principles of segmentation will actually appear in the future marketplace.

- Several principles of restriction and aggregation were used to generate a shorter or condensed list of markets from the general map. These principles include:
  - whether there is a reasonable possibility of funding or direct influence over components from ATP's DV program. (For example, all military applications have been omitted.)
  - the relative likelihood that a given market will come into existence in that particular disaggregated form
  - the relative likelihood that it will happen within 15 years
  - the relative likelihood that it will be economically significant, defined as:
    EITHER obtaining at least $100M in sales per year;
    OR being technologically significant -- embodying generalizable or seminal technology
  - following the same aggregation schemes likely to be used in published data

- aggregating in most cases over markets that are likely to be segmented or differentiated "vertically", i.e. by quality
- aggregating in many cases over markets that are likely to be segmented or differentiated "horizontally", i.e. by specialized characteristics appropriate for particular sub-types of applications.

The condensed map is given in Chapter 10. It includes around a hundred possible markets.

- The map exhibits some general patterns. As expected, many applications are in industries that already use videos and communications, including entertainment, computing, networking, and telecommunications. Applications are likely to especially numerous and differentiated in a few other major sectors of the economy. These sectors include medicine, transportation, and information-intensive activities such as education and finance. Differentiated applications appear likely to be numerically under-represented in manufacturing and extractive industries. (Military applications, which could be very important, were not explored in detail because they are not fundable by ATP.)

- The degree of accuracy of the map would be hard to measure in an ex ante or forecasting sense. Ex post (i.e. after the fact), we might identify an "error" in the general map as any market segment that did eventually come into existence but was not included in the map. In that sense the map does make specific forecasts about future markets. On the other hand, the map is not intended as a prediction that *all* listed market segments will actually come into existence; indeed, that will almost certainly *not* happen, because some of the possible ways to segment the market are in direct competition with others. The more relevant question is not accuracy, but rather completeness of the map: does it cover all of the logical or practical possibilities? Our sense is that this map is relatively complete, especially at the higher and more abstract levels of the hierarchy; but the only possible empirical test would be to construct two independent maps of the same terrain, and then compare them for coverage.

- The intended application of this report is to support an ongoing study of the economic impacts of the ATP DV program. This report could also serve as a model for use in other studies of the impact of technology and R&D programs. Other applications of this or similar methodologies might include framing NAICS codes and data gathering plans by national statistical agencies to account for goods and services that do not exist at the time when data gathering plans are being drawn up.

- Separate Work Papers from this study contain:
  - full transcripts of the workshop, together with video tapes of the proceedings;
  - detailed summaries of results from the survey of experts;
  - full reports from the SIC manual search performed by student assistants; and
  - complete results for all sectors from the input-output analysis.

1. INTRODUCTION

Purpose

This report is part of a research initiative entitled "Pathways to Economic Benefit for the Digital Video Program." The Digital Video Program is a Focus Area of the Advanced Technology Program (ATP), a branch of the National Institute of Standards and Technology (NIST), which is funding this research. This research initiative is concerned not only with the potential economic impacts of digital video in particular, but also with developing models for other technology impact studies by ATP. Two different approaches to that research are being pursued independently by two different research groups. One group is the Institute for Public Policy and Business Research at the University of Kansas, which prepared this document; the other group is the Research Triangle Institute in North Carolina.

As a first step in that research initiative, this report seeks to:

> "identify the markets which are likely to be significantly affected by the Digital Video Program."[1]

This statement provides a clear general direction. However, before we can specify a particular analytic procedure we need to make words like "markets" and "likely to be" and "significantly affected" more precise, and to define them in light of the approach we plan for the subsequent steps of this research.

Theoretical approach

In particular, our subsequent research will embed an economic impact analysis in a computable general equilibrium model. This initial step in that analysis will identify affected markets using a hierarchical Lancastrian model of the characteristics of products.

Net benefit analysis

We will identify "benefits" of the digital video program with "*net* benefits", i.e. benefits less costs, in the sense of an economic impact analysis, or as in a benefit-cost analysis in the general theoretical sense of Drèze and Stern (1987). Some implications for this report are that we are concerned with:

- markets that experience costs and negative benefits as well as with positive benefits; and
- causal linkages, not simply with observed outcomes. For example, we are able to *narrow* the focus of this report to markets that are directly affected by ATP, exactly because we expect to follow causal linkages, or "spillovers," to other markets in subsequent reports.

[1] This is the goal set for Task 1 in the original RFP (ATP, 1997a, p. 2).

General equilibrium modeling

The subsequent impact analysis will be rooted in a computable general equilibrium model, following a causal chain that can be diagramed as follows:

ATP funds-->
digital video R&D-->
changes in directly affected markets-->
spillover changes in other markets-->
simultaneous endogenous changes in all markets.

For consistency with the planned impact model, this report will identify as relevant markets, only those that may be *directly affected* by ATP-funded R&D. In particular, we will restrict our attention to markets for goods that contain a digital video (DV) technology, and markets for services that directly depend on a DV technology, but only in cases where that technology could potentially be directly changed by ATP-funded research. Later steps in the research will identify the spillovers and so on down the causal chain.

Defining the goal

We will make a number of additional assumptions about the goals of this report. (These particular assumptions will not necessarily apply in any subsequent research). The assumptions are listed below, together with some explanation where needed.

1. A *market* is an exhaustive collection of intercompetitive commercial goods and services; i.e. a set of products that generally compete directly with each other and generally do not compete directly with any other markets.[2] This is a fairly narrow definition that will lead to an expansive set of markets; we believe it is better to aggregate these markets only at a later stage of the analysis, so as to provide as complete a picture as possible.

Note that, in general, markets can be described in terms of actors as well as products. Those actors may include not only producers and consumers, but also third party funders such as advertisers and government, and, in addition, fourth party direct beneficiaries such as citizens and voters who are affected by public goods. However, keeping track of the actors is a significant task that will be reserved for later research. In this report we will focus mainly on products (i.e. goods and services).

2. In particular, if a given type of market is differentiated or segmented, either vertically (by quality

[2] This definition is still a bit vague, and intentionally so. We do not use the more precise term "direct substitute", first, because that term includes several different technical definitions; second, because it would be impractical to actually measure coefficients of substitution over literally thousands of markets, many of them not yet in existence; and third, because the economist's "direct substitute" does not exactly correspond to a business person's perceptions of what goods he is competing against. We have the later sense of intercompetition in mind.

and price), or horizontally (by specialized application), then each separate segment is a separate market. Therefore, one major focus of this initial research will be to categorize products, qualities, and specialized applications.

We will use the term *components* to refer to either a market, or else an aggregate type of markets for products with an essentially similar function. For example, the marketplace for TV sets is a component; the marketplace for high-end TV sets is a market, proper.

3. A market is *significantly affected* if and only if it is both:
   a. *directly affected* and
   b. *substantially affected*.

4. A market for a material commodity is *directly affected* if a particular technology of the exact type that was assisted by the ATP program is embodied in some instances of that commodity. A market for a service is *directly affected* if a particular technology of the exact type that was assisted by the ATP program is embodied in a material commodity that is *necessarily* used in the performance of that service. (As noted above, later tasks in this research project will take up the question of indirect effects, and especially "spillovers" and "general equilibrium effects.")

5. A market is *substantially affected* if the direct economic impact exceeds $100M. A direct economic impact of a technology is the difference between the maximum amount that all buyers would be willing to pay collectively for that commodity or service in the presence of that technology, and the amount they would be willing to pay in the absence of that technology. (This figure is set very low because we are seeking to obtain an expansive list of markets, which will be described in Chapter 9. However, in Chapter 10 we will provide a more selective summary.)

6. A market is *likely* to significantly affected if and only if:

   a. there is a subjective probability estimate of at least 30% that the particular technology will appear in the market place in the form of that commodity within the next 15 years, and
   b. that particular technology is of a kind that ATP might be willing to fund under the Digital Video program.

(Again, we are seeking a relatively expansive list of markets, at least at this stage of the research.)

7. The subjective probability estimates refer to expectations about the future held by qualified experts in DV applications, and/or by expert economists, using methodologies that will be developed below.

Characterizing markets

Measuring the present and future size of the various markets in the digital video marketplace is a difficult job that will be deferred to subsequent stages of this research; however, it is known that those markets are and will be large. Today in the California entertainment industry alone, the marketplace

includes many hundreds of video production companies, all of which either use digital video directly, or else are or soon will be in direct competition with other companies that do use DV. The DV market is also very complex, because it crosses a number of industries that were previously very distinct, industries which digital video and other technologies are bringing into direct connection and competition with each other. The DV marketplace includes, or will include, major parts of the computer hardware and software industries; the computer and information networking industry; the telecommunications industry; the entertainment industry; the information content media and centralized information providers; and also numerous application areas such as education, medicine, and scientific research. Because of the new possibilities that are arising for specialized applications of DV, the marketplace is likely to grow even more complex in the future than it is today.

Given this complexity, there is a need for a systematic descriptive approach. The approach adopted in this report has several key features that are designed to organize the complexity and provide a systematic approach for data gathering.

- Lancastrian model: products are viewed as bundles of characteristics (Lancaster, 1971).
- Hierarchical description: characteristics are described in terms of a hierarchy of general and specific uses, specialized applications, and scales of quality.
- Systematic representation: to the extent possible, rules of exhaustiveness and disjointness are imposed on the description of the hierarchy.

A variety of data sources were used to instantiate this data structure.

Empirical methods

The data sources we consulted are as follows.

Reviews of literature

We examined scholarly literature, trade and popular journals, and especially electronic literature on the World Wide Web.

Expert consultants

We sought the oral advice of digital video consultants in individual conversations, both face-to-face and by telephone, and also collectively, at a face-to-face workshop.

Survey of experts

We performed a mail and website survey of expert users of digital video from a variety of fields.

Input-output analysis

We analyzed the implications of input-output data which show the quantity and intensity of use all goods by some 500 industries. We examined the use of goods and services that either utilize DV products, or else utilize products that actually or potentially compete with DV products.

Systematic imagination

Student assistants systematically read through the Standard Industrial Classification (SIC) Manual and attempted to imagine new uses for DV in each industry.

US and international focus

The ultimate goal of ATP is to have positive economic effects for the US. Therefore the DV impact study will focus on US impacts. Yet some of these impacts will occur as a result of changes in US imports and exports, so they are linked to international markets. Therefore it is intended that the DV market map should cover international as well as US markets.

At the same time, most of the data that are conveniently available to us are from US sources and are concerned disproportionately with the US economy. Yet the US market is so large and diversified that it provides a very good representation of the world market map. (It is not nearly as good as a representation of world production input and consumption patterns and dollar flows, because the US tends to be near the world extremes with respect to prices and per capita income.) Consequently, the present report does not attempt to distinguish between US and world markets, except in cases where that distinction is essential to the map itself (such as in segmentation between PAL and NTSC). The distinction will of course be very important in the subsequent impact analysis.

Roadmap for the report

The remainder of this report is organized as follows:

- Chapter 2 describes our theoretical approach in more detail.
- Chapter 3 explains how the various empirical methods we used fit together.
- Chapter 4 reviews some of the electronic and hard-copy literature on digital video.
- Chapter 5 summarizes the proceedings of a workshop of DV experts.
- Chapter 6 describes a survey of other experts using mail and a website.
- Chapter 7 describes the results of our students' imaginative efforts.
- Chapter 8 provides some input-output analysis on the utilization of DV-related products.
- Chapter 9 analyzes these data sources and provides an expansive hierarchy describing the potential characteristics of DV-related products. (However, for brevity, links showing relationships across levels of the hierarchy are given only in Appendix 5.)
- Chapter 10 summarizes and selects items from the hierarchy which will be proposed as the focus for subsequent research tasks.
- Chapter 11 discusses some of the implications of this work for further research on impacts of DV in particular, and on impacts of technology in general.

Appendices to this report include additional information:

- Appendix 1 describes the agenda and the individual attendees at the workshop of experts.
- Appendix 2 provides the protocols used in the survey of experts.
- Appendix 3 provides the complete survey instrument used in the survey of experts.
- Appendix 4 contains the instructions used for the SIC manual search as an aid to imagination.
- Appendix 5 summarizes the downward links in the hierarchical model of DV characteristics.

Separate Work Papers provide some additional materials, which include:

- full transcripts of the workshop, and in addition, video tapes of the proceedings;
- detailed summaries of results from the survey of experts;
- full reports from the SIC manual search by student assistants; and
- complete results for all sectors from the input-output analysis.

2. THEORETICAL APPROACH

This Chapter describes the conceptual framework we used for defining and characterizing the future digital video (DV) marketplace.

A hierarchical Lancastrian model

We will conceptualize the DV marketplace as identified with particular goods and services within a *structured, abstract space of possible characteristics.*

The idea of viewing market goods as points in a space of characteristics is due to Lancaster (1971). In the Lancastrian model, goods are described as discrete bundles of characteristics selected from an infinite set of possibilities. The space of possibilities is assumed to have a metrical structure (i.e. each attribute takes on various values which are either countable or can be measured by degree). Human beings have varying preferences; each individual's preferences can be described as a utility function over the space of possible characteristics. The selection process is the marketplace. In the marketplace, firms offer products at positions in possibility space which are chosen with respect to other products in the marketplace, and also with respect to consumer demands; products are chosen in such a way as to maximize profits. Each individual consumer then selects the best bundles of characteristics available in the marketplace, relatively to his or her preferences. Because there are economies of scale in producing many copies of identical goods, goods are standardized into a relatively small number of types rather than customized perfectly to the individual taste of each consumer. Firms may decide what types of goods to produce in several ways, for example by looking for bundles of characteristics that are as distant as possible from the characteristics of goods offered by other firms, yet as close as possible to the characteristics that are highly valued by as many consumers as possible.

Lancaster gave no particular procedure for modeling the space of characteristics, but his examples of possible goods were simple Cartesian products of characteristics (i.e., each good has a single value or coordinate for each type of characteristic), so that the resulting space was an ordinary vector space (i.e. a good equals an ordered list of coordinates). In this paper we will adopt a more complex structure, which may include many different and embedded vector spaces. We do so because we are concerned with an entire realm of possible future goods and services, and with a large number of possible characteristics, rather than a single type of good with a limited number of characteristics. Moreover, the full extent of the digital video realm is not known in advance; the problem addressed here is how to map it. Moreover, the realm is potentially vast (depending on the amount of detail with which it will be described); therefore a substantial amount of structure may be needed simply to keep control of the descriptive map.

We will assume, in particular, that the Lancastrian characteristics are organized into a hierarchical network. We will make additional assumptions about the nature of the particular levels of that hierarchy. Some key levels in that hierarchical map are:

- activities: things that people want to do;
- components: discrete types of functions or capabilities that help people perform their activities;
- quality improvement scales: ways in which components can be made better; and
- specialized uses: differing applications of components which lead to differing detailed designs.

Quality improvements and specialized uses are two ways in which particular components can be separated into multiple non-competing markets. In industrial organization theory, similar goods are said to be *differentiated* if they have varied characteristics which reduce competition between them. In this report we will use the more general term *segmentation* rather than differentiation, because the collection of things being differentiated may include multiple types of goods and may even cross multiple industries rather than consisting of a single basic type of good.

Some more detailed definitions are given below.

Desirable features for the map of characteristics

Ideally, the map or taxonomy of future DV markets would have a number of properties that would make the map more useable or more accurate or easier to construct. In particular, the map should:

- cover a specific realm (in this case, uses of DV potentially affected by ATP);
- be exhaustive within the realm (either logically or empirically);
- contain disjoint categories;
- have *logically demonstrably* exhaustive and disjoint categories (if possible);
- failing that, at least be empirically based;
- have a systematic and logical structure in other respects;
- initially, be as expansive as is practical; and
- later, be trimmed as needed.

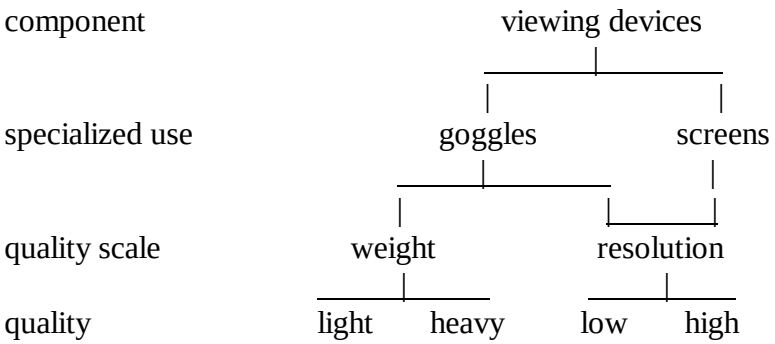
Maintained hypothesis: Commodity characteristics are hierarchical

We now make a key set of assumptions to impose a relatively simple logical structure on the map. We will assume that:

- all possible characteristics of DV-related commodities can be defined within a single hierarchy;
- the hierarchy is ordered by:
  (general, abstract, complex, aggregated)
  <------>
  (specific, concrete, simple, individual);
- items at a given level of the hierarchy are (or should be) exhaustive and disjoint; and
- items may have multiple parents and multiple descendants.
  (I.e., the logical structure is a directed network, not necessarily a tree.)

An example of a structure that fits this model is:

Figure 2.1
A model hierarchy



Note that the types of viewing devices become more specific as we move down the hierarchy, because they are qualified by additional characteristics; note also that the characteristics related to resolution have multiple parents (goggles as well as screens).

Levels of the hierarchy

In this particular report, we will assume a hierarchical structure that takes the following form.

Table 2.1
General levels of the hierarchy

Level	*Content*	*Example*
Realm	the limits of discussion	digital video
Human activity	what people want to do	transmit DV content
Range of specialized use	list of alternative circumstances they might do it under	transmission method
Particular specialized use	a given circumstance	wired network
Component	a thing or service to do it with	codec
Subcomponent	a part of the thing	internal microprocessor
Quality improvement scale	how well the thing works	higher resolution per cost
Type of technology	what might make it work better	video compression
Specific technology	how we could do that	block-based motion compensation
Implementation	how we did do that	MPEG
Brand and model	how we sell what we did	MediaStation 5000 Multimedia System™

Note: there may be additional levels within each major level.
Source: IPPBR

Of course, in order to actually construct such a map, these various levels will need to be defined and distinguished with a certain amount of detail. In particular, we will make definitions as follows.

Detailed definitions for the levels

1. A *realm* is a collection of things and ideas that can naturally be considered together. In the present context, the relevant realm consists of all human actions that are directly related to digital video.

2. An *activity* is a general and abstract description of a particular type of goal seeking behavior by human beings within that realm of discourse.

Examples: creation of DV; utilization of DV

Within a particular realm, activities are assumed to be organized into a descriptive hierarchy based on generality, with the most general activities at the top and the least general activities at the bottom.

Example: creation of DV is divided into authoring and managing of DV.

The hierarchy of activities is assumed to be:

a. directed (i.e. ordered or ranked from more general to more specific), and
b. disjoint (i.e categories can be defined in such a way that they do not overlap).

Hence, the structure of activities is formally a tree structure. In addition,

c. the structure is (intended to be) exhaustive (i.e. it attempts to cover all possible activities in a given realm).

Unfortunately, it cannot be known with certainty that a given descriptive structure actually exhausts all human possibilities within a given realm. The best that we can do is to be as logically clear as we can about ways in which activities are organized, and then search empirically for exceptions. When no more exceptions can be found, then we will have to assume that the structure exhausts the given realm of discourse.

Activities are descriptions of the demand side of the marketplace, in terms of what people want or need (either currently or potentially). The main importance for describing the set of activities contained in the given realm is to enable us to identify *components*, *ranges of specialized use*, and *scales of quality improvement* in a comprehensive way. The listed human activities are not themselves directly necessary parts of the description of a market, but they do help make that description comprehensive and intelligible.

In principle, our analysis could also proceed from the supply side of the market place, in terms of

capabilities. However, the demand side would appear to be a better starting point in the Lancastrian framework because the relevant space of characteristics is defined by human needs and wants, rather than by technological capabilities.

3. A *capability* is a unified function that can support or assist a particular human activity or set of activities. Capabilities are descriptions of the supply side of the market place, in terms of what is technologically possible (either currently or potentially).

> Examples: DV-enabled seeing and hearing of events at a distance in real time; DV-enabled seeing and hearing events that are remote in time.

Capabilities can also be described at various levels of generality.

> Example: DV-enabled seeing and hearing real time events at a distance can be divided into one-way transmission and two-way communication.

The two ways of looking at the market (activities versus capabilities) often sound very similar when taken case by case. What distinguishes them is how the market as a whole is mapped or described. Capabilities cover the range of technical possibilities; activities cover the range of human desires.

4. A *component* is a given type of good or service which could provide a particular technical capability that supports a particular human activity. In other words, a component is a type of good or service that could potentially succeed in the marketplace. A component could be a single market in the specialized sense defined in Chapter 1 (i.e. a single class of commodities that are mutually competitive), but in general a component will be an aggregate of markets, because activities and capabilities can be defined at various levels of generality and hence may themselves be aggregates.

A component can be further differentiated or segmented in two ways:

> a. by specialized uses; and
> b. by qualities, as defined below.

The components of an activity consist in all of the goods and services needed for, or helpful to, carrying out a particular activity.

> Example: creation of DV requires commodities such as cameras, monitors, and editor hardware, as well as services such as camera operation.

In that sense, components are lower in the hierarchy than activities. They do not form a tree structure, however, because the same component can be used in multiple activities. (I.e., components can have multiple parents; while by definition a tree is a hierarchy in which each node has unique parents).

> Example: monitors are used both in creating DV and in consuming it.

We are seeking a list of DV components which is both disjoint and exhaustive. Disjointness can be accomplished, at least in principle, by imposing careful descriptive logic; but exhaustiveness is an empirical rather than logical property. We reiterate that exhaustiveness can be approached but not demonstrated. In particular, we cannot ever be sure that we have listed all of the possible human activities that potentially might make use of DV; therefore we cannot be sure that we have listed all of the possible types of goods and services that might support those activities.

Components can have *sub-components*, i.e. sets of features that in principle could be marketed separately, but which in practice are likely to be bundled together into a unit (the component) that is sold with a single price. The separate production of subcomponents could possibly lead to the existence of additional OEM markets.

5. A *specialized use* is a possible way for segmenting a component market by application area. A specialized use is basically a possible further subdivision of an activity into particular market segments. However, specialized uses, unlike activities, are concrete rather than abstract. They should refer to types or characteristics of activities that have simple English names (or will have in the future). Also, in general they are likely to be overlapping rather than disjoint, because both English language concepts and actual human activities are organized into network structures, not trees.

> Example: the category of high resolution monitors might overlap the category of medical imaging equipment.

Also, a given specialized use may have multiple components as ancestors.

> Example: both components, monitors and cameras, are used in the specialized use of creating movies.

However, specialized uses will be organized into *ranges of specialized use*, i.e. a set of disjoint uses that (hopefully) exhaust a particular category.

> Example: TV monitors might be segmented by screen size and portability into: very large screens used in theaters, medium sized screens used in households, small screens used in hand held devices, and very small screens on video smart cards.

Ranges of specialized use are a *horizontal* form of market segmentation, meaning that there is usually no particular sense of superiority or inferiority implied by comparisons across categories within a range.

The number of different ranges of specialized use that can be imagined has no innate limit, except plausibility or likelihood.

> Example: DV cameras might conceivably be designed differently for left handed persons; for color-blind persons; for persons whose hair color does not look good with bright colors; for

persons who wish to display their wealth conspicuously; for persons who do not wish to buy products made outside the US.

We will have to place plausibility limits on the list in two ways:

First, by completely omitting ideas from the report if they simply seem too far-fetched in the opinions of the authors;

Second, by flagging ideas that seem possible but unlikely (e.g. have not been mentioned in the literature we reviewed, and also didn't seem plausible to the research team).

6. A *scale of quality improvement* is a way in which a component may be segmented by adding improved characteristics that usually cost more money, or else by adding additional features (the importance of which may vary with preferences of different users). Scales or ways of measuring quality should be in terms that are directly important to the ultimate user of DV. Each scale represents a direction along which competing products can be ranked; hence it constitutes a *vertical* form of potential market segmentation.

Examples: transmission services could be ranked by error rates; editing systems could be ranked by the presence or absence of capability to operate on compressed images.

Some of these scales or directions are specific to broadcast; others to computation; others to creation of program content; while still others are more general.

Qualities can be thought of as lower in the hierarchy than specialized uses, insofar as we cannot be sure of what is a valuable characteristic until we have ascertained the specific goals which it supports. However, a given quality scale can apply to multiple specialized uses and even to multiple components.

Once again, there is no innate limit to the number of quality scales that could be imaged. In practice they will have to be limited by:

- the plausibility of that form of segmentation occurring in the marketplace; and
- the existence of references to that quality scale in the literature.

We will describe the lower levels of the hierarchy in less detail. Like the structures of activities and capabilities at the top of the hierarchy, the structures at the bottom of the hierarchy are not necessary parts of the description of markets. ("Markets" are identified with "components" as segmented by specialized uses and/or quality scales.) In principle, the importance of the lower levels of the hierarchy is purely operational or empirical; in particular, constructing those levels can provide a check on the completeness of the description of markets that has been developed at a higher level of generality. In practice, these lower levels contain an extremely large number of members. At the very bottom of the hierarchy, there are literally thousands of distinct DV-related brands and models. We are not able

to follow the analysis of digital video with full detail into the lower levels of the hierarchy.[3]

7. A *type of technology* is a general strategy, or category of methods, for achieving quality improvements. For example, data compression is a general technique for increasing bandwidth or reducing cost.

8. A *specific technology* is a particular method of achieving quality improvements. For example, block-based motion compensation is a specific technology for achieving data compression.

9. An *implementation* is a specific design using a specific technology. For example, MPEG2 is a set of specific standards which implement block-based motion compensation.

10. *Brands and models* are objects actually available in the market place. For example, MediaStation 5000 Multimedia System™ is a product which implements MPEG2.

[3] However, we do plan to form a restricted map of relevant technologies for the next stage of this research project.

3. EMPIRICAL APPROACH

This Chapter summarizes how we joined together empirical results from several sources so as to construct a coherent map of the future DV marketplace. Chapters 4 through 8 below describe the particular empirical data sources that were used.

A pseudo-algorithm

Our research efforts could be summarized as an iterative process that proceeded much like the following (partly tongue-in-cheek) algorithm:

Develop an initial hierarchical structure of DV commodity characteristics;
Repeat:
  Gather new data on future DV market possibilities;
  Fit the data into the hierarchical structure;
  Test for anomalies for categories within each level of the structure:
    is it disjoint?
    is it exhaustive?;
  Test for anomalies across levels for each item in the structure:
    is its list of parents exhaustive?
    is its list of descendants exhaustive?;
  Revise the structure to remove anomalies;
  If size threatens to be become excessive:
    Trim the structure;
Until: resources are exceeded;
Select and summarize the results in a form suitable for subsequent research;
Publish.

Although described here as if it were a computer algorithm, the actual process was, of course, nothing of the kind. Rather, like any research project, it involved problems and solutions that could not be foreseen in advance. For example, the focus on disjointness and exhaustiveness actually emerged in the course of the research (even though we "could" have thought of it in advance).

Also, the types of tests that are possible for exhaustiveness or completeness of categories turned out to vary with different levels of the hierarchy.

Demonstrating exhaustiveness within a level

Consequently, there are differences in the degree of demonstrability, or in the certainty we can have that a given level has been exhaustively described. The type of demonstration depends both on the level of the hierarchy and on whether the present or the future is being considered. Five different cases emerged. In order of decreasing demonstrability or certainty, we have:

1. Levels that are logically exhaustible

Example: activities, the highest level of description, which shows existing and future possible human actions related to DV.

Because it is stated in abstract and general terms, this level appears able to be made complete, or nearly complete, and to be *shown* to be complete, based on considerations of reasons and logic. (However, even given an exhaustive and disjoint set of abstract categories, we would still need to make ongoing efforts to classify and distinguish which concrete real-life activities fall into which abstract categories). In particular, at the very top sublevel, there seems logically to be nothing that can be done with a DV object other than to create it, to distribute it, or to use it. (Destroying it is a trivial case; we could define destroying DV objects as either a negative form of use, or a negative form of distribution.) And continuing to the next logical sublevel, when a DV object is used, it is used either individually by one person, or interactively among multiple persons. And so on. Logical considerations of this type were used to generate a hierarchy of DV-related human activities. (Of course, there may still be omissions in the structure due to mistakes in our reasoning; the point is that this level of the structure is completely knowable in principle.)

2. Levels that are empirically exhaustible in practice, or at least nearly so

Examples: general and specific types of existing DV-related technologies.

We believe it is both possible and feasible to form a roughly complete list of types of technologies that are now under active consideration in the laboratories. (We are not satisfied that we have a nearly complete list at this time, however, and so it is not included in this report. Compiling such a list would be helpful but not necessary for determining the relevant DV markets, because this level is not part of our formal definition of a market; see Chapter 2.)

3. Levels that are in principle inexhaustible, yet may be practically sufficient

Examples: quality scales and specialized uses for future DV-related goods and services.

In principle, the number of different possible ways to segment markets can be expanded without limit, or rather is limited only by human imagination (as argued in Chapter 2 above). Yet, we believe that in practice a sufficiently dedicated search can probably identify most of the market segments that will emerge in the next 5 to 15 years. In other words, most of the things that can be imagined will not emerge. Conversely, given a short enough time horizon, most of the things that will emerge are already on the drawing boards, or at least in the planning or discussion stages, and hence can be identified by a sufficiently determined search.

4. Levels that are empirically exhaustible in principle but not feasible in practice

Example: brands and models of DV-related hardware and software now in existence.

In principle, it is possible to take a complete census of all brands and models. In practice, that would not be feasible, given resources that are available for a project such as this. Instead, that is a task that might be appropriate to the Census Bureau, or to a wholesale trade bureau.[4]

Table 3.1
Levels of the DV product hierarchy:
Degree of demonstrability of exhaustiveness

Level of the hierarchy	Type of demonstrable exhaustiveness...	
	For existing markets	For future markets (≤ 15 years)
Human activities	1. Logical	1. Logical
Components	3. Empirically sufficient	3. Empirically sufficient
Subcomponents	3. Empirically sufficient	3. Empirically sufficient
Quality scales	3. Empirically sufficient	3. Empirically sufficient
Ranges of specialized use	3. Empirically sufficient	3. Empirically sufficient
Types of technologies	2. Empirical in practice	3. Empirically sufficient
Specific technologies	2. Empirical in practice	5. Inexhaustible
Implementations	4. Empirically infeasible	5. Inexhaustible
Brands and models	4. Empirically infeasible	5. Inexhaustible

Source: IPPBR

5. Levels that are inexhaustible

Example: future brands and models of goods.

There is no possible way to list future brand named models, except those that already exist or have been announced. The same goes for future implementations of technologies. Even given a known and

[4] This conclusion applies specifically to the DV market place, which is large and diverse. In cases of technology studies where the currently existing marketplace is relatively small, a survey of existing brands and models might be entirely feasible.

finite number of general technologies, the number of possible specific ways to implement them is practically unbounded. (For example, how many bits are contained in a packet? What specific code does one use to indicate a given error condition? There are many combinations of possible answers to these and other questions, each of which leading to a different implementation.)

Note that these cases have been arranged in decreasing order of the relative certainty with which they can be demonstrated. Table 3.1 gives our judgements about the rank order of demonstrability that is possible for each level of the hierarchy. The table provides judgements both for existing markets and for markets during the next 15 years. Some of the these characterizations may be open to debate, but no reasonable considerations are likely to move a given level up or down by more than 1 rank order.

Trimming the tree of possibilities

As this discussion suggests, the hierarchical structure could easily become intractably large -- and in fact did threaten to grow excessively large in the present research. Given the scale of the mapping task, it is important to eliminate from consideration as soon as possible all branches of the network that can be eliminated. To control the growth of the network, we imposed three kinds of restrictions.

1. Eliminating the lowest levels

The bottom three levels (specific technologies, implementations, and brands and models) were judged to be "inexhaustible" for future markets, which is to say, empirically intractable. Therefore, we eliminated them from consideration. We also eliminated the fourth lowest level (general types of technology), but did so later in the process, when it appeared that we could not complete the task in a timely fashion. In addition, we eliminated the level of "subcomponents", another level that is not strictly necessary for a description of the market.

2. Eliminating implausible branches

As discussed above and in Chapter 2, there is no innate limit on the number of market segments that can be imagined. While we did in fact allow the lists of possible segments to grow rather large (as will be seen in Chapter 9), we imposed informal plausibility judgements to keep it from getting completely out of hand.

3. Restricting branches not likely to be funded by ATP

At each level of the hierarchy, we tried to identify types of markets that ATP would probably not be willing to fund. (In Chapter 9, these branches of the hierarchy are indicated with asterisks.) Branches that had been so identified were generally not subjected to further disaggregation or analysis in Chapter 9. Moreover, those branches were entirely omitted from the summarization contained in Chapter 10.

What is and is not fundable by ATP

Consequently it is important to know what ATP will or will not fund. However, it is not a trivial task to determine what DV research is potentially eligible for funding under the DV Focus Area. Indeed, that is itself part of the research that needs to be done in order to complete the DV market map. The following somewhat tentative assumptions are based on conversations with ATP.[5]

1. Possible conditions for omitting an item from the scope of ATP DV funding and direct effects

a. The ongoing US private research base is already active.
b. The research is heavily funded by another government agency.
c. The activity is too broad, technically related more to non-video than video issues, and not highly leveraging for DV applications.
d. The expected payoffs are too small; e.g. existing technology is good enough for the stated purposes.
e. Foreign domination is clear and probably incontestable.
f. ATP is too small to make an impact (e.g. displays, core networking functions)
g. There is substantial overlap with another ATP program (but the DV program will make a referral in that case).

2. Some particular classes of items and issues likely to be outside ATP's DV program scope

a. non-video related items

non-video-centric broadcast technology
non-video-centric intellectual property rights
non-video-centric data privacy and security systems
general purpose remote audit and payment systems
general purpose computers
general purpose memory units
non-video-centric data-base equipment
non-video-centric information retrieval systems
non-video-centric information surveillance systems

b. video items with large research programs

video cameras and mikes
CR tubes and thin screens
speakers (but not head sets)

[5] We are grateful in particular for David Hermreck's help in constructing this list. Additional sources include the ATP White Paper on Digital Video (Advanced Technology Program, 1997b) and the ATP Proposal Preparation Kit (Advanced Technology Program, 1994).

general VR, geometric imaging, and FX

c. specialized and well funded application areas

expressly military technology
expressly earth-satellite and space-oriented equipment
expressly medical equipment

3. Some classes of items potentially included in ATP's DV program scope

head sets
video implants
video smart cards
specifically video transmission technologies
integration of DV with other data
video interoperability
content-based searching
automated video content interpretation
video-oriented data bases
applied VR: telepresence
integration of editing and transmission; interoperable editing
collaboration support software
personal matching systems
surveillance devices

Summarizing the market map

Even after extensive trimming, the DV hierarchical map remained very extensive (around a thousand lines of description as it now stands in Chapter 9 and Appendix 5). That level of detail is inconveniently large, both from the point of view of a reader of this report, and as a basis for the subsequent impact analysis. Therefore we imposed some additional selection and aggregation, as described in Chapter 10.

Eliminating markets not fundable by ATP removed about half of the Chapter 9 structure. The remaining structure was condensed further by making specific predictions about which forms of market segmentation would actually emerge in the next 15 years.

Predicting market segmentation

In conceptual terms, one might predict market segmentation using the following steps:

1. estimate future sizes of component markets, using
   subjective expert belief

input-output data
estimates of price elasticities and quality elasticities
estimates of future changes in prices and qualities

2. estimate number of segments possible per component, based on
existing market segmentation
expected changes in market size
expected changes in costs of specialization
3. rank the quality scales and specialized uses by market importance, based on
existing market segmentation
subjective expert belief
4. select the required number of highest-ranked segments.

In practice, such a project would duplicate much of the work of the subsequent impact study -- a study which presumably will be based on the market segments we are now trying to predict. There is evidently a circularity problem here.

Consequently, for the Chapter 10 summary we adopted a less formal procedure. Using input-output data, survey and workshop results, and a Delphi panel approach, the research team simply formed its own best judgment about the most likely segmentation for each component. (In other words, we made independent judgements and then discussed them so as to reach, at best, a consensus, or, at worst, an average view.)

Undoubtedly, many of the market segmentations we predicted this way will not come to pass. However, the consequences need not be fatal to the subsequent impact study. It is important to keep in mind that the Chapter 10 summary is merely a “most likely case”; the main analysis of possible market segments exists in Chapter 9.

4. LITERATURE REVIEW

One strand of our work to define the markets that may be significantly affected by digital video has been to sample the literature. We use the term "sample" rather than the conventional term "survey" in order to more accurately convey the flavor of our efforts. The literature relevant to DV technology and applications is simply too vast to be reviewed here in any systematic way. This chapter provides an overview of the literature we examined; for conciseness, numerous ideas we found in the literature are included in the Chapter 9 summary but not in this chapter.

The World Wide Web is an especially fertile source of literature. Using the Alta Vista search engine in late 1997 a search for the term "digital video" uncovered about 75,000 web documents. About 4,000 of these referred explicitly to products available or events occurring in the “future”. Many hundreds of different companies advertised digital video products and services, and thousands of models and brands and proprietary versions of digital-video related software, equipment, and services were offered for sale. The web also contains extensive detail on patents that have been issued in the U.S. since 1971, including the patent abstracts (*U.S., Patent and Trademark Office*, 1998; *Community of Science*, 1998). More than 1500 patents have been issued domestically in the past two years that reference digital video.

In addition to the vast electronic literature, there is also a wealth of more conventional printed material in technical and engineering books and journals, trade publications, and the popular press. Sudalnik and Kuhl (1994), for example, have compiled an annotated bibliography of close to 1,500 articles and books published between 1981 and 1992 solely on the topic of High-Definition Television.

Purpose

The development of digital video technology promises to reduce the cost of creating, editing, transmitting, receiving, storing, organizing, and using visual information of all kinds At the same time, it offers to make possible significant improvements in the quality of visual information. On the one hand, lower cost and higher quality will encourage increased use of video in existing markets. On the other hand, it will make possible the emergence of entirely new markets, where considerations of cost, quality or convenience previously made incorporation of visual information impractical.

Our objective in sampling the literature on digital video was to obtain a sense of where the major market opportunities and developments will occur as these technology evolves, as well as the time frame in which they will occur, as seen by informed observers and participants involved in the development of the technology. Although we found many suggestions about how digital video will affect existing and new markets, we found much less guidance about how quickly or slowly these effects will take place.

No simple scheme can capture all of the details of the digital video literature. But much of the

discussion can be organized around a small number of themes which are listed below, along with citations to a selection of representative articles, publications, and World Wide Web sites.

Video production, distribution, and consumption

Television (including the video delivery of theatrically released movies) is one of the major existing markets that will be affected by the advent of digital video. New standards for High Definition Television (HDTV) have already been adopted incorporating the use of all digital transmission formats. A relatively accessible introduction to digital video at the engineering level is Poynton (1996). A survey of current issues is given by Weiss (1998).

Because of the large size of the consumer markets associated with broadcast television, cable, and home video, and the significant impacts that changes in broadcast standards will have on these markets, this is one of the most extensively discussed topics related to digital video.[6] Brinkley (1997) offers an up-to-date history of the conflict over HDTV standards, and a portrait of the competing interests involved.

Much of the literature here is focused on the issue of how quickly the transition from existing formats will take place, and what the costs and benefits will be. Owen and Wildman (1992, ch. 7) offer a useful conceptual overview of the issues involved here. As they note, the pace of diffusion of HDTV and the profitability of adoption by content producers will be substantially affected by issues such as network externalities, and the compatibility of new broadcast standards with the existing base of NTSC receiving equipment.

The first stages of the transition to HDTV have recently begun to attract the attention of the popular press. A recent article in the *Wall Street Journal* (1998), for example, reported that broadcasters are holding back investment in production and broadcast equipment because there are few consumers able to receive high-definition pictures, and TV makers are waiting for high-definition broadcasts before launching their products.

But not all broadcasters appear so pessimistic about the prospects for HDTV. A number of stations have already begun to experiment with the new technology and are actively promoting its development and diffusion (see *Mediaweek* 1997). PBS stations in Seattle, Milwaukee, and Boston, for example, have already begun, or are committed to begin experiments broadcasting HDTV signals (*Current Online* 1997a). While recognizing that problems will arise, those involved are optimistic that these challenges will be overcome.

> "There's a lot to be figured out," says Ed Williams, a veteran engineer working on DTV planning at PBS. Practical DTV technology is so young that engineers still have to invent

[6] There is a great deal of relevance to HDTV on the World Wide Web. Among the sites that proved useful in preparing this section were: the *HDTV Newsletter* (1998), *Advanced Television Systems Committee* (1998), and *Electronic Business Today* (1998).

> a way to prevent a visible glitch when they switch between video sources, he says. "It's like starting off in the early 1950s, when we didn't know how to do that with analog technology," says Williams. "Eventually, we learned how to make synchronous switches for a clean transition." (*Current Online* 1997b).

Other issues that the PBS stations have begun to confront involve the extent of compression that will be necessary and desirable for DTV programs before feeding them by satellite to other stations.

As the transition to HDTV takes place it will require substantial new investment at all levels. Numerous producers have already begun to enter the marketplace. Dielectric, a major supplier of broadcast antennas, for example, has begun to develop solutions to the problem of replicating NTSC broadcast coverage without massive energy requirements, and to the practical problems of antenna design during the transition to HDTV (Dielectric Communications, 1997).

There are related issues involving the need to standardize and integrate the TV information flow in terms of bitstream management technology (the European Broadcasting Union and SMPTE, 1997b).

Personal computers and hypermedia

The other major existing consumer market that will certainly be affected by digital video is the personal computer industry. Already digital image creation, manipulation, and transmission is an important activity. But issues of cost, quality, and compression have so far limited markets for many potential applications.

Recent advances have already made it possible to use relatively inexpensive personal computers to perform sophisticated manipulations of still and video images that previously required much more expensive specialized commercial equipment. Incompatibilities across hardware, and software, along with computational and data storage constraints still limit the scope of what can be done on a personal computer, and restrict this market to dedicated enthusiasts. But the rapid pace of improvement in hardware and software in the last few years suggests that these problems will be substantially resolved in the foreseeable future (*PC Magazine* 1997a).

As these problems are overcome they will open up a wide range of new consumer uses for personal computers, such as editing, storing, and transmitting home video; instant digital photography; and home produced DV greeting cards.

Another developing strand is the extension of hypertext and multimedia to include DV in increasingly interconnected ways, so that video clips on a CD-ROM or a DVD may contain links to other video clips on the world wide web. A survey of current and future hypermedia is given by Nielson (1988).

Video conferencing is another area where rapid improvement is beginning to make new consumer uses of personal computers practical. Existing products are still limited in their capabilities, but better compression, higher bandwidth connections to the Internet, and continued improvements in hardware

should overcome these difficulties (*PC Magazine* 1997b)

Convergence of television and personal computers

One of the implications of the shift from analog to digital video images in television is the convergence of television and computers. The Digital Audio Visual Team--a consortium of Microsoft, Compac, Intel, and Lucent--predicts that "The shift from traditional analog broadcasting to new digital broadcasting presents exciting new opportunities...[P]eople increasingly are demanding new forms of information, entertainment and communication beyond the passive television experience. As the lines that have historically separated televisions and PCs blur, consumers will expect to view digital broadcasts on devices ranging from traditional PCs to new 'big screen' PC theaters to digital television information appliances."(*DTV Team*, 1998).

As the producers of television programming shift toward the supply of digital information, and computer users increase their creation, and use of visual information, these two previously distinct technologies will grow increasingly alike. Looking ahead, participants in the International Broadcasting Convention in September 1996 identified several important implications (Turner 1996; Forrest 1996; Laven 1996; Li 1996).

First, television will become more interactive. Digital transmission will encourage video-on-demand (VOD), news-on-demand, and provision of linkages between programming and advertising on the one hand, and additional data and news, on the other. Academic researchers at MIT's Media Lab and elsewhere have begun to explore even more advanced types of interactivity, such as interactive cinema (*Media Lab*, 1998).

The popularity of the Internet provides some indication of the potential. Users of the Internet can interact with various information suppliers to obtain a wide-range of updated and customized materials. But so far, the ability of this medium to supply more than rudimentary visual images is limited. Better compression, higher bandwidth connections, and the interoperability of digital video standards will greatly expand the scope of visual information that can be drawn upon, and will blur the lines between Internet and Television. "If ever two media were meant to be wed," a recent article in the *Economist* (1997) summarized, "they are television and the Internet."

Second, the way that consumers interact with visual information will be radically changed. Convergence will eliminate platform specific implementations. They will be replaced by a variety of different "information appliances" that will enable users to interact with streams of visual information in a variety of different ways. Contemporary television receivers, computers, telephones, and other devices currently used in the household will give way to new products that will combine characteristics of all three to provide transparent and simple access to streams of visual and text data.

What these information appliances will look like and how they will be built are still open questions. Researchers at MIT suggest, for example, that they will have to be built in modular fashion, so that fast changing processing components can be replaced, while longer lasting display interfaces can be

reused (*Software Devices and Systems Group*, 1998). There is also a lively controversy over the extent to which encoding and image construction can be shared between hardware and dynamically shifting software at the users' end.

Storage Media, Data Access, and Transmission Technologies

Unlocking the potential convergence of television and personal computers will require shifts in the way that data are stored, organized and transmitted. To make possible storage and rapid access to the vast amounts of visual data necessary for video-on-demand and news-on-demand, as well as other interactive uses will require new storage media, improved systems of cataloging visual data, and the development of a high bandwidth transmission infrastructure.

An excellent introduction to the issues involved is provided by the European Broadcasting Union and SMPTE (1997a). Balakrishnan, Basile, Cugnini, and Shen (1996), offer an overview of U.S. efforts to build high-speed networks to deliver digital video services to homes and consumers. As they note, current networks provide voice and data at relatively slow speeds. Providing access to high quality digital images and enabling two-way communication will require overcoming both regulatory and technical obstacles. Among the regulatory obstacles are the restrictions current federal laws place on the services that regional telephone systems can provide. Highest among the technical obstacles they describe is the need to provide much higher bandwidth than is currently available. In addition, it will be necessary to develop appropriate equipment (such as video servers capable of storing and delivering massive quantities of video data to multiple users), and provide mechanisms for data security and authentication.

The Berkeley Multimedia Research Center (*Multimedia Research Center*, 1998) is engaged in a variety of research to develop technical solutions to a number of these problems in an academic setting as are labs at MIT and other locations.

Cable companies and companies engaged in various aspects of the personal computer industry are also actively engaged in efforts to shape the development of solutions to these problems (*Business Week*, 1997).

Remote Sensing and Imaging

Satellite monitoring and other remote imaging applications are also poised to be transformed by the development of new DV technologies.

Slow motion and historic sequences of telescopic long-distance and satellite images are being analyzed for many purposes that may be loosely aggregated as "environmental monitoring", using techniques that are increasingly DV-based (Richelson, 1998; Kerber 1998). What DV adds to still images is the ability to rapidly detect changes. Images may be captured using a variety of passive (light and infrared) and active (sonar and radar, including ground-penetrating radar) sensors. Many new applications are arising, not only military, but also civilian government and commercial: weather,

climate, plate tectonic, erosion and pollution monitoring and prediction; real estate and land use planning; farm crop, forest, and fishery management; law enforcement, industrial espionage and private investigations.

Unpredictable developments

Many future applications of digital video are likely to be almost completely unpredictable, in the sense that the largest single creative step consists in conceptualizing the application, rather than in implementing it. In particular, the application might be a "second order" function, meaning a completely new functionality which enhances an existing function rather than providing for an existing or known end use. One such example is a new DV technology that measures the brightness, steadiness, and focus of the picture at different areas on a movie screen, and then provides a feedback signal which can be used to readjust the movie projector (Hayes, 1998). By their nature, innovations of this type will often address specialized or niche markets. However, the over-all economic impacts of unpredictable DV-related innovations could be large, either because many separate niches will be addressed, or else because a few such innovations may have mass appeal.

Is there any formal model for evaluating the relative potential that a given fundamental development has for generating truly unpredictable or unanticipated applications? We are not aware of any in the literature. An informal and very general argument has been made by DV backers along the following lines: visual sensory reception is the most important way most human beings have of learning about the world. Therefore, human-generated images are important means for sharing what humans know or experience. DV provides a set of new and powerful tools for manipulating and transmitting visual images. Therefore, it will have many important, and often unanticipated, consequences for how we routinely share what we know (see e.g. ATP 1997b, p. 1, 12). That argument doesn't shed much light on which particular DV development are most likely to lead to unexpected applications.

By definition, we can't fit a product with unknown characteristics anywhere into a map of known characteristics. We cannot even leave a general space for *terra incognita* in any definite location in the map, because unpredicted applications might arise anywhere on the map. The best we can do is to point out that unanticipated applications could arise. They must be searched out on a continuing basis in any effort to monitor the economic effects of DV.

5. WORKSHOP

This Chapter summarizes the proceedings of a one day workshop on the future of the digital video economy.

Description

The workshop took place on December 19, 1997 at the University of Kansas in Lawrence. About twenty persons attended. The speakers and discussants consisted of persons with expertise on various aspects of DV, together with several economists from the Institute for Public Policy and Business Research. The DV experts included individuals from several milieus, including KU faculty and staff, national consultants, individuals engaged in private industry, as well as a representative from the ATP DV program. One participant (Poynton) was present only via speaker phone. The format consisted of prepared talks on previously assigned topics, with each talk followed by general discussion. The workshop lasted about five hours, including a working lunch. Several participants had to leave before the end, and others attended only part of the event.

The proceedings were videotaped and a transcript was prepared. (The taping was performed using an analog camcorder, which still has a cost advantage over a DV device.) A full transcript of the proceedings is included in the Work Papers.[7]

The agenda and the names and backgrounds of all participants are described in Appendix 1. In the excerpts given below, the speakers (listed in order of their first comments) are:

Charles Poynton, a consultant on digital video applications in TV and computing
David Burress, Research Economist at IPPBR
S. Merrill Weiss, consultant in electronic media technology and management
Gary Minden, Associate Professor of Electrical Engineering and Computer Science, KU
Leonard McMillan, Assistant Professor of Electrical Engineering and Computer Science, MIT
John Gauch, Associate Professor of Electrical Engineering and Computer Science, KU
David Hermreck, Program Manager for Digital Video Technologies at ATP
Larry Hoyle, Information Systems Manager at IPPBR
Charles Krider, Director of IPPBR
Susan Gauch, Associate Professor of Electrical Engineering and Computer Science, KU

Selected findings

We will summarize some of the major points that were made in the workshop and excerpt some of the supporting dialogue. These excerpts are presented in time order from the workshop, and therefore

[7] Videotaping was performed by Vincent Glaeser. Workshop arrangements were handled by Susan Mercer.

are not necessarily organized by subject matter.

The major gains from HDTV are in visual fidelity and screen angle.

> Poynton: There's great color fidelity in DV that's not available in traditional analog technologies, and that's going to open the application areas of DV. You can, with digital video technology, it is possible to get a very wide picture angle. Now that's kind of a technical thing, but to give you the one minute version of that, your conventional television today is optimized for viewing where the picture angle is about ten degrees. That means, if you stick your hand, hold your palm up, the angle of your palm held there is at about ten degrees, and no matter how far back your television is and how big it is, that's about the angle of the picture. That's a very narrow angle, and in the cinema and HDTV that angle is much wider. It leads to a more compelling and more interesting picture.

Major change in ways of moving images will be driven by advances in the consumer's ease of use.

> Poynton: There's an increasing ability to send digital images across networks that digital video technology is going to have a lot to do with the Internet over the next fifteen years. Today, consumers communicate images mainly through photographs and, to some extent, through video tapes. Over the fifteen years that's also going to have a lot to do with the Internet. The products, in terms of commodities in digital video, are getting much easier to use, and I think if you cap that in an economics framework it's interesting to think of the famous quotes from George Eastman at the dawn of the photographic industry. His quote was "You push the button, we do the rest." And that signified that all the complexity of the photographic process was Kodak's. It was in the manufacture of the film and subsequent purchasing and printing of the film. That was all controlled by Kodak. The technology we never use. And so, we're seeing that same dynamic taking place in digital video. We can expect the technology to be controlled by the companies designing and manufacturing the equipment, and the users not knowing too much about it, whether the users are in traditional consumer stage or even users in businesses.

Underlying technology will continue to migrate between TV, film, networking, and computing, with the particular products tending to remain separate or segmented, but many new intermediate categories will evolve.

> Poynton: I'd like you to consider the, well, coalition or convergence, it depends on who you talk to, of computing technology or, what they call in Europe, information technology, or IT, and consumer electronics. Fifteen years ago these areas were completely separate. What we find now is that they're just right in the process of colliding or converging. Over the course of the last fifteen years, we've seen technologies move from consumer electronics into computing, and the examples are ... the CRT displays, and compact disk digital audio. Another example more recently would be CCD cameras which started out for consumer applications but have found their way into computing. And we've also seen technology migrate the other direction from computing into consumer electronics. The examples would be the random access memory or

DRAM, which was developed in computing, obviously, and now is widely used in computer electronics. And in fact, that's really the basis for digital video. Another example is the microprocessor, again, obviously, originating in the computer domain but now used in consumer electronics. Now, an example of the convergence or coalition would be MPEG, which is really, sort of didn't know it at the time, but was really jointly developed between both computer communications and consumer electronics companies ... Now, I think a lot of people have got the opinion, where we used to think five years ago that perhaps all of these areas were going to evolve into the same set of products, now I think it's more likely, and there's widespread agreement, that the products are going to remain separate but the underlying technologies are going to get closer and closer and closer. And so MPEG is the example, that we can expect virtually the same MPEG decoder chip to be used both in consumer electronics applications, like perhaps the decoder box for digital television receiver, and in computing products like for motion video decoder... So the key is the underlying technology, I think, will become virtually identical, but the products, I think, are likely to remain separate. Finally, I think there's going to be, the task that you guys have set yourselves is going to be quite difficult, parceling these things out into different markets, because I think there's going to be an erosion of the traditional categories. Where in the past it was possible to differentiate professional equipment from consumer equipment, that's just becoming increasingly difficult. Now I give you an example--the 35mm film camera is the same underlying technology used for both professional and consumer applications, and there's a whole range of products available within the same underlying technical standard, across a wide range of markets. So where thirty years ago you had 4x5 view cameras used for magazine and newspaper publishing, and other film formats used particularly used in a specialized fashion for consumers, now those divisions are all blurred and the categories are really sort of gone, and there's a whole continuum of products.

True 3-D TV will be significant, but it is not going to happen very quickly, and it is less significant than the wide angle screen.

Burress: [HDTV is] some kind of incremental change as opposed to big, qualitative jumps. What about real three dimensional television. Now that's a qualitative jump. Is that going to happen, Charles?

Poynton: Well, yes, I think it will happen. My own personal opinion is it's still a long way out, maybe fifteen years. Technically, we can do it; it's been demonstrated several places and several times.

Burress: Why, then, is it fifteen years out?

Poynton: Well, it's difficult. It's been demonstrated, but it's difficult.

...

Weiss: There are a number of issues related to 3D Television. I saw a demonstration, a very effective demonstration, of 3D television as early as the 1980's. Just to give you an idea of the

power this one has, somebody I was with at the demo has a phobia to snakes, and the particular demo was one where they had a tropical jungle scene and somebody came out--we were sitting right, watching the monitor. We were sitting right in the studio where this was made and you could see a long pole sitting over in the corner and kind of guess what was going to happen. And somebody actually walked out onto the set with a snake on the end of the pole. They started walking straight into the set and then turned it toward the camera. Well, my friend who was sitting right next to me when this happened went back in his seat to the point--he couldn't go through the back of the seat and ended up toppling over backwards trying to get away from the thing because it had that much of an impact on him, given his phobia. So, it can be an extremely powerful experience. The issues are that you then have to have appropriate displays, and in that particular case you had to be wearing the right kind of glasses, they were shuttered, and it took two independent displays to do it, or you can use a new kind of head-mounted displays, but then there are issues of band width. Are you going to devote essentially double the band width? You know, there might be some ways of compressing that, but they're still in the future to be developed. Right now, it's double the band width.

....

Poynton: Also, a point upon the specific issue of 3D. Movies have been able to do 3D with a certain degree of success, like handing out glasses out to all the audience members, for twenty or twenty-five years, and that has not seemed to get market penetration or market size. There's even a few fixed venues where 3D is used every day. But it's just not the important thing to do.

Minden: On the other hand, look at IMAX, which is a very wide angle immersive type of format and the success of IMAX as a technology.

Poynton: IMAX is actually much more economically significant than 3D.

McMillan: IMAX is not the key point, and the key point is not really 3D. The key point is immersion. However, it's cheating, why fill the view, IMAX, you know, why fill the view with this type of display. You know, I think immersion is a quantitative difference. In fact, you know, driving toward wider screens in HDTV all point in the direction, you know, an experience is more compelling if you can immerse the user in it in some way. You know, 3D is just, stereo or any other form of 3D, is just another way of getting a little more immersive. I think in conjunction, I mean, if I had to trade off a wide field of view for stereo, I think I'd take a wider field view any day, merely because I think it's more effective...stereo is a visual cue that only operates at a distance of a few feet away, where immersion really allows me, seeing things with my peripheral vision, really gives me the context of living in another place.

The measure of degree of immersiveness should be the effect it has on human activities or thought processes:

J. Gauch: Question is, perceptually you have to see, how immersive is. You either can do a task better because of that immersion, then you can pick up something with a glove that you couldn't

do if it were immersed. You have to have a quantifier.

McMillan: Actually, there had been recent studies in that particular area. For example, Randy Pausch at CMU recently did a study trying to quantify the value of the head-mounted display (HMD) in performing various tasks and it was a searching task, and really, he actually found, quite interesting, a person with a CRT, if they were given the case of finding a particular object was about as effective as doing it with a head-mounted display. However, given the same situation and asked to find if an object existed at all, he was considerably more effective than with the head mount display because you have your vestibular system giving you feedback. What happened is that if the person looked on the CRT display they would tend to go through the space. You know, an average it would take about 50% of the time it takes you to rotate around in order to find that an object is in a room or not, identify that it is there. He found in his case that in the specific task of finding that an object was not in the room, and it was in the room, the people tend to search, perhaps, two to three times longer in a mount immersive display. So it's particularly effective in giving yourself a reference point and being able to say, I searched this room once and a letter "a" is not on the wall anywhere. Where that was particularly, doing the same task, using a track ball and a possible screen. They searched it several times so immersiveness equals search done.

....

J. Gauch: You can also have a visceral reaction to a snake and then your measurement is, just toss them out. If they don't react, you know it wasn't very immersive.

Increasing computing power and bandwidth will lead to automated retrieval of program material in the near horizon:

McMillan: I think a very important technology in the near form is going to be software agents. The strange thing is, it's kind of a strange model, but in the future there will be in effect--you'll be leasing a person to watch television for you and to filter out the things that are important. But instead of having a literal intelligence this will be a computer embodied intelligence in the form of a software agent. You know, a person who can--you set down through a series of defined filters, specifying your preferences, structuring a query of your interests, and then you basically set free an agent who does the job of watching all the 120 channels that are coming to your television, or possibly could come to your television in one given time, and basically lays it out in a format that you'd like to see it. If you'd like to see it produced in such a way of seeing Tom Brokow, sort of introduce in between from story to story, you could basically do that in the form of agents; so I think that's an important key technology we'll see. I think these technologies are in the short term horizon.

Screens are likely to be separate modules from tuners and receivers:

McMillan: Another thing that I think is very important is the whole notion of video system modularization. Many years ago we used to buy our stereos all as one unit that had built in

> phono player, the radio, and then there was the general trend toward modularizing so you could choose between the various sources you want. A lot of people focused on the reason HDTV is not going to be delivered in the near future is because of the cost of the CRT tube. What we need to do is we need to decouple the purchasing of the CRT tube, the CRT tube might very well be the computer display you bought last year, and what we're talking about here in the delivery of digital video is the introduction of intermediate components, in particular, a component that is equivalent to your stereo receiver that, in fact, is a receiver for your digital video streams interpreting.

McMillan claimed that there will be a trend towards increasingly distributed processing of video content, so that, for example, each user will select and compute his/her own viewpoint on the underlying event or program. This claim led to a lively controversy with Weiss, Poynton, and others, who expect processing to remain centralized for the most part. However, no examples were given that showed that the outcome would seriously affect the functionality available to end-users, since choice of viewpoint can also be accomplished using more centralized processing.

Storage costs are dropping about as fast as computing and transmission costs:

> Minden: First of all, I want to reiterate that computation, band widths, and storage are all coming along. The basic rule of thumb is that computing power is increasing about 50% per year; storage capacity is increasing about 50% per year, and band width, computer networks are coming along at the same, about actually, DRAM storage is about the same rate. That means that the kinds of things you can think about, one of the most interesting projects in this area that would be a good place to look at what you can do with digital video, I think, is Phil Byrd's digital history project, doing a show of video history of survivors of the holocaust and the kind of capacity he's thinking about is interviewing 50,000 survivors at an average or two hours per interview, so that's 100,000 hours of video, which works out to 130 Terabytes, and that's doable today. He's building that system. They've completed about 40,000 interviews. He not only wants to have that archived, but he wants, there are about 60 museums around the country, he wants to make sure that he, given any museum, can walk up to a kiosk, and pull up, do a search on a data base, a comparable data base, pull up the video, and see that interview or parts of that interview within a couple of minutes. Still, 135 Terabytes are on the tapes.

There was much discussion of several obstacles to adoption of new technologies, including lack of standards, legacy equipment, and the unwillingness of many consumers to invest in capital goods that may be only transitorily useful. Several individuals more closely aligned to TV argued that TV hardware and software will continue to change incrementally, and will change more slowly than computing and networking hardware and software.

The specific technology of image capture and transmission is now very much up for grabs...

> J. Gauch: ... But, you know, how are we going to make this happen on the video capture side? Really, one of my fundamental thoughts when I was putting this talk together is there's just so

much opportunity out there, that there's almost more confusion than there is consensus. There's a variety of CCD and non-CCD cameras out there available: some are high resolution, some are low resolution; some have different fidelity properties; some have hybrid analog video. What comes out? Some of them are analog. What comes out? some of them are digital. There are different color systems that are possible, you know, RGB and YIQ are currently out there, you know, YUB and XYZ, sounds like an alphabet soup again, but, you know, there are perceptual color spaces out there that are actually better color spaces for visual perception than RGB. And, you know, should they be in the cameras, and how are we going to decide that? What data should the cameras output and how should we support this variety up above? I guess, you know, the way it's working now is people are just throwing darts out and trying to make a product and see if it will catch on. It doesn't necessarily mean that the best one is going to catch on.

...and lack of stability and standardization is a critical obstacle for adoption:

J. Gauch: Well, tomorrow I might invent something twice as good as MPEG, and I've got to chuck this box into the trash and buy another one? No one's going to like this disposable technology, and so we do need to have ways to convert between formats and then we need to have programmable decoders that can support multiple formats. But this is just going to make things more complex. This is one of the headaches we had with our digital library of video that we made. How do we make this video library interoperable between people who have MPEG encoded stuff and AVI encoded stuff and HTUT263 encoded stuff? There's a new vendor every week that's got a new video compression format on the web, and so, how are we going to deal with that? And who's going to decide which is best? There was a tremendous success of MPEG, it was the fact that it came out and it was a standard and a lot of people picked it up, but I've seen sort of a reverse happening lately. It seems like there's a real proliferation of nonstandards all trying to duke it out. And at this stage it's just adding more confusion than it is moving us forward. But, in order for the future digital video technology to happen and work, we need to either come up with ends that we think are the best ends or else we need to have a prescription that says if you come up with Format X we have to have a way to make that playable on all these different platforms somehow.

Adoption of new technology in the TV industry has a 15-20 year time constant:

Weiss: The principal objective of the [SMPTE] task force has been to set the direction for the next decade or two in the television industry using technologies that we expect to be available in roughly the next five years, and this is a problem of capitalization and roll out. If we decide it now, it will take a good ten to twenty years to get it all in place throughout the industry. And we understand that latency from prior roll outs where standards that I personally did a lot of the testing, and Charlie was involved in some of the testing, back in 1981, those standards are still being rolled into operations today because of the problem of capitalization in the markets.

Film will remain the standard of merit for image capture for a long time to come...

Weiss: What we have is a common medium that can be translated into all the others that preserves the maximum value; and so you will find that where television production a few years ago was headed toward being done in video, it's reversed itself in the last few years as people have thought about the future of digital television. And, in fact, something like 95%, where it used to be down to 70%, I guess, being done in film, it's back up to 95% for just that reason.

But the 500 channel universe will come a lot sooner:

Hermreck: Merrill, what kind of time span do we have on this? When is this niche broadcasting really going to be feasible economically, technically?

Merrill: Well, to an extent that depends on the distribution networks and when the cost of, for instance, the fiber, the bits in the fiber, come well enough to support it. But in terms of the production, I mean, within the next five years, certainly we can have that kind of low cost production capability. You have it today practically.

Hoyle: Isn't it already happening you know, on the net, with dirty pictures, I mean, people are making money on that now, aren't they?

Weiss: I mean, you have the capability today where you can get a, was it Charles who used the term "prosumer" earlier, and you can get consumer equipment that is of essentially the same quality as "prosumer" equipment. The "prosumer" equipment has a few more features to make it easier for somebody to use, but, for instance, get a DV Cam, the new digital video compression scheme that's designed for consumer applications. You're talking a couple thousand dollars for a camera that gives you digital image quality, and I use that in a good sense, and then you can take it back and play it back into a computer using a buss that's almost there, the IEEE1394, that allows you to exchange not only the digital video but also all the control and audio and other data that has to go with it, and use your computer as an editing system. You can actually produce a pretty reasonable program at that low level now. But, the kind of very sophisticated production values that would go into the high end are independent of that. But it will allow somebody who doesn't need to put all those, really high end production values into the program, to be able to create a program on very inexpensive equipment, if the equipment was the limiting factor. So for a few thousand dollars, you can have a full blown editing system sitting at your computer desk.

Krider: I've heard for several years we're going to have 500 channels. It hasn't happened, and, is it ever going to happen, or should it happen, or ----

Weiss: Actually, that's because of the cost of the distribution network. That's what I was saying a minute ago. It's the cost of the bits in the pipe and what it takes to receive them. The economic model for the cable industry is that they need, in order to get that 500 channel universe, they need digital compression, and they need their set top boxes that handle that to be in the range of two to three hundred dollars. Right now they're in the range of about $400. So, when that

comes down to the $300 and under range, we can expect to see the implementation develop.

Digital processing of images has already two distinct market segments:

> Weiss: ....let me differentiate in the electronic graphics from electronic image processing. Electronic graphics, I'm talking about things like ET or the dinosaurs in Jurassic Park, or the terminators and the way they move ----, that's all electronic graphics. But there's also electronic image processing where you take a real world image and, based on the ease now of conversion between film and digits and back to film, you can do things like removing lines.

Cost and quality improvements in digital imaging will *not* lead to drastic and rapid market changes in the entertainment industry, because the main costs are personnel and imagination rather than computation:

> Burress: Question about what kind of graphics. Presumably if the cost goes down then you might try to do fancier stuff. Are we doing the fancier stuff, are we pretty close to there, or are there quite a lot of fancier things on the drawing board?
>
> Weiss: The issue is, what are the software models? When you talk about electronic graphics, you're talking about creating images in a computer. And the issue is, the really expensive part of doing that whole process is the talent who does it--the artists who sit there and do the drawings. And so, what you're trying to do is to minimize the time that it takes them, and so that's why it's worthwhile putting these millions and millions of dollars of compute power into their hands because it minimizes their time. And so, the machinery that can render faster, for instance, when you go to the final output, is all beneficial. ---- There are more and more sophisticated software techniques that are coming along, and that are being developed that, for instance, allow you to develop a shape, have that shape have three dimensions in computer space, and then model textures onto it and apply various light sources to that texture into that three dimensional model. All that takes a lot of very complex computing; a lot of that has to be under the control of the artist to say "Here's the way I want this object to look ... here's the way I want to manipulate it ... and then here's the way I want to light it." So there are more and more complex and more and more realistic algorithms--algorithms that can produce more and more realistic results coming along that take advantage of more and more computer power. So they're kind of both drawing together. But for any given level of image call, or image conceptual freedom and flexibility, given as the computer power gets cheaper and cheaper, then you can do that in a real world .

Digital processing will continue to produce final images for delivery to users, not models of images, for the foreseeable future:

> Poynton: ...the most important word in the title of our session is "economy" and I argue that it will be a very, very, very long time before the transmission of models from Hollywood studios is economically important. Certainly, there's a little economic activity in Hollywood today which is undertaken by companies that are in the business of buying and selling models, that's what--we

could talk about that--that's sort of a little 20 million dollar business today--but in terms of the distribution of entertainment to consumers, the videos are focused on delivering image, not on the making of models. Thinking of models is secondary to their goals.

Delivery of film or video content is, and will continue to be, segmented rather rigidly, depending on the rents available in each delivery method.

Weiss: If you think about the films that the film industry puts together, ... independent productions, but they still end up being released by a universal distributor. There is a small amount of independent distribution ... and all the other release of that film production ends up on video media; and so a big part of the profits for, probably most, you just count the number of productions--the biggest amount of profit for most of those productions comes from their release in video. And there is a separate food chain for that release within the video media where the highest return media come first. And then you go down to the lesser and lesser returns, somewhat like the way airplanes are sold. And, of course, the objective is the maximization of returns and profits. The packaged media yield the highest returns, and so they come first, and the mass distributors are then put in profit order following that. So, for instance, if you look at film delivery, you have theatrical releases, as I say here, currently on film, there have been various attempts to distribute it electronically, for instance, using high definition television,. It requires digital compression, and to this point, at least, the kind of compression that was necessary to deliver an image adequate for theatrical presentation on 20 and 30 and 40 foot screens required too wide a band width to be economically viable. That doesn't mean it can't be done, it can be technologically done, but the band width that you need and the equipment you need in all the figures is prohibitive at the moment. People like Sony have the large theaters and also the technological ability and continue to work this problem, and someday we might see it, but right now it's not there.

So then we talk about the alternate electronic media, and there are both packaged media and then there's electronic distribution, packaged media, VHS tape, and also the video disk gets the first release. The DVD is coming along and very soon will plug in exactly the same point. It's essential--the technology is essentially done, with some remaining arguments about access control, and that's the principal thing that's been holding it up, probably for the next two years I'd bet. And then there's electronic distribution where pay-per-view comes first and pay-per-view included video on demand and near video on demand. Then the cable networks, and we have two classes there, subscription networks and basic networks. Finally, it gets to the broadcast networks, and that's followed then by local television stations, where local stations can buy packages of movies, sometimes 20, 30, 50 at a time, and can schedule them for whenever they want, or for their every night movies or week end movies, or whatever.

TV broadcasting equipment will continue to be segmented by stages of production of the bit stream...

Weiss: When we talk about components, I've listed a bunch of hardware items here--encoders and multiplexers and decoders; stream splicers, which are a way of concatenating streams or

inserting commercials, and that sort of thing--also, doing the facts--compression translators, which let you distribute at one bit rate and then deliver at a different bit rate--something that's somewhat necessary to enable some of these stream splicers to--and especially affects the way ---- to do their work. Media services, kind of like servers in computer systems except that they handle video and audio and data and metadata, which I'll mention in a minute; editing systems, resource management systems. I mentioned earlier the complexity. If you think about this as a manufacturing facility where you're, instead of manufacturing cars, you're manufacturing continuous television programs, or maybe it's a chemical plant--maybe that would be an even better analogy, where you have lots of parameters to adjust so you have a continuous output that has to be maintained.

... but what gets delivered will rapidly get more varied and more interactive.

Weiss: ...you may want a whole collection of metadata by itself. For instance, to point you to where the content is to be found--or to help you search to find the right content to go to the ... So then I look at products as the increased number of channels that will be available over various delivery media. A number of new delivery methods that are coming along, we talked about DVD. There will be other packaged media that certainly will arise. In addition, there will be increased band width to the home, band width to the business, band width to the viewer. The Internet is a good example of another band width element that's becoming in greater and greater supply, and demand as well. There will be new kinds of programs and, you know, we talked a little bit about interactive programming. Microsoft has the model that they show, if you've been to the Microsoft home, you'll see that they'll show you their enhanced version of Moesha that's running on UPN at the moment. When you see part of the program, there will be a little segment on the screen. This is one where, instead of having the image fill the whole screen, the image fills part of the screen and wrapped around it there are other things going on so, for instance, you can have an area where, if there's some jive jargon that's used, there's an explanation for those of us who don't speak that dialect. They can have places where you can write letters to the stars; where if you want to know what somebody's wearing, it will tell you, well you know, it came from such and such a designer, or whatever the case might be.

Minden: That can take up the other half of your brain while you're watching TV.

Weiss: I mean, the broadcasters are going to be in a quandary over this, because if you give, I mean if you accept the Microsoft model as it stands, and you give the viewer the ability to point at the corner of that and make the images as big or small as you want, and then you fill the screen with other stuff going on, the broadcaster has been used to selling a screen's worth to the advertiser; and if the viewer was in front of the screen at all, got the impression of a screen's worth. Now, what you'll have is the possibility that the viewer will make the ...

Minden: See Ford on the screen and check out the Chevy website.

The news business is going to change fundamentally because of online competition.

S. Gauch: It used to be, how many newspapers could I get delivered to my door--OK, the *Lawrence Journal World*, the *Wall Street Journal*, *Kansas City Star* would all deliver, and that was pretty much it. Now I can, from my computer, I went to this one server and they claim that they have 7000 on-line news sources. So from one location, I can access 7000 on-line newspapers, special purpose information groups, and what have you--the direct news feeds, all those kinds of things. That there is a lot more choice for the consumers and I think this is going to create a great problem for locally produced information which may be at a reasonable quality compared to globally produced information at a very high quality. Now I can see what the--instead of reading the editorial that someone in the *Lawrence Journal World* puts out, I can read the editorial from the *New York Times* just as easily and contrast it with the editorial from the *Washington Post*, and all these other newspapers that formerly only the very dedicated persons who would go to the library to look up these national newspapers could get. Now I can get it all from my desktop. And I think it's going to put a lot of pressure on people who--newspapers and information sources that look at geographically local areas to support them. And the other advantage of digital information vs. print media, in general, is that I can view it at my own convenience. We've got this temporal breakdown now where the *Lawrence Journal World* came every day and after, you know, not many people stacked up all the back issues of the paper, there's a very physical horror to that ---- take it to recycling, and you start all over again. Well, with the digital media, the information kind of hangs around someone else's disk and they archive it and I can go away for vacation, and not have to worry about two weeks of newspapers accumulating on my doorstep, and if I miss a story, having to search all the way back through those or just never getting to it. I can now, at my time steps, read the information, not at your time steps.

Online news sites will be segmented by subject matter, leading to advertising losses for conventional newspapers.

S. Gauch: Yeah, in general the advertising, the whole idea is that if there is a whole second media at which people can advertise and bypass the local newspaper, I think it's going to really hurt the local newspaper. And if there's a whole second media at which people can publish the news ... if I get my news from the point cast and news pages, whatever, even just go direct, straight to CNN's website, straight to NBC's website, I can bypass my local news providers. And I think that what we've seen before in the information market place has been information partitioned or segmented in economic terms geographically, whereas now we're going to see more segmentation along type of content. There is one site that has all the movie information you could ever want in the world and more; there's one news site, you know, there's ESPN site, for example; NBC sports site, one information source that would give you more sports information than any human being could digest in their lifetime.

....

S. Gauch: And I think that there's two way that I can see this going. It's hard to say which one's going to win out. Either everything will be come ... on the one hand you have this tremendous homogenization, everybody goes to CNN to get their news and everyone across the country gets

the same news, but then on the other hand we have the ability to have local, very small operators, put things up very cheaply, we might get the chess channel, and it's not clear to me which way's going to win out, or whether they'll both win out.

Minden: I'd lay on the table an alternative, which is, it's a national size entity that franchises out to small localities--Borders model, Barnes and Noble, Gap. You know, we get 'em all now in Lawrence, and it'll be a national sized entity that's going to franchise so that there is a market in local news, local information, and we know how to go in at marginal cost and provide that service to people in the local area.

There will a be market for screening against commercials:

J. Gauch: A related issue is the sale of commercials. If we can have a little filter, which I guess has been made numerous times, to detect commercials and turn them off, or when we've got our little information feed that's only feeding us the good parts, unless we have set it to get the Maxwell House Commercials sent to us, we won't get the ...

S. Gauch: That does happen with these video feeds. We chop off the commercials.

J. Gauch: If they don't have closed caption they never get found.

S. Gauch: And even if they do have closed caption, they don't generally match the users' news profiles and so they get essentially commercial free news.

And a market for authenticating images:

Minden: ... let me bring just another aspect ... it's close to security ... it's that I don't think we've touched on this. We've touched on the idea of protecting the creator's intellectual property, but there's another side that with digital video--that is, how do I authenticate the video that I'm seeing, that I trust that it's the local newscaster is really standing in front of The Whitehouse at this moment doing a "live" broadcast--that I'm not seeing a merge of some cameraman standing in front of the Whitehouse pointing his camera and somebody doing a blue screen. And I think we know we see it as today, and those kinds of things, and so, there's-- and it applies not only to the digital side, but to the photographic side these days. There's an IBM commercial with an IBM laptop sitting on a gargoyle over ---- City. Now, do you think they really did that? In 1960, we knew they did lift the Chevy truck on the plateau, right? But today, how does the broadcaster or creator give me some kind of certificate that what you're seeing is what I--

S. Gauch: And even if it's real or not real--whether it's merged or not real--how do we know it is from ABC, not something doctored along the way.

Minden: And so I think that's a little different twist, but something that has to feed into this--in the creator side of it. It really is the Terminator II movie I'm seeing now, and it really is worth

paying $10 for, that you're not seeing something doctored or--

And a market for archival methods:

> S. Gauch: And the last impediment that isn't up there that I wanted to mention was these archival purposes. There has been mention of the vault and how people take the vault and make more money out of it and use it again. If we have stored everything digitized in MPEG format, what are the chances that twenty years from now we'll be able to find anything that can read MPEG and get us that movie back again. There needs to be this constant, you know, my Ph.D. data is on some, you know, 8 inch floppy, and I couldn't read it today if I had to. And so we have to guard against this when we talk about archiving videos. In what format are we going to archive?
>
> Weiss: There is a SMPTE activity, by the way, looking to try to create a universal preservation [product]...
>
> S. Gauch: I think that's a big issue.
>
> Weiss continues: That has a lot of librarians...
>
> J. Gauch: Have to watch how we put it on some magnetic media or -- the hospitals have dealt with this for fifteen years, since they've done digital X-rays, and storing them on magnetic media. They've got these rooms the size of this thing filled up with magnetic media that you can't read anymore, even though they still own the tape drives, or whatever drives...

There was general discussion of how rapidly the available bandwidth would increase, with no consensus reached.

6. SURVEY OF EXPERTS

This Chapter describes an effort to construct a list of DV experts and survey them about their expectations for the future DV marketplace.

Purpose

As an empirical technique, a survey is severely limited both in the complexity of concepts and in the extent of the detail it can encompass. At the same time, this report adopts a theoretical mapping structure which is both complex (there are a number of levels and concepts in the hierarchy of characteristic) and extensive (there is a large mass of possible detail at each level). Therefore, our survey of experts was intended to support and supplement our data gathering, but not to serve as a self-sufficient source.

Moreover, a survey of this type faces a trade-off between, on the one hand, the detail and sophistication of the questions being asked, and, on the other hand, the sample size that it is practical to obtain given those questions. That is, as the questions grow more detailed and difficult, a declining proportion of experts will be willing to make the effort required to master the survey. Our initial intent had been to design a survey which was relatively superficial yet easily accessible for the experts. As the study continued, it seemed to us that what we most needed was a sophisticated analysis of holes or omissions in the ideas we had already accumulated. Consequently, we designed a survey that was relatively more sophisticated but less accessible.

Most of the survey focused on major features of the mapping structure we were developing as it stood at the time the survey instrument was designed. We asked for judgements about the likely future importance of various possible market segments. We also asked open-ended questions soliciting additional ideas on how DV markets might segment. The survey focused on “components”, “quality improvement scales”, “ranges of specialized use”, and “market segmentation” as defined in Chapter 2. An effort was made within the survey instrument itself to partly explain the latter three concepts to the survey respondents (it did not seem necessary to explain the concept of “components”).

We made no effort to obtain any kind of statistically representative coverage of experts. That is, we specifically were not attempting to estimate a snapshot of the universe of expert opinion. Instead, our goal was to obtain a variety of expert viewpoints. We hoped to obtain two types of information from those viewpoints:

- Can some of the experts suggest additional ideas we had not thought of?

- On particular questions about future DV markets, is there a rough general consensus among experts, or are there rather a wide variety of opinions?

We generally did not calculate averages or mean values for the quantitative judgements provided by

our respondents. Indeed, a mean value would be meaningful only if the experts generally agreed; and in that case, their consensus opinion could be reported. The experts came from several different fields, and could not possibly be equally knowledgeable on any given question. When experts from various fields disagree on a given question, then we believe the appropriate action is to identify specialized experts who are especially knowledgeable on that particular question. A statistical average that includes both informed and uninformed opinions lacks much merit.[8]

Moreover, by design most of our respondents were engineers or technical specialists rather than marketing personnel. While they could be expected to know what DV products within their various fields of expertise may be technically feasible and affordable, they are likely to have more limited knowledge about what consumers are actually willing to pay for in the market place. Certainly, it would have been helpful to survey individuals who had made actual marketing studies of future DV goods and services. However, it is our understanding that only a few such studies have been made, and all that we know of are either already published or else proprietary.

Protocols

We initially planned a two-step survey. In step one, we would use telephone and email polling techniques to construct a list of experts. In step two, we would mail and email the experts questionnaires on future DV. In practice, we encountered difficulties which led us on a more complicated route.

A scientific or representative survey should start with a "sampling frame", which is to say, an exhaustive list of all possible sampling units in the population under consideration. Unfortunately, future DV applications cross many diverse fields. Consequently, there is no list that includes all, or even most, persons knowledgeable about future DV. But we were not seeking a representative survey, and therefore we planned on a less systematic approach. In particular, we identified DV-relevant companies and individuals from an informal Internet search, then contacted them by telephone and email about their expertise and their willingness to participate in our survey. We also asked them for leads to other experts.

We attempted to contact roughly 80 firms by telephone and 300 firms by email. However, about 90 of the email addresses were no longer valid. From this effort we located some 50 individuals who stated that they worked directly with digital video or used some digital video applications. (See the detailed protocol in Appendix 2.) Of these, about 40 agreed to complete a mail survey. (About equal numbers were produced from the telephone and the email efforts). Respondents were promised a report on the survey results in return for completing the survey. However, only 15 actually returned the survey. Through telephone and emails, we attempted to contact the non-respondents. Eight individuals responded that they did not feel qualified to complete the survey once they examined it;

[8] In the second research Task of this project, we do plan to break out more specialized questions and try to target them individually to more specialized experts. The range of markets and issues covered in Task 1 seemed both too broad and too little known in advance for that approach to be feasible here.

the others could not be reached. The respondents may also have been deterred by the length and technical detail of the survey instrument (some 4000 words), although the instructions suggested that respondents could answer only part of the survey.[9]

We believe that negative self-selection by the survey respondents who claimed to lack expertise was an appropriate feature of this survey design, because individuals who state that they are not expert should probably be taken at their word. On the other hand, these low response yields were discouraging from a cost point of view.

Therefore, we redesigned the mail survey as an on-line website survey. Announcements of the survey were posted to 12 DV-related Internet Discussion Groups. (The Internet Discussion Groups are listed in Table 6.1.) About 30 additional responses were obtained at our website.

As noted, the protocols we used are described in Appendix 2; the complete questionnaire is contained in Appendix 3.

Table 6.1
Internet discussion groups that received website postings

alt.cyberpunk	comp.sys.sgi.graphics
alt.video.digital-TV	rec.video
comp.compression.research	sci.image.processing
comp.dcom.videoconf	sci.engr.television.advanced
comp.graphics.visualization	ucb.digital-video
comp.multimedia	uk.tech.broadcast

Source: IPPBR

The respondents

It is not possible to estimate a meaningful survey response rate. The respondents were essentially self-selected, recruited from several venues; we don't know how many individuals became aware of the opportunity to volunteer but declined. It is probably fair to say, however, that most of the potential respondents who became aware of the survey from the various newsgroups declined to participate.

The survey began with several questions on characteristics of the survey respondents. The respondents, without exception, appeared to be experienced or knowledgeable on subjects relevant to the future DV economy. All were employed in a field that created or used film or video hardware, software, or content. Most were employed as practitioners or managers or consultants in engineering or software development; a few were in sales or finance. Most had more than 5 years experience in that field, with an average of 13 years. Most were employed in private sector firms. All of the firms

[9] Phone and mail surveys were performed by the University of Kansas Survey Research Center under the direction of Kevin Nelson.

were oriented to technology, entertainment, or consulting.

Respondents who completed the survey appeared highly motivated. Most respondents answered most of the questions. There were many comments, and many of the comments were technically sophisticated.

Findings on components and adoption benchmarks

One series of closed-end questions focused on particular components (i.e. types of products) that have been widely predicted, and asked for judgements about their significant social impacts and speeds of adoption. Identifications of additional components were solicited using open-ended questions. The formula used in this series was as follows: a particular component and adoption benchmark was listed. (For example: 20% of households are wired for VOD.) Respondents were then asked to give their opinions on two scales:

A. When is it most likely to occur?

now
1-3 years
4-7 years
8-15 years
> 15 years
never
no opinion

B. If it happens, how important will the social impacts be? Please show anticipated impacts on a scale of 1-5, as follows:

1 not important at all
2 slightly important
3 moderately important
4 very important
5 extremely important
no opinion

These findings are summarized in Tables 6.2 and 6.3.

Table 6.2
Predicted adoption rates for benchmarks

Question	Benchmark	PERCENTAGES FOR:					
		Now	1-3 yrs	4-7 yrs	8-15 yrs	>15 yrs	Never
1	The majority of television broadcast is in digital format.	3%	9%	31%	53%	0%	0%
2	20% of households are wired for video on demand.	3%	9%	34%	41%	6%	0%
3	20% of households are connected to visual content-searchable DV databases	0%	9%	22%	50%	13%	0%
4	20% of households subscribe to videomail	3%	3%	31%	44%	13%	0%
5	20% of households are equipped for videophone.	0%	3%	31%	38%	19%	0%
6	20% of individuals have access at home or work to teleconferencing.	16%	9%	41%	22%	6%	0%
7	20% of individuals are equipped at home or work to communicate using "immersive telepresence."	0%	3%	16%	28%	38%	13%
8	Television and computing video technologies are largely interoperable.	3%	16%	34%	28%	9%	0%
9	A universal standard for video compression which is scalable in terms of bandwidth has been almost fully implemented.	6%	19%	31%	25%	6%	6%
10	20% of households own a DV editor.	0%	6%	25%	28%	22%	13%
11	Video editing software for home or office is standardized to the point that there are one or two main interchangeable types.	3%	9%	19%	34%	16%	9%
12	A majority of commercial motion pictures are originally created in DV format.	3%	0%	38%	13%	31%	9%
13	20% of households own a high resolution binocular or holographic video headset.	0%	0%	9%	13%	50%	9%
14	20% of multi-employee businesses have video-based advertisements on the Internet.	6%	19%	34%	22%	13%	0%
15	20% of households are wired for incoming bandwidth of at least T1 (or 1.5 Mbps).	3%	3%	19%	50%	13%	3%
16	20% of households are wired for outgoing bandwidth of at least T1 (or 1.5 Mbps).	0%	6%	6%	44%	31%	3%

Source: IPPBR

Table 6.3
Social importance of benchmarks

Question	Benchmark	PERCENTAGES FOR:						
		Not answered	No Opinion	Not important	Slightly important	Moderately important	Very important	Extremely important
1	The majority of television broadcast is in digital format.	3%	0%	6%	22%	28%	25%	16%
2	20% of households are wired for video on demand.	6%	0%	6%	22%	31%	22%	13%
3	20% of households are connected to visual content-searchable DV databases.	3%	3%	0%	25%	41%	22%	6%
4	20% of households subscribe to videomail.	6%	0%	13%	22%	38%	19%	3%
5	20% of households are equipped for videophone.	9%	0%	9%	22%	34%	22%	3%
6	20% of individuals have access at home or work to teleconferencing.	6%	0%	6%	28%	28%	13%	19%
7	20% of individuals are equipped at home or work to communicate using "immersive telepresence."	3%	6%	19%	9%	19%	31%	13%
8	Television and computing video technologies are largely interoperable.	9%	0%	3%	13%	22%	25%	28%
9	A universal standard for video compression which is scalable in terms of bandwidth has been almost fully implemented.	6%	3%	3%	9%	3%	41%	34%
10	20% of households own a DV editor.	9%	3%	28%	25%	25%	6%	3%
11	Video editing software for home or office is standardized to the point that there are one or two main interchangeable types.	9%	6%	19%	19%	22%	9%	16%
12	A majority of commercial motion pictures are originally created in DV format.	6%	6%	19%	16%	28%	22%	3%
13	20% of households own a high resolution binocular or holographic video headset.	6%	16%	38%	25%	13%	3%	0%
14	20% of multi-employee businesses have video-based advertisements on the Internet.	3%	3%	3%	16%	22%	25%	28%
15	20% of households are wired for incoming bandwidth of at least T1 (or 1.5 Mbps).	3%	6%	6%	0%	16%	22%	47%
16	20% of households are wired for outgoing bandwidth of at least T1 (or 1.5 Mbps).	3%	6%	3%	16%	25%	31%	16%

Source: IPPBR

Time scales for adoption benchmarks

In general, there is a very wide range of opinion on the most likely time scale for each adoption benchmark. In nearly all cases, there are some responses predicting more than 15 years, and other responses predicting less than 3 years. However, there does appear to be some limited information content in the pattern of responses -- that is, there is some limited degree of consensus on relative rates of adoption. In particular, the responses are generally unimodal, with a rough bell-curve shape; and the peak of the curve shifts in time, depending on the particular benchmark. On all questions, most of the respondents had a definite opinion.

Given the bell-curve shape, the information content of responses can be tracked by comparing the time range of the response peaks across questions. That is, if the response peak is lower than average on a given question, then the distribution as whole tends to be lower as well. (Tracking response peaks is a non-parametric statistical approach, which seems appropriate for this type of data.)

Substantively, for a majority of the benchmarks, the predictions peak in the 8-15 year range. Several benchmarks peaked in the 4 to 7 year range, and a few peaked farther out than 15 years. None had peaks in the ranges of "now", "1 to 3 years", or "never".

Four predictions that had response peaks in the earlier (4 to 7 year) range were:

- 20% of individuals have access at home or work to teleconferencing.
- A universal standard for video compression which is scalable in terms of bandwidth has been almost fully implemented.
- 20% of multi-employee businesses have video-based advertisements on the Internet.
- Television and computing video technologies are largely interoperable.

The last prediction above suggests that many respondents believe HDTV will be adopted as planned, and also view HDTV as interoperable with computing standards, or else believe that computing standards will adjust to be interoperable with HDTV.

Two predictions with response peaks at greater than 15 years were:

- 20% of individuals are equipped at home or work to communicate using "immersive telepresence" (which provides the illusion of being present with a distant person).
- 20% of households own a high resolution binocular or holographic video headset.

In one interesting case, the responses were bimodal, with separate response peaks in the 4 to 7 year range and in the over 15 year range:

- A majority of commercial motion pictures are originally created in DV format.

It is possible that those who selected the shorter time scale, construed the question as including

conventional analog pictures that incorporate digital special effects. According to our consultants who are specifically knowledgeable about cinema, a shift to digital format is not likely in the near future.[10]

One could certainly raise the question of whether these observed differences in predicted time of adoption across benchmarks represent real differences in opinion, or merely represent sampling fluctuations. In other words, we might want to test the following null hypothesis:

H_0: Any one benchmark question elicits the same range or distribution of responses about adoption timing as would any other benchmark.

It turns out that this null hypothesis does fail at a reasonably high level of significance. Actually setting up and describing a test is complicated, however, by the use of interval responses, an unbounded category ("15 years"), and a discrete category ("never"). In light of our previous comments on interpreting a non-representative survey, this issue does not seem to merit a full discussion.[11]

---

[10] See Chapter 5 for the views of Charles Poynton and Merrill Weiss on this subject.

[11] However, we will describe one simplified and approximate test, as follows.

First consider Benchmark 15: "20% of households are wired with incoming bandwidth of at least T1 (or 1.5 Mbps)". This question had a typical middle-of-the road response pattern. Suppose that the pattern of sample responses to this question accurately reflects the average pattern for all questions among the population of experts; focus on responses other than "never" and "no opinion"; assume that responses are uniformly distributed within response intervals; and assume that the average for the over 15 year group is 30 years (which would be a relatively conservative assumption if the distribution is log normal). Then we can calculate a sample mean of 12.1 years and a standard deviation of 8.01 years.

Next focus on the responses to Benchmark 1: "The majority of television broadcast content is in digital format". Under the same assumptions, its sample mean is 8.27 years. Now use a t-test on the null hypothesis that the given sample mean for benchmark 1 could have occurred based on a draw of N observations from the population (which is assumed known from Benchmark 15). The standard error of estimate for sample means drawn from the population would be $\sigma/(N-1)^{.5} = 1.46$ with N=31 degrees of freedom. Then the t-statistic for the deviation of the sample mean from the population mean would be 2.62, which is significant at p=.01.

Of course, that significance level would be misleading when applied to whole the whole ensemble of results, since actually there were sixteen separate sets of draws (one for each of the 16 questions of this type). With 16 independent draws, the null hypothesis could be rejected based on the single Benchmark 1 outlier, only at a significance level of around p =16(.01) = .16. Actually, however, it can be rejected much more soundly than this, because there were several additional questions that had extreme outlying response distributions. (A non-parametric statistical approach would be more appropriate, but modeling would be needed to set it up as well.)

Social importance of adoption benchmarks

There was a somewhat higher degree of consensus on the social importance of the each benchmark, but still a wide range of opinions. On nearly every benchmark, there were responses at both extremes ("not important" and "very important"). However, the distributions of responses always appeared approximately bell shaped, and 50% or more of the non-missing responses always fell in just one or two adjacent categories out of the 5 categories.

A majority of the benchmarks had response peaks in the "moderately important" category. Only one benchmark had its peak in a lower category of importance. Several had peak responses in one of the two higher categories of importance.

One benchmark had its response peak in the "not important at all" category:

- 20% of households own a high resolution binocular or holographic video headset.

No benchmarks had response peaks predicting a "slightly important" social impact. As noted, a majority of the benchmarks had response peaks in the "moderately important" category.

Five benchmarks had a response peaks predicting a "very important" social impact:

- 20% of individuals are equipped at home or work to communicate using "immersive telepresence" (which provides the illusion of being present with a distant person).
- Television and computing video technologies are largely interoperable.
- A universal standard for video compression which is scalable in terms of bandwidth has been almost fully implemented.
- 20% of households are wired with incoming bandwidth of at least T1 (or 1.5 Mbps).
- 20% of households are wired with outgoing bandwidth of at least T1 (or 1.5 Mbps).

One benchmark with a response peak predicting an "extremely important" social impact was:

- 20% of multi-employee businesses have video-based advertisements on the Internet.

The differences across benchmarks in judgements about social importance appear to be meaningful; for example, they would be highly significant under conventional statistical tests.

Additional components

An open-ended question early in the survey instrument asked about major future developments in DV. Some of the comments here and elsewhere in the survey mentioned components or subcomponents not mentioned in the survey instrument, including the following:

set-top box ad banners (e.g. in return for advertiser provision of the box)

digital guides to HDTV
standardized set-top and cable boxes (purchased by the consumer)
DV billboards and wall murals
point and click menus
digital still photography
DV interfaces (between camera; editor; memory; printer)

Findings on quality improvements

A second series of questions focused on quality improvement scales, and asked for judgements on the relative likelihood that significant improvements would appear in the DV marketplace along each listed scale within the next 5 to 7 years. Examples showing the formula used in this series of questions are:

yes no no-opin. (significant improvements in quality in the next 5-7 years)
__ __ __ number of people with access
__ __ __ number and variety of people accessible

The findings are summarized in Table 6.3.

Anticipated quality improvements

In general, respondents expressed great optimism for increasing quality in most aspects of products that will be offered in the DV marketplace. There were, however, a few notes of pessimism.

A marked majority of experts expect, in the next 5-7 years, to see significant improvements in marketed goods along virtually every conceivable scale of technical or engineering quality. For example, pictures and sounds will be bigger, better, and more accurately represented, with lower prices. And, they expect that improvements in underlying technical sophistication will drive these benefits; for example, data compression ratios, accuracy of human perceptual models, and effectiveness pattern recognition methods will improve. Respondents also expect improvements in the quantity and variety of the content that is available.

Respondents are much less optimistic that the new technology will lead to improvements in quality of the content. This result at first seems somewhat at odds with two other findings: respondents expect to see improvements in the degree of competitivity and in the locus of market control. (The possible loci of control were listed as advertisers; non-profits; and end-users. Presumably, respondents believe that control will shift away from advertisers and towards non-profits and/or end-users.) These changes in competitivity and control would seem to imply that users will have better opportunities to get the content quality that they want; yet quality is not expected to improve. By implication, the respondents may feel that users do not *want* improved content quality, or they may feel that the public's notions of quality differ from the respondents' notions of quality.

Respondents predict significant increases in all aspect of connectivity: numbers and variety of individuals and organizations connected, ubiquity of hyperlinks, and ability of individuals to retrieve data easily. Respondents predict significant improvements in most aspects of simplicity and convenience, interoperability, ergonomics, and user control of data and viewing conditions. The only exception here is that users are not expected to gain much control over remote camera points of view in the next 5 to 7 years.

Additional quality improvement scales

The listed quality scales were grouped into five categories, as follows:

1. Picture and sound quality
2. Program content quality and diversity
3. Connectivity
4. Control and convenience
5. Technological sophistication

This series solicited the identification of important additional quality scales using open ended-questions at the end of each category. Several quality scales not listed in the survey instrument were mentioned here and elsewhere in the comments:

access delays
batch versus foreground data searches
frame rate
signal-to-noise ratio
production effort required per given video content

Table 6.4
Quality improvement scales

Question	Quality Improvement Scale	Will this undergo significant changes in 5-7 years?	
		% YES	% NO
	1. Picture and Sound Quality		
1a	accuracy of transmission (data error	56%	25%
1b	availability of transmission signal (obtaining channel access, dropouts, delays)	78%	6%
1c	size and number of monitor screens and speakers	63%	25%
1d	resolution, video and audio (bandwidth; distortion and artifacts)	78%	13%
1e	level of presence (simple video; virtual reality/telepresence; immersive telepresence or simulation)	56%	31%
1f	degree of spatial discrimination	53%	31%
1g	character of virtual reality (availability, quality, control -- e.g. selection of avatars)	44%	25%
	2. Program content quality and diversity		
2a	quality of video content	31%	56%
2b	numbers and variety of video channels	78%	9%
2c	size and variety of video content	88%	3%
2d	degree of competitivity or	69%	13%
2e	locus of market control (e.g. advertiser, end user, non-profit)	44%	28%
	3. Connectivity		
3a	number of people with access	88%	3%
3b	number and variety of people	81%	9%
3c	number of organizations with access	84%	6%
3d	number and variety of organizations and services accessible	81%	6%
3e	number and variety of public places that can be viewed on line	75%	9%
3f	physical ubiquity of transmission service outlets	66%	13%
3g	effectiveness of searching, indexing, browsing, and pattern recognition capabilities	81%	6%
3h	number of contexts in which hypertext is available (e.g. when viewing a TV ad)	81%	6%
	4. Control and convenience		
4a	number and variety of editing/presentation functions; integration of tool suites	63%	19%
4b	certifiability or authentication of images	47%	25%
4c	convenience of transactions (e.g. payment methods)	78%	13%

TABLE 6.4 QUALITY IMPROVEMENT SCALES, CONTINUED

Question	Quality Improvement Scale	Will this undergo significant changes in 5-7 years?	
		% YES	% NO
4d	interoperability: modularity and interconnectability of components	66%	19%
4e	interoperability: commonalities across specialized markets	53%	19%
4f	interoperability: independence between creation, transmission, and utilization	66%	9%
4g	interoperability: seamless merging of TV, computing, teleconferencing, etc.	63%	19%
4h	degree of local control of picture (split screen, picture-in-picture, full windows)	66%	22%
4i	amount of local storage	81%	9%
4j	degree of local control of program stream	63%	25%
4k	degree of adult control over children's access	59%	28%
4l	degree of remote control of camera point of view by viewer	28%	56%
4m	level of security and data privacy (storage, transmission, display)	72%	13%
4n	speed of operations (editing, searching / retrieving, converting, virtual reality computation)	75%	13%
4o	capability of equipment to learn and anticipate user's preferences	69%	22%
4p	availability of voice control input	69%	22%
4q	user simplicity	66%	25%
4r	physical comfort and ergonomics of equipment	50%	31%
4s	weight and portability	66%	19%
4t	thinness of monitor	78%	3%
	5. Technological sophistication		
5a	accuracy and completeness of human perceptual models	44%	19%
5b	error rates of pattern recognition models	44%	22%
5c	data compression ratios	56%	25%
5d	availability of editing and pattern recognition operations on compressed images	66%	6%
5e	prices and costs	75%	16%
5f	degree of scalability	66%	16%
5g	degree of redundancy in streaming	31%	28%
5h	available bandwidth	75%	9%
5i	maximum manageable size of remote video databases (number of videos; number of accesses per hour)	75%	6%
5j	wirelessness	56%	25%

Table 6.5
Likelihood of segmentation

Question	Description	PERCENTAGES FOR:				
		<5% likely	5-30% likely	30-70% likely	70-95% likely	>95% likely
	1. Picture and Sound Quality					
1.1	Viewing and transmission services segmented by resolution (e.g. low resolution, high resolution [HDTV], super-high definition [up to 7000	16%	6%	19%	22%	22%
1.2	Transmission services are segmented by availability and dependability (channel access, dropouts, delays)	9%	19%	28%	19%	3%
1.3	Conferencing services are segmented by general quality (resolution, trans-mission reliability, number of channels connected, presence) (e.g. household and casual business televideo; distance learning and teleconferencing; high quality [e.g. immersive	9%	0%	16%	38%	22%
1.4	Computational imaging is segmented by degree of motion (e.g. translation and magnification of 2D object; rotation in space of 3D object; depiction of 4D object [e.g. 3D objects changing over time]; rotation in 4-space, n-D	13%	22%	9%	19%	13%
	2. Control of Viewing Conditions & Access					
2.1	Interactive video controllers are segmented by degree of interactivity (e.g. local [game/interactive educational program]; single-person multi-site interactive; multi-person multi-site interactive)	9%	38%	19%	13%	6%
2.2	Video cameras are increasingly segmented by portability of local equip-ment (e.g. stationary; local change in aim, focus, zoom; locally mobile; mobile, shoulder or tripod; mobile, hand held)	16%	28%	16%	9%	16%
2.3	Non-theatrical screens and speakers are segmented by viewing location (e.g. home; portable; workplace; open	16%	13%	16%	25%	16%
2.4	Content transmission services are segmented by number of channels (number available; number that can be simultaneously active)	0%	13%	28%	25%	16%

TABLE 6.5 LIKELIHOOD OF SEGMENTATION, CONTINUED

Question	Description	PERCENTAGES FOR:				
		<5% likely	5-30% likely	30-70% likely	70-95% likely	>95% likely
2.5	2-way communications services are segmented by numbers present at the same time (e.g. one-to-none [video mail]; one-to-one [videophone]; one per location, several points; several to several [videoconference]; several to many [teleconference]; many to many [virtual convention])	9%	19%	16%	22%	16%
2.6	2-way communications services are segmented by degree of privacy (e.g. private; private within small group; private within a large group; public)	13%	28%	6%	19%	16%
2.7	Virtual collaboration services are segmented by scale of institution (e.g. group, team [virtual classroom]; building, school, plant [virtual library]; community, enterprise [virtual corporation, virtual academy]; nation [virtual polity]; world [virtual inter-polity?])	16%	16%	22%	19%	3%
2.8	Content-based indexing and searching software are segmented by means of the search (e.g. different users will need specialized searches based on: visual content; associated text; text inside visual field; audio content)	19%	16%	16%	9%	16%
	4. Type of Application					
4.1	Complex authoring equipment will continue to be differentiated by application (e.g. games; instructional software; special effects)	3%	3%	16%	31%	28%
4.2	Video cameras will be increasingly segmented by photographic locations (e.g. home and casual business; portable; studio; on location; surreptitious; public fixed location)	9%	9%	13%	28%	22%
4.3	Monitoring equipment is segmented by application (e.g. scientific [there may be subspecialities]; institutional [monitoring clients]; household; surveillance and security; process monitoring and control; inventory control; traffic control; shipping item control)	6%	6%	13%	41%	16%

TABLE 6.5 LIKELIHOOD OF SEGMENTATION, CONTINUED

Question	Description	PERCENTAGES FOR:				
		<5% likely	5-30% likely	30-70% likely	70-95% likely	>95% likely
4.4	Commercial matching services are segmented by forum (e.g. home shopping for goods; demonstration of services and designs; shopping for travel locations; business shopping; dating services; forming business or research alliances)	6%	16%	22%	6%	19%
4.5	Virtual collaboration services are segmented by application (e.g. medicine [subspecialities are possible]; science & engineering [many subspecialities are possible]; business telecommuting; virtual enterprise; distance learning; video and non-video joint authoring and editing)	3%	6%	22%	25%	25%
4.6	Complex imaging equipment are segmented by application (e.g. medical imaging and tomography; industrial tomography; computing and modeling output; computing input; data retrieval; specialized data analysis [statistics, biometrics]; scientific data display; animation and special effects)	0%	0%	19%	19%	41%
	5. Timing conditions for viewing					
5.1	Content delivery services will be increasingly segmented by search technique and access control (e.g. unsolicited delivery; regular scheduled programs [broadcast or narrowcast]; transmitted by reservation or prior request [push]; on demand, remote, closed catalog; on demand, remote, open Internet search; transfer of physical copy [retail; rental])	3%	9%	19%	22%	25%
5.2	2-way communications services are segmented by simultaneity (e.g. real-time [e.g. videophone]; time-shifted [e.g. videomail]; archived/historical)	9%	9%	31%	13%	25%
5.3	2-way communications services are segmented by who made the appointment (e.g. joint negotiated [appointment]; joint unilateral [public conference, open house]: one-sided [cold call, home page]; random [chat room, bulletin board])	16%	13%	22%	22%	6%
5.4	Data searching services are segmented by timing of the search (e.g. episodic foreground; continuous background)	19%	19%	13%	16%	6%

Findings on segmentation by specialized use

A third series of questions focused on ranges of specialized uses. This series asked for judgements on the likelihood that each range would be an important principle of market segmentation in the future. No particular time frame was given. The usual formula used in this series of questions was as follows: a particular range of specialized use was described. In some cases, additional categories were solicited within the range. Then respondents were asked to express their opinions on a scale of 1 to 5:

1 < 5% likely: significant segmentation is very unlikely to occur
2 5% to 30% likely: significant segmentation is rather unlikely to occur
3 30% to 70% likely: significant segmentation about as likely to occur as not
4 70% to 95% likely: significant segmentation is rather likely to occur
5 >95% likely: significant segmentation is very likely to occur
no opinion

The findings are summarized in Table 6.5.

Anticipated segmentation by specialized use

There was a moderate degree of consensus on the relative likelihoods of segmentation along different ranges. On each question, 50% or more of the non-missing responses fell in either one or two of the five categories. However, on most questions there were a few responses at each extreme (>95% likely and <5% likely). The distributions of responses usually appeared bell shaped, with the two highest response rates in adjacent categories. A few questions had bimodal responses, but the two peaks were never separated by more than one category. Consequently, for a given question, if one of the two largest groups of respondents thought the outcome was a practical certainty (either >95% or <5% likelihood), then the other large group either came close to agreeing (70-95% or 5-30% likelihood, respectively), or else was neutral (30-70% likelihood).

Substantively, about nine questions had response peaks in the upper ranges of likelihood (70% to 95%, or >95%). Only four questions had peaks in the lower ranges (<5% or 5-30%), and around eight were in the wide middle range of uncertain outcomes. In other words, respondents were typically somewhat more likely than not to expect segmentation along the suggested lines.

Four cases where most respondents definitely do not expect segmentation are:

- Interactive video controllers are segmented by degree of interactivity (e.g. local [game/interactive educational program]; single-person multi-site interactive; multi-person multi-site interactive).

- Video cameras are increasingly segmented by portability of local equipment (e.g. stationary; local change in aim, focus, zoom; locally mobile; mobile, shoulder or tripod; mobile, hand held).

- Content-based indexing and searching software are segmented by means of the search (e.g., different users will need specialized searches based on: visual content; associated text; text inside visual field; audio content).

- Data searching services are segmented by timing of the search (e.g., episodic foreground; continuous background).

In eight cases, respondents were generally neutral or divided about the likelihood that:

- Transmission services are segmented by availability and dependability (channel access, dropouts, and delays).

- Computational imaging is segmented by degree of motion (e.g., translation and magnification of 2D object; rotation in space of 3D object; depiction of 4D object [e.g. 3D objects changing over time]; rotation in 4-space; n-D objects).

- Content transmission services are segmented by number of channels (number available; number that can be simultaneously active).

- Virtual collaboration services are segmented by scale of institution (e.g., group, team [virtual classroom]; building, school, plant [virtual library]; community, enterprise [virtual corporation, virtual academy]; nation [virtual polity]; world [virtual interpolity?]).

- Commercial matching services are segmented by forum (e.g., home shopping for goods; demonstration of services and designs; shopping for travel locations; business shopping; dating services; forming business or research alliances).

- 2-way communications services are segmented by simultaneity (e.g., real-time [e.g. videophone]; time-shifted [e.g. videomail]; archived/historical).

- 2-way communications services are segmented by who made the appointment (e.g., joint negotiated [appointment]; joint unilateral [public conference, open house]; one-sided [cold call, home page]; random [chat room, bulletin board]) .

- 2-way communications services are segmented by degree of privacy (e.g., private; private within small group; private within large group; public).

Respondents evidently tend to be especially uncertain about how some aspects of 2-way communications systems will shake out. Nine cases where respondents do expect segmentation are:

- Viewing and transmission services are segmented by resolution (e.g., low resolution; high resolution [HDTV]; super high definition [up to 7000 lines]).

- Conferencing services are segmented by general quality (resolution; transmission reliability; number of channels connected; presence) (e.g., household and casual business televideo; distance learning and teleconferencing; high-quality [e.g. immersive telepresence]).

- Content delivery services will be increasingly segmented by search technique and access control (e.g., unsolicited delivery; regular scheduled programs [broadcast or narrowcast]; transmitted by reservation or prior request [push]; on demand, remote, closed catalog; on demand, remote, open Internet search; transfer of physical copy [retail; rental]).

- 2-way communications services are segmented by numbers present at the same time (e.g., one to none [video mail]; one to one [videophone]; one per location, several points ; several to several [video conference]; several to many [teleconference]; many to many [virtual convention]).

- Non-theatrical screens and speakers are segmented by viewing location (e.g., home; portable; workplace; open public).

- Video cameras will be increasingly segmented by photographic locations (e.g., home and casual business; portable; studio; on location; surreptitious; public fixed location).

- Monitoring equipment is segmented by application (e.g., scientific [there may be subspecialities]; institutional [i.e. monitoring clients]; household; surveillance and security; process monitoring and control; inventory control; traffic control; shipping item control).

- Virtual collaboration services are segmented by application (e.g., medicine [subspecialities are possible]; science and engineering [many sub-specialities are possible]; business telecommuting, virtual enterprise; distance learning; video and non-video joint authoring and editing).

- Complex imaging equipment are segmented by application (e.g., medical imaging and tomography; industrial tomography; computing and modeling output; computing input; data retrieval; specialized data analysis [statistics, biometrics]; scientific data display; animation and special effects).

- Complex authoring equipment will continue to be differentiated by application (e.g., games; instructional software; special effects).

Additional ranges of specialized use

The ranges of specialized use were broken out into four categories:

1. Picture and sound quality
2. Timing conditions for viewing
3. Control of viewing conditions and access

4. Type of Application.

At the end of each category, additional ranges of use within that category were solicited. The new ranges suggested by the respondents included:

higher motion fidelity for sports events
pay-per-view versus subscription versus free program content
content quality (Hollywood, TV, independent, home)
viewing location (theater, home)
interactivity of access (broadcast, VOD, local memory)
content type (news, entertainment, education)
sophistication of DV author (home, business, professional, graphic artist)
encrypted versus non-encrypted storage and transmittal
synchronous vs. isochronous vs. asynchronous
NTSC vs. PAL
traditional realms: computer, TV, film, specialized imaging
immersive telepresence as an alternative to travel to expensive/dangerous/inaccessible locations
non-entertainment data broadcasting to computers

Findings on economic and technological methods

Many of the comments had more to do with the techniques and marketplace process than with the ultimate nature of the service that is being delivered. Some of the comments stressed the importance of:

3D hardware acceleration
economies of scale with a mass market
competition from satellite service providers
digital interface standards (IE1394)
an analogy for cheap DV: the ubiquity of clock chips once they became very cheap
MPEG2
cheaper memory, cheaper CPU
merging of Internet and TV
plasma screens
cameras on most new monitors
increased bandwidth on telephone
the high cost of high quality content, as a limit on entry of new producers

Several of these points were made independently by two or more respondents.

Conclusion

Even though some respondents expressed a wide variety of opinions, a reasonable degree of

consensus can be discerned in many of their views. Respondents appear to expect that much progress will occur in the DV market place, some of it in the next 7 years, but more of it in 8 to 15 years out. They are confident that technological changes in DV goods in the marketplace will produce quality improvements along practically every important scale of quality, with a possible exception being made for the good taste of the viewers. They expect increasing diversity or segmentation of products along a number of lines.

Some of the underlying concepts used in this survey were relatively complex, and some were taken more from economics than from engineering. Did respondents who were mainly engineers understand them? There is evidence that in general they did (although some of the comments and response patterns suggested that one or another question was perceived as ambiguous). The comments the respondents made were generally helpful and made sense in context. Also, it is noteworthy that there was an especially high degree of consensus in several cases where we, as authors of the survey, also believed that segmentation outcomes were not seriously in doubt. In particular, there was strong agreement that complex imaging will be segmented for specialized uses such as tomography and data analysis (a view also shared by the research team): only 19% of all respondents placed the likelihood below 70%, and none placed it below 30%. That kind of agreement would be harder to explain if the respondents did not understand the concepts of "specialized use" and "complex imaging".

It is a very different question whether these expert opinions can be credited with a high degree of predictive accuracy. There is some recent literature implying that technological forecasting at the level of individual R&D projects is highly *in*accurate, not because results are biased up or down, but rather because the outcomes are innately highly uncertain and also highly skewed (Scherer, 1988).

It turns out that this pattern of high variability also holds for relative returns to industry-specific stock portfolios for technology-related firms. Yet there are good reasons to believe that relative prices in the stock market provide the best publicly-available predictors of future returns to investments in publicly traded companies, including R&D investments.[12] If stock prices are relative inaccurate predictors of industry-wide R&D outcomes -- and apparently they are -- then it seems likely that *all available prediction methods* lead to relative inaccurate predictions of investment outcomes. (Again, we are not saying that stock prices imply *biased* forecasts of R&D outcomes -- in fact, they are probably fairly accurate, in terms of average returns over all technology investments. What we are saying is that stock prices, as well as all other methods, yield extremely *noisy* predictors of outcomes

[12] In particular, an accurate prediction of future returns to an investment can yield extremely high dollar profits to anyone willing to make a bet on it in the stock market (especially if the risks and rewards are amplified using stock options). Consequently, the stock market is ordinarily that market which pays the highest dollar price for accurate forecasts, is publicly known to be such, and is available to all comers. Except in very special cases, goods are sold to their highest known bidder. Therefore we would expect that goods consisting of "reliable forecasts of market outcomes" will be sold to persons who will use them on the stock market. And therefore stock market prices should reflect investment dollars based on the best available predictions. Moreover, if reliable market prediction methods are known to *anybody*, then they are very likely to be used on the stock market. (However, this argument is complicated greatly by the market presence of less-informed investors and "noise traders" who may create temporarily self-fulfilling prophecies.)

of any given type of investment. DV R&D would be one such type of investment.)

And in particular, expert opinion about future technology outcomes are likely to be highly noisy predictors. On the other hand, they still may be the best predictors that are available.

7. SIC MANUAL SEARCH

This Chapter describes an effort to bring imagination to bear on the future of digital video. The effort was kept under control and focus by systematically searching though the U.S. Standard Industrial Classification (SIC) Manual.

Purpose

Predicting markets for digital video that don't exist yet is necessarily an exercise in imagination. Most of the methods for identifying new markets that are reported in this study made use of imagination at second hand; that is, we searched for the products of imagination that were reflected in the literature, or in the views of consultants expressed in oral conversations, or in the views of other experts responding to a survey. The exercise described in this chapter attempted to make systematic use of the first-hand imagination of some of our student assistants.

Method

Undergraduate student assistants were assigned particular pages of the SIC manual and asked to focus their imagination on the ways in which those industries might make new uses of digital video. The students were regular hourly employees of the Survey Research Center, who came from a variety of departments. They were given background literature on digital video and a 2-page explanation to read prior to undertaking the task. They were asked to think about upstream suppliers and downstream users of the industry as well. Ideas were generated on an individual basis and also in small group (up to three people) brainstorming sessions.[13]

The 1987 (and final) edition of the SIC manual was used. The new North American Industry Classification System (NAICS) manual was not yet available at the time of this project.

Research team members with some technical knowledge of digital video then looked at the findings from the SIC code scan. In the case of the best ideas, they were usually able to generalize these ideas or generate new ones.

Results

After 56 hours had been expended by approximately 16 different students, the scanning staff had covered all 2-digit and 4-digit SIC codes. This task was completed in segments; first the 2-digit codes, then the 4-digit codes. In that time, they identified a total of 650 potential applications of digital video technologies (about 12 per person hour). However, there was a great deal of crossover among types of applications and considerable duplication of ideas that had either already been

[13] The SIC search was performed by students at the University of Kansas Survey Research Center under the direction of Kevin Nelson.

identified by other means or were inherently obvious applications. Further, the second segment (4-digit code scanning) did not seem to provide many significant new ideas beyond the first segment (2-digit code scanning). Many were just variations of the general idea theme presented in the first segment.

Generally, the ideas can be grouped into six categories of applications: previewing and simulation, monitoring, archiving, training, product improvements, and remote-site tasks. The majority fell under the category of monitoring. These six general categories were already represented in the map of DV we had constructed from other sources; in that sense, the students had nothing to contribute that was absolutely fundamental. What they did have to contribute was a great deal of detail about the specific possibilities.

Potential Applications

Listed below are some of the best or most interesting ideas that were generated by the students. Ideas that are unique (i.e. ones with a small twist we have not learned of from any other source) and that also seem plausible are marked with a pound sign (#). However, a majority of these unique ideas are specific applications of somewhat more general or aggregated ideas that we did learn about from other sources. In many of the cases of this type, we judged that the more aggregated level provided enough information, and therefore, we did not include the new idea in the final mapping in Chapter 9.

Please note that the code number information is provided only to establish which section of the SIC sparked the students' ideas. It is *not* necessarily an indication of where the idea would be classified within the SIC code. A complete listing of the ideas (about 35 pages) is included in the Work Papers.

SIC 01: Agricultural Production--Crops
DV allows for specialized monitoring of soil conditions, disease, and pests.
Weather forecasting for precise locations is aided through DV.

SIC 02: Agricultural Production--Livestock & Animal Specialities
#DV allows wireless remote viewing of animals by satellite.
#Field surveillance by watch groups on treatment of animals or contamination practices is possible through DV technology.

SIC 07: Agriculture Services
#DV provides a real-time picture of an animal to a customer instantly via the Internet.
SIC 0761, 0762: Farm Labor Contractors and Crew Leaders; Farm Management Services
DV allows surveillance of employees by management.
DV allows maintenance surveillance and monitoring.
SIC 0781: Landscape Counseling and Planning
#Through DV, the consultant can visually show the clients a simulation of what the planned horticulture/landscaping will look like.

SIC 0782, 0783: Lawn and Garden Services; Ornamental Shrub and Tree Services
#DV assists in the upkeep of lawns, i.e. monitoring triggers technology or lawn care specialist to spray chemicals, trim and cut lawn, water lawn, *etc.*

SIC 08: Forestry
DV facilitates the monitoring of various areas simultaneously to analyze tree health or fire prevention.
#DV camera uploading of fire sites to headquarters allows officials to dispatch required services and personnel.
#DV allows safety to be monitored at the mill or in rural/remote sites.
DV expedites the treatment of injuries through first aid transmission via DV.
SIC 0851: Forestry Services
DV allows foresters the ability to temper deforestation and ozone problems by locating the best areas to harvest.

SIC 09: Fishing, Hunting, Trapping
SIC 0912: Finfish
#DV allows the comparison of the physical health of caught salmon to a prototype salmon transferred through DV.
SIC 0913: Shellfish
#DV allows the early detection of environmental accidents, i.e. if there is too much nitrogen that will kill the lobsters, DV can pinpoint the sources of pollutants through satellite imaging.
SIC 0971: Hunting and Trapping, and Game Propagation
#Wildlife Management can use DV units to more closely monitor game numbers and health.

SIC 12: Coal Mining
DV allows the monitoring of toxins and employee health.
DV allows early detection and warning to individuals immediately affected by toxins.

SIC 14: Mining and Quarrying of Non Metallic and Non Fuel Resources
#DV allows asynchronous communication between contractor and consumer, i.e. a picture of an area sent to a concrete supplier allows the supplier to determine how much product is required for the job.

SIC 15: Building Construction
#DV facilitates easier manipulation of contractor specifications, i.e. to better view a house being constructed through multiple angles and increased resolution.
#Building site progress is monitored remotely using DV.
SIC 1541: General Contractors -- Industrial Buildings and Warehouses
#In constructing and/or monitoring a cold storage unit, DV is attached to a heat-seeking device to detect leakage from a remote locale.

SIC 16: Heavy Construction Other Than Buildings
SIC 1629: Heavy Construction, Not Elsewhere Classified
In constructing an athletic field, DV simulates the effect of varying amounts of rain on the field.

SIC 17: Special Trade Construction
SIC 1742: Plastering, Drywall, Acoustical, and Insulation Work
#For acoustical work, DV shows images of sound waves in order to gain a more precise and dimensional view of the acoustics of a room or building.
SIC 1743: Terrazzo, Tile, Marble, and Mosaic Work
#DV digitally archives a Fresco artist's work for future contractors to copy.
SIC 1771: Concrete Work
#Via DV, a client is able to compare the proposed new driveway with the existing one.
SIC 1793: Glass and Glazing Work
#DV allows workers to locate small imperfections in glass.

SIC 20: Food and Kindred Products
DV allows education and training processes to occur without the educator/facilitator to be present on-site.

SIC 21: Tobacco Products
SIC 2131: Chewing and Smoking Tobacco and Snuff
DV helps rid tobacco products of unwanted materials (contaminants).

SIC 22: Textile Mill Products
#Through DV, designers consult with manufacturers on plausibility of different fashions/styles.
SIC 2251, 2252: Women's Full-Length and Knee-Length Hosiery, Except Socks; hosiery, Not Elsewhere Classified
DV improves ability of worker to see the product being knitted.

SIC 23: Apparel and other Finished Products Made from Fabrics and Similar Materials
DV is used to assess the quality of the final product as well as monitor the production process.
SIC 2392: House-furnishings, Except Curtains and Draperies.
#DV allows a business to color match desired products with a customer's existing product(s).

SIC 24: Lumber and Wood Products Except Furniture
SIC 2451: Mobile Homes
#A business uses a DV computer to design a mobile home according to the client's preferences.
SIC 2491: Wood Preserving
#DV is used by businesses to monitor when wood preservation is necessary.

SIC 25: Furniture and Fixtures
SIC 2514: Metal Household Furniture
#DV aids in calibration of box springs, testing the amount of pressure.

SIC 26: Paper and Allied Products
SIC 2653,2655: Corrugated and Solid Fiber Boxes; Fiber Cans, Tubes, Drums and Similar Products
DV simulates the amount of weight that the pallet or hamper can hold before being overloaded.

SIC 27: Printing, Publishing, and Allied Industries
DV allows books to become "storybooks" with visual acting along with text.
Phone books become phone disks with more information storage capabilities and automatic information updating through DV.
SIC 2731, 2732: Books: Publishing, or Publishing and Printing
Textbook publishers are never caught with outdated information since DV allows textbook editing and printing changes simultaneously.
SIC 2771: Greeting Cards
DV allows design coloring and physical properties current technologies cannot.
SIC 2782: Blank Books, Looseleaf Binders and Devices
#Scrapbooks and diaries have a DV chip insert that allows a user to see pictures of recorded events.

SIC 28: Chemicals and Allied Products
SIC 2836: Biological Products, Except Diagnostic Substances
While testing a new drug an employee views a DV presentation of previous tests on the same drug and updates it.
SIC 2873, 2874, 2875: Nitrogenous Fertilizers; Phosphatic Fertilizers; Fertilizers, Mixing Only
#DV allows a farmer to connect directly to the manufacturer/distributor in case of application problems.

SIC 30: Rubber and Miscellaneous Plastic Products
SIC 3011, 3021: Tires and Inner Tubes; Rubber and Plastics Footwear
DV simulates road conditions and tire breakdown to aid in the design of better tires.

SIC 33: Primary Metal Industries
SIC 3315, 3316: Steel Wiredrawing and Steel Nails and Spikes
#DV helps decide how much wire can be loaded onto a truck with visual manipulation of properties.

SIC 38: Scientific Instruments, Watches, Optical Goods
Missile guidance systems have a DV chip that shows a target until impact (an improvement in resolution and ability to tell what trajectory the missile is going at the same time).
Appliance regulators are hooked up to DV to tell someone watching TV that the dryer has finished its cycle.
Photographic equipment and supplies are replaced by digital microfilm and photo processing equipment revolutionized by better resolution, options include print previewing the photo.

SIC 39: Miscellaneous Goods
#Outdoor scenes are shown as someone runs on a treadmill, simulating "a jog in the park".

SIC 40: Railroads
#DV monitors view the railroad further up the trail to identify potential hazards.

SIC 41: Local and Suburban Transit and Interurban Highway
#Parents watch their children on a school bus or at a bus stop via DV.

SIC 42: Motor Freight Transport Warehousing
#DV allows truckers to communicate with their family when out for long periods of time.

SIC 44: Water Transportation
DV allows for multiple language, international communication.
SIC 4412: Deep Sea Domestic Transportation of Freight
DV provides an instant account of inventory in multiple languages.

SIC 45: Transport by Air
SIC 4522: Air Transportation, Nonscheduled
DV allows ambulances/rescue helicopters better, immediate communication with a hospital.

SIC 50: Wholesale Trade-Durable Goods
#DV is used for a simulated driving range for golf.
DV is used for medical imaging.

SIC 54: Food Stores
SIC 5411: Grocery Stores
#A DV console on a shopping cart tells a customer which items are on sale.
#Interactive DV console on shopping cart allows customer to key in their shopping list and then alerts customer to which brands are on sale and includes product/nutritional information. (Console also includes location of item in store.)

SIC 58: Eating and Drinking Places
#DV (touch-screen) is used by servers as an ordering station.

SIC 59: Miscellaneous Retail
#DV assists with authenticating an antique.
SIC 5921: Liquor Stores
DV allows an establishment to have a database to validate a customer's ID instantly.

SIC 60: Depository Institutions
SIC 6081: Branches and Agencies of Foreign Banks
International banking is made easier with DV teleconferencing.
#Real-time exchange rates are shown in multiple languages.

SIC 62: Security and Commodity Brokers
SIC 6211: Security Brokers, Dealers and Flotation Companies
DV makes floor trading obsolete with split screen capabilities, i.e. broker is able to monitor all commodities and stocks on their computer as well as communicate through the computer.

SIC 65: Real Estate
#DV allows auctions to take place at a distance.

SIC 70: Hotels, Rooming Houses, Camps, and other Lodging Places
SIC 7011: Hotels and Motels
DV provides hotel guests with a friendly wake-up call.

SIC 73: Business Services
SIC 7331: Direct Mail Advertising Services
Direct mail becomes direct video mail, allowing the individual to accept or reject the mailing or to reply and/or order.
SIC 7338: Secretarial and Court Reporting Services
A secretary uses DV to transmit messages to business partners with textual attachments, like faxes, but with sound and visual capabilities.

SIC 75: Automotive Repair, Services and Parking
#A DV camera is used to view hard-to-reach areas of a car engine for repair.

SIC 79: Amusement and Recreation Services
SIC 7996: Amusement Parks
#A DV virtual ride supersedes today's rides since the content of the ride can be changed quickly.
#DV replaces dangerous and costly tracks with virtual rides.

SIC 82: Educational Services
SIC 8211: Elementary and Secondary Schools
DV allows a sick child to participate in a class.

SIC 83: Social Services
SIC 8322: Individual and Family Social Services
A pregnant teenager receives encrypted on-line counseling through DV.

SIC 84: Museums, Art Galleries, Botanical and Zoological Gardens
A family takes a virtual vacation, otherwise unaffordable, to points of interest around the nation and world.
#Via DV, a child "visits" an historic location which is the topic of discussion in his American history class at school.

SIC 92: Justice, Public Order, Safety
SIC 9224: Fire Protection
Using DV, a fire department maps the best route to a fire with up to date traffic information, thus saving minutes and lives.

SIC 95: Administration of Environmental Quality and Housing Programs
SIC 9532: Administration of Urban Planning and Community and Rural Development
DV provides planners with the ability to transmit complicated 3-D plans to the respective constituencies.

SIC 96: Administration of Economic Programs
SIC 9661: Space Research and Technology
DV allows space researchers better visual links between ground and space, and thus, more effective research capabilities.
DV allows the transfer of visual, audible, and textural information through space.

SIC 97: National Security and International Affairs
#Immigration is more closely monitored and controlled along borders, i.e. illegal immigrants could be detained and processed through digital technologies; video can alert the Border Patrol of their initial presence.

Conclusion

In our view, these results were moderately productive in total. The costs were also relatively low. The net yield was about 40 "unique" applications (as defined above) per 56 person hours, or a little under 1 per hour. (Additional time was required for the research team to scan and analyze the results.) About 20 of these applications had a noticeable affect on the final map (usually in the form of a generalization). Generally, we believe that this activity may have been a somewhat less productive use of marginal student hours than, for example, scanning Internet literature. On the other hand, this activity probably turned up a few twists that appear nowhere else on the Internet or in print.

Note, however, that outcomes could be sensitive to the particular personnel involved; some students were much more productive than others. Additionally, scanning by individuals with some degree of

technical knowledge about DV might have led to heightened creativity; on the other hand, knowledgeable individuals could also tend to have ideas that are channeled into pre-existing tracks.

Finally, this activity helped to convince us that no map of the potential DV future can ever be entirely complete in detail. That is, we received the impression that almost any creative person exposed to some of this material for the first time can come up with a few completely new twists on what might happen. On the other hand, we also felt reassured that it may be possible to make at least the general outlines of the DV map complete. That is, all of the ideas these students came up with are variations on general themes that were already present in a map we had constructed independently.

8. INPUT-OUTPUT STUDIES

This Chapter describes input-output data that should help predict some aspects of the future digital video economy.

Purpose

In particular, we will address two questions:

- What sectors of the economy will make specialized uses of DV in the future?
- What sectors most stand to benefit from uses of DV?

Predictions of the future ordinarily start with the past because that is the source of all of the information that we have. The most systematic information we have on specialized uses of goods and services in the recent past are national input-output accounts. Accounts of this type divide the economy into N separate sectors, and then measure the directed dollar transactions (i.e. both purchases and sales) between each pair of sectors, for a total of N^2 dollar flows in the given accounting period. (The accounting periods are conventionally one year.) From these accounts, we can characterize each sector in terms of what other sectors are its most important customers. That is important because uses by high-demand sectors are especially likely to be specialized or segmented.

Of course, no single sector available in data from the past that represents the future uses that might be made of DV commodities. However, to a large extent, future DV will be used in ways that substitute for existing commodities that do appear in the existing input-output sector scheme. Therefore, we will seek to characterize all existing sectors of the economies in terms of demands for DV-related goods now in existence (such as analog video and telephones). From this characterization, we can get several kinds of hints about the future DV economy.

- If a sector is a already specialized segment of the market for video-related goods and services in the present, then it is likely to continue to be segmented in the future.

- If a sector is an important aggregate user of video-related goods and services in the present, then it is likely to be an important aggregate user in the future.

- If a sector uses video-related goods and services fairly intensely in the present (i.e., if they constitute a large share of its total dollar value of inputs), then improvements in DV may have a disproportionately positive effect on growth and change in that sector in the future.

- Similarly, if a sector makes significant aggregate use of goods and services that DV could substitute for or compete with, then that sector is a good candidate for developing specialized uses of DV in the future.

Of course, some types of change can *not* be predicted by this data. The main examples are:

- Increases in the intensity of use of DV-related commodities might happen if new DV developments led to a significant structural change in the whole pattern of productive techniques used in the industry.

- New demands might issue from wholly new industries that do not exist in the current input-output accounts.

- Demands might be created by wholly new uses of DV that have no simple substitutes or counterparts in terms of existing commodities.

This chapter reports on an effort to analyze some of this information, using detailed input-output accounts for the U.S.

Method

First, we identified several types of commodities and aggregated commodities that potentially include DV products or else compete with them. The commodities are summarized in Table 8.1, and the aggregates in Table 8.2.

Second, we looked at inputs of these commodities into some 500 distinct sectors and ranked them in various ways. We used data from the US input-output Benchmark accounts, which are constructed at 5 year intervals. (Accounts for the intervening years use only some 80 sectors.) 1992 is the most recent benchmark year that is available. In particular:

- For each DV-related commodity, we identified the top 30 sectors ranked by intensity of direct use of that commodity.
- For each DV-related commodity, we identified the top 30 sectors ranked by intensity of direct plus indirect use of that commodity.
- For each DV-related commodity, we identified the top 30 sectors ranked by total direct dollar use of that commodity.
- For each DV-related commodity, we identified the top 30 sectors ranked by total direct plus indirect dollar use of that commodity.

Third, we grouped and analyzed the resulting rankings. Selected results are shown in Tables 8.3 and 8.4.

Results on intensity of use

Table 8.3 shows sectors that have relatively intense direct input demands for one or more of the DV-related commodities. In particular, sectors are included if any one DV-related commodity constitutes at least 2% of input cost to that industry. The sectors are ranked in order of decreasing intensity of

demand for DV-related commodities.[14]

Table 8.1
Selected DV-related commodities

Input-output Category	Input-output Commodity ID	Category or Commodity Description	Included SIC Codes
51		Computer and office equipment	
	51.0104	Computer peripheral equipment	3572, 3575, 3577
56		Audio, video, and communication equipment	
	56.0100	Household audio and video equipment	3651
	56.0500	Communication equipment	3663, 3669
58		Miscellaneous electrical machinery and supplies	
	58.0600	Magnetic and optical recording media	3695
62		Scientific and controlling instruments	
	62.0800	X-ray apparatus and tubes	3844
	62.0900	Electromedical and electrotherapeutic apparatus	3845
63		Ophthalmic and photographic equipment	
	63.0300	Photographic equipment and supplies	386
66		Communications, except radio and TV:	
	66.0000	Communications, except radio and TV	481-2, 484, 489
67		Radio and TV broadcasting:	
	67.0000	Radio and TV broadcasting	483
76		Amusements	
	76.0101	Motion picture services and theaters	781-3
	76.0102	Video tape rental	784
78		Federal Government enterprises	
	78.0100	U.S. Postal Service	43

Source: IPPBR

[14] So as to simplify the analysis and avoid making untested assumptions about the byproducts technology, we made no attempt to infer a specific production technology by disentangling the Make Matrix. Instead, we merely divided the Use Matrix entry for each commodity and industry by the corresponding industry output.

Not surprisingly, the top six sectors in rank are themselves DV-related sectors. Moreover, most of the other DV-related sectors appear somewhere on this list, as well. Most of these sectors are heavy users of commodities from other companies in their own particular sector, as well as commodities from other DV-related industries. Also high on the list are several sectors that produce commodities that were not initially classed as DV-related, but nevertheless are used in close conjunction with them: computers, office equipment not otherwise classified, calculating and accounting machines, portrait studios and photo finishing.

A majority of the remaining sectors are various types of government, education, non-profit, and social services. These industries use DV-related goods intensely for the reason that most of these sectors are fundamentally concerned with communications and information.

Interestingly, defense does not appear on this list. Even though it is one of the major users of DV-related commodities, its usage in *percentage* terms is relatively small. In part, that is because some defense communication services are produced internally, rather than purchased from the market economy. In part, that is because other DV-related commodities are purchased indirectly, as bundled, for example, into aircraft and guided missiles.

Most of the rest of the sectors are business sectors that make intensive use of information: arrangement of passenger transportation; credit agencies; banks; brokers; advertising; protection and security; book publishers.

Just three of the remaining sectors are fairly narrowly defined production commodities: guided missiles; aircraft; and plate making. This is a very small fraction of the many production sectors that are included in the benchmark accounts. Note that absolutely no extraction, construction, or transportation sectors appeared on the list.

Finally, there is a unique sector for personal (i.e. household) consumption, which is a very large aggregated sector that is not broken out in any detail by the US input-output system of accounts. Households are the major direct user of entertainment services and other DV-related commodities.

The general implication of these findings is that, based on existing patterns, DV-related commodities constitute very small shares of input costs for most sectors, except in the information-intensive sectors. However, we point out there are several possible limitations to the data source used above.

a. These data are based on direct inputs to production, which by definition do not include investment goods. That could be important in the data to the extent that equipment such as X-ray tubes and TV monitors are depreciated over time rather than expensed. This problem can be overcome by looking at detailed commodity inputs to capital investment by sector; unfortunately, the existing data of this type are very old (they date back to 1977) and they are disaggregated only to the 80 sector level. Without going into detail, these older data do not challenge the conclusions drawn here.

b. These data include direct inputs only. That is, indirect inputs to upstream suppliers of these sectors are ignored. These indirect inputs could provide additional opportunities for particular future uses of DV which are to the advantage of the given sector. Fortunately, the input-output accounts do include data on indirect plus direct requirements (referred to as the "total requirements matrix"). An analysis of that data led to no serious inconsistencies with the story told above. Of course, the rank orderings changed for many of the sectors. A very few sectors moved on or off the list. Typesetting and the Post Office joined the list; both are closely allied to DV-related commodities. Aircraft and security and commodity brokers were pushed off the list. (These data are not shown in this report, but are included in the Work Papers.)

c. These data look at individual DV-related commodities only, not at the aggregate of all DV-related commodities. However, a reanalysis using the aggregates described in Table 8.2 led to another reordering, but added no new sectors to the list.

Table 8.2
Selected aggregates of DV-related commodities

Aggregate	Description	Included Input-output Commodities
1	Communications equipment and services	56.05, 66, 67, 78.01
2	All DV-related equipment	51, 56, 58.06, 62.08, 62.09, 63.03
3	Entertainment equipment and services	56.01, 67, 76
4	All DV-related commodities	51, 56, 58.06, 62.08, 62.09, 63.03, 66, 67, 76, 78.01

Source: IPPBR

d. The data are for 1992, the most recent benchmark year. The current research is taking place in 1997-98, and is aimed at projecting up to 15 years out into the future; these input-output data will become up to 20 years old within that time frame. Therefore, we need some idea of how stable over time the patterns we have identified are likely to be. To partially address that issue, we repeated the analysis described above using benchmark input-output data from 5 years earlier (i.e. 1987). Although there were changes in the detailed ordering of sectors during that time, there was no important change in the over-all pattern. That is, 1987 data also showed that sectors with intense DV-related inputs are overwhelmingly information-related sectors.

These data taken together suggest that advances in DV-technology will probably not lead to substantial growth in productivity in most non-information-using sectors, at least in the short run, because the input costs that can be saved by substituting DV commodities for existing commodities are simply too small. The major exception to this is the DV-related industries themselves, together with their close allies. These sectors are intensive users of each others' goods, and can be expected

to undergo substantial changes in their own production techniques as a result of the DV transition. Other exceptions may fall in aircraft, guided missiles, and platemaking.

In the longer run, there could be cases where DV technology will have significant productivity effects in non-information-oriented sectors; but that will depend on developing entirely new ways of doing things in a more explicitly information-dependent way. That kind of fundamental structural change is not likely to happen very quickly.

These data also suggest that specialized market segments for DV are especially likely to emerge as inputs to the information-intensive sectors. Next we will look at data showing the potential for segmentation in less information intensive-sectors that nevertheless are high-volume users of DV-related commodities.

Table 8.3
Intensity of demand for DV-related commodities, 1987
(by Sectors with High Demands)

Input coef.	DV-Related commodity demanded		Demanding sector	
	I-O ID	Description	I-O ID	Description
0.4200	760101	Motion picture services and theaters	760101	Motion picture services and theaters
0.0048	630300	Photographic equipment and supplies	760101	
0.2700	760101	Motion picture services and theaters	760102	Video tape rental
0.2500	760101	Motion picture services and theaters	670000	Radio and TV broadcasting
0.0100	670000	Radio and TV broadcasting	670000	
0.0065	630300	Photographic equipment and supplies	670000	
0.0014	580600	Magnetic and optical recording media	670000	
0.0007	510104	Computer peripheral equipment	670000	
0.0001	560500	Communication equipment	670000	
0.2000	660000	Communications, except radio and TV	660000	Communications, except radio and TV
0.0042	760101	Motion picture services and theaters	660000	
0.0900	510104	Computer peripheral equipment	510104	Computer peripheral equipment
0.0700	510104	Computer peripheral equipment	510103	Electronic computers
0.0700	660000	Communications, except radio and TV	980003	State and local government, other education
0.0042	630300	Photographic equipment and supplies	980003	
0.0013	510104	Computer peripheral equipment	980003	
0.0002	560100	Household audio and video equipment	980003	
0.0500	510104	Computer peripheral equipment	510400	Office machines, n.e.c.
0.0500	580600	Magnetic and optical recording media	560200	Prerecorded records and tapes
0.0087	780100	U.S. Postal Service	560200	
0.0500	630300	Photographic equipment and supplies	260806	platemaking and related services
0.0500	630300	Photographic equipment and supplies	730108	photofinishing labs and commercial photography
0.0100	780100	U.S. Postal Service	730108	
0.0500	780100	U.S. Postal Service	770502	Labor organizations, civic, social, and fraternal

0.0033	630300	Photographic equipment and supplies	770502	
0.0013	760101	Motion picture services and theaters	770502	
0.0002	560100	Household audio and video equipment	770502	
0.0400	510104	Computer peripheral equipment	510102	Calculating and accounting machines
0.0400	560500	Communication equipment	130100	Guided missiles and space vehicles
0.0400	560500	Communication equipment	560500	Communication equipment
0.0022	560100	Household audio and video equipment	560500	
0.0400	630300	Photographic equipment and supplies	720203	Portrait photographic studios, and other miscellaneous personal service
0.0200	660000	Communications, except radio and TV	720203	
0.0098	780100	U.S. Postal Service	720203	
0.0400	780100	U.S. Postal Service	770700	Child day care services
0.0077	760101	Motion picture services and theaters	770700	
0.0033	560100	Household audio and video equipment	770700	
0.0300	560100	Household audio and video equipment	560100	Household audio and video equipment
0.0300	630300	Photographic equipment and supplies	260803	Typesetting
0.0007	510104	Computer peripheral equipment	260803	
0.0300	630300	Photographic equipment and supplies	991001	State and local government, hospitals and..
0.0100	620900	Electromedical and electrotherapeutic apparatus	991001	
0.0009	510104	Computer peripheral equipment	991001	
0.0007	620800	X-ray apparatus and tubes	991001	
0.0000	560500	Communication equipment	991001	
0.0300	660000	Communications, except radio and TV	650702	Arrangement of passenger transportation
0.0002	560100	Household audio and video equipment	650702	
0.0200	560100	Household audio and video equipment	950000	Imports of goods and services
0.0100	510104	Computer peripheral equipment	950000	
0.0097	630300	Photographic equipment and supplies	950000	
0.0063	560500	Communication equipment	950000	
0.0029	580600	Magnetic and optical recording media	950000	
0.0016	620900	Electromedical and electrotherapeutic apparatus	950000	
0.0014	620800	X-ray apparatus and tubes	950000	
0.0200	560500	Communication equipment	600100	Aircraft
0.0200	660000	Communications, except radio and TV	700200	Credit agencies other than banks
0.0200	780100	U.S. Postal Service	700200	Credit agencies other than banks
0.0200	660000	Communications, except radio and TV	700500	Insurance agents, brokers, and services
0.0076	780100	U.S. Postal Service	700500	
0.0016	580600	Magnetic and optical recording media	700500	
0.0200	660000	Communications, except radio and TV	730104	Computer and data processing services
0.0093	510104	Computer peripheral equipment	730104	
0.0072	580600	Magnetic and optical recording media	730104	
0.0200	660000	Communications, except radio and TV	730106	Detective and protective services
0.0200	660000	Communications, except radio and TV	730109	Other business services
0.0080	780100	U.S. Postal Service	730109	
0.0080	630300	Photographic equipment and supplies	730109	
0.0021	580600	Magnetic and optical recording media	730109	

0.0011	510104	Computer peripheral equipment	730109	
0.0002	760101	Motion picture services and theaters	730109	
0.0200	660000	Communications, except radio and TV	770900	Social services, n.e.c.
0.0100	760101	Motion picture services and theaters	770900	
0.0100	780100	U.S. Postal Service	770900	
0.0200	660000	Communications, except radio and TV	910000	Personal consumption expenditures
0.0052	560100	Household audio and video equipment	910000	
0.0013	760101	Motion picture services and theaters	910000	
0.0011	760102	Video tape rental	910000	
0.0004	670000	Radio and TV broadcasting	910000	
0.0000	560500	Communication equipment	910000	
0.0200	660000	Communications, except radio and TV	970000	Federal Government purchases, nondefense
0.0045	630300	Photographic equipment and supplies	970000	
0.0029	560500	Communication equipment	970000	
0.0006	760101	Motion picture services and theaters	970000	
0.0003	620800	X-ray apparatus and tubes	970000	
0.0003	620900	Electromedical and electrotherapeutic apparatus	970000	
0.0200	660000	Communications, except radio and TV	993009	State and local government purchases, other general
0.0100	780100	U.S. Postal Service	993009	
0.0055	630300	Photographic equipment and supplies	993009	
0.0015	510104	Computer peripheral equipment	993009	
0.0002	560500	Communication equipment	993009	
0.0002	560100	Household audio and video equipment	993009	
0.0200	670000	Radio and TV broadcasting	730200	Advertising
0.0200	760101	Motion picture services and theaters	770403	Private libraries, vocational schools, and education
0.0034	630300	Photographic equipment and supplies	770403	
0.0200	780100	U.S. Postal Service	260301	Book publishing
0.0200	780100	U.S. Postal Service	700300	Security and commodity brokers
0.0100	660000	Communications, except radio and TV	700300	
0.0200	780100	U.S. Postal Service	991004	State and local government purchases, sanitation
0.0010	510104	Computer peripheral equipment	991004	

Source: IPPBR

Results on aggregate use

Table 8.4 is arranged similarly to Table 8.3, except that sectors are sorted on total dollar purchases (rather than intensity) of DV-related commodities. For reasons of space, we have omitted sectors that purchase less than $1B of any single DV-related commodity. (The full data are available in the Work Papers.) Since the sectors listed in Table 8.4 have such very large dollar purchases of DV-related goods, we expect that in many cases specialized or segmented markets will develop for the DV-related goods they use in the future.

Many of the sectors that appear on this table are the same as those that appeared in Table 8.3, although the rank orders are very different. But there are also some new sectors. Even though these

new sectors have relatively low intensities of DV-related inputs, the sectors are so large that their gross DV-related dollar purchases are substantial.

Two of the new sectors consist of broad final demand aggregates, namely exports of goods and services, and gross private fixed capital investment. These two sectors are much too aggregated to contain any useful information about the characteristics of DV demands and its likely segmentation. Another new sector, national defense, is also too broad to provide much information about industry segmentation (and, in addition, is outside of ATP's area of interest).

Three new sectors in Table 8.4 simply follow a patterns already seen in Table 8.3. Newspapers, printing, and household audio and video equipment are examples of sectors closely allied to DV-related commodities.

The most striking change is the addition of several medical fields to the list (doctors and dentists; hospitals; other medical professions). Because sum of dollars devoted to health care in the US is so huge (currently some 14% of GDP), these fields use substantial amounts of DV-related commodities even though their intensities of use are not all that high. For this reason, and also because there is rapid growth and technical change in all aspects of medical care, we can expect that a very detailed segmentation will arise in the future for medical-related DV commodities. Some of the specialized issues are:

- Needs for types of imaging differ for each medical speciality. Computerized tomography, urology, heart surgery, and gynecology, for example, each use very specialized imaging devices.
- Needs for pattern recognition will differ across diagnostic specialities. For example, 3D imaging is useful for tomography; motion studies might be useful for microscopy and physiology.
- Needs for image databases differ with the type of institution. Family practices, hospitals, and utilization review organizations all have different needs.

On the other hand, since *intensity* of DV-related uses is relatively low in the present, we can hazard a prediction that the DV transition will *not* lead to large short-run gains in medical productivity as a share of total medical costs. Nevertheless, because the medical field is so large, there could be productivity gains that are quite noticeable in dollar terms. In the longer run, given the intensity of research and the dollar amounts involved, medical DV applications could well emerge that have noticeable percentage effects on productivity.

Only a few other sectors are really strikingly new, and most of these are transportation related. Freight and warehousing, motor vehicles and auto bodies, auto repair, auto rentals, air transport are all new additions to the list. Therefore, we should predict substantial market segmentation in the area of transportation. Some of the specialized functions in transportation are:

- entertainment during travel
- communications for bookings and customer service
- communications for physical operations

- tracking of goods, persons, and vehicles
- communications and databases for financial operations
- billboards and public signage.

As in the case of medicine, we would not expect the resulting productivity improvements to constitute a large share of total costs, at least in the short run.

Table 8.4
Aggregate demands for DV-related commodities, 1987
(by Sectors with High Demands)

Sales ($10M)	DV-related commodity demanded		Demanding Sector	
	I-O ID	Description	I-O ID	Description
61962.7	660000	Communications, except radio and TV	910000	Personal consumption expenditures
16087.9	560100	Household audio and video equipment	910000	
6429.9	780100	U.S. Postal Service	910000	
4087	760101	Motion picture services and theaters	910000	
3336	760102	Video tape rental	910000	
2685.6	630300	Photographic equipment and supplies	910000	
1350.7	510104	Computer peripheral equipment	910000	
1326	670000	Radio and TV broadcasting	910000	
1084.9	580600	Magnetic and optical recording media	910000	
123.7	560500	Communication equipment	910000	
33184.2	660000	Communications, except radio and TV	660000	Communications, except radio and TV
684.3	760101	Motion picture services and theaters	660000	
250.5	780100	U.S. Postal Service	660000	
172.6	580600	Magnetic and optical recording media	660000	
57.6	510104	Computer peripheral equipment	660000	
13518.6	510104	Computer peripheral equipment	920000	Gross private fixed investment
7757.1	560500	Communication equipment	920000	
5652.6	630300	Photographic equipment and supplies	920000	
4388.9	660000	Communications, except radio and TV	920000	
2492.9	620900	Electromedical and electrotherapeutic apparatus	920000	
1690.2	620800	X-ray apparatus and tubes	920000	
475.8	560100	Household audio and video equipment	920000	
11860.6	760101	Motion picture services and theaters	760101	Motion picture services and theaters
134.4	630300	Photographic equipment and supplies	760101	
32.5	580600	Magnetic and optical recording media	760101	
7453	760101	Motion picture services and theaters	670000	Radio and TV broadcasting
470.5	670000	Radio and TV broadcasting	670000	
190.5	630300	Photographic equipment and supplies	670000	
40.1	580600	Magnetic and optical recording media	670000	
20.3	510104	Computer peripheral equipment	670000	
3.1	560500	Communication equipment	670000	
5572.9	660000	Communications, except radio and TV	690100	Wholesale trade
870.7	780100	U.S. Postal Service	690100	
342.7	760101	Motion picture services and theaters	690100	
188.4	630300	Photographic equipment and supplies	690100	
159.2	580600	Magnetic and optical recording media	690100	
18.2	560100	Household audio and video equipment	690100	
4989.6	510104	Computer peripheral equipment	940000	Exports of goods and services
2496.2	660000	Communications, except radio and TV	940000	
2074.9	630300	Photographic equipment and supplies	940000	

1913.2	560500	Communication equipment	940000	
1180.1	760101	Motion picture services and theaters	940000	
1150.7	620900	Electromedical and electrotherapeutic apparatus	940000	
806.1	580600	Magnetic and optical recording media	940000	
755.7	560100	Household audio and video equipment	940000	
284.3	620800	X-ray apparatus and tubes	940000	
4.2	760102	Video tape rental	940000	
4574	660000	Communications, except radio and TV	690200	Retail trade, except eating and drinking
1454.5	780100	U.S. Postal Service	690200	
114.8	630300	Photographic equipment and supplies	690200	
88.8	580600	Magnetic and optical recording media	690200	
31	560100	Household audio and video equipment	690200	
4210.8	560500	Communication equipment	960000	Federal Government purchases, national defense
1954	660000	Communications, except radio and TV	960000	
1752.4	510104	Computer peripheral equipment	960000	
702.7	630300	Photographic equipment and supplies	960000	
512.6	760101	Motion picture services and theaters	960000	
312	780100	U.S. Postal Service	960000	
32	580600	Magnetic and optical recording media	960000	
14.1	620800	X-ray apparatus and tubes	960000	
9.7	620900	Electromedical and electrotherapeutic apparatus	960000	
3774.1	660000	Communications, except radio and TV	700100	Banking
3350.9	780100	U.S. Postal Service	700100	
965.1	630300	Photographic equipment and supplies	700100	
316.2	580600	Magnetic and optical recording media	700100	
19.5	560100	Household audio and video equipment	700100	
2304.6	510104	Computer peripheral equipment	510103	Electronic computers
25.8	580600	Magnetic and optical recording media	510103	
2284.3	660000	Communications, except radio and TV	110000	New and maintenance and repair ?
1988.5	560500	Communication equipment	110000	
243.2	780100	U.S. Postal Service	110000	
22.9	560100	Household audio and video equipment	110000	
2071.6	660000	Communications, except radio and TV	993009	State and local government purchases, other general
2031.7	510104	Computer peripheral equipment	510104	Computer peripheral equipment
1899.2	660000	Communications, except radio and TV	970000	Federal Government purchases, nondefense
552.6	780100	U.S. Postal Service	970000	
416.5	630300	Photographic equipment and supplies	970000	
268.8	560500	Communication equipment	970000	
59.1	760101	Motion picture services and theaters	970000	
30.9	620800	X-ray apparatus and tubes	970000	
26	620900	Electromedical and electrotherapeutic apparatus	970000	
1734.1	780100	U.S. Postal Service	700300	Security and commodity brokers
702.9	660000	Communications, except radio and TV	700300	
41.8	580600	Magnetic and optical recording media	700300	

1570.6	660000	Communications, except radio and TV	730104	Computer and data processing services
566.3	510104	Computer peripheral equipment	730104	
438.1	580600	Magnetic and optical recording media	730104	
259.3	780100	U.S. Postal Service	730104	
1539.2	660000	Communications, except radio and TV	710201	Real estate agents, managers, operators, and lessors
466.5	780100	U.S. Postal Service	710201	
21.5	560100	Household audio and video equipment	710201	
1530.8	660000	Communications, except radio and TV	770100	Doctors and dentists
1235.4	780100	U.S. Postal Service	770100	
226.5	620800	X-ray apparatus and tubes	770100	
226.4	630300	Photographic equipment and supplies	770100	
195.8	620900	Electromedical and electrotherapeutic apparatus	770100	
1424.9	660000	Communications, except radio and TV	650300	Motor freight transportation and warehousing
1347.4	560100	Household audio and video equipment	590301	Motor vehicles and passenger car bodies
1344.7	780100	U.S. Postal Service	730301	Legal services
1301.8	660000	Communications, except radio and TV	730301	
584.3	630300	Photographic equipment and supplies	730301	
107.3	510104	Computer peripheral equipment	730301	
1256.2	660000	Communications, except radio and TV	700400	Insurance carriers
314.7	780100	U.S. Postal Service	700400	
131	630300	Photographic equipment and supplies	700400	
84.7	580600	Magnetic and optical recording media	700400	
12.9	560100	Household audio and video equipment	700400	
1253.2	660000	Communications, except radio and TV	980001	State and local government purchases, elementary a
392.9	630300	Photographic equipment and supplies	980001	
139.8	510104	Computer peripheral equipment	980001	
46.3	560100	Household audio and video equipment	980001	
19.2	760101	Motion picture services and theaters	980001	
0.9	620900	Electromedical and electrotherapeutic apparatus	980001	
0.3	620800	X-ray apparatus and tubes	980001	
1148.6	660000	Communications, except radio and TV	700500	Insurance agents, brokers, and services
373.4	780100	U.S. Postal Service	700500	
122.9	630300	Photographic equipment and supplies	700500	
80.1	580600	Magnetic and optical recording media	700500	
7	560100	Household audio and video equipment	700500	
1086.2	660000	Communications, except radio and TV	730105	Management and consulting services, testing and research lab
463.3	780100	U.S. Postal Service	730105	
108.7	580600	Magnetic and optical recording media	730105	
55.8	510104	Computer peripheral equipment	730105	
5.6	560100	Household audio and video equipment	730105	
995.3	780100	U.S. Postal Service	993009	State and local government purchases, other general
960.7	560500	Communication equipment	600100	Aircraft
19.2	510104	Computer peripheral equipment	600100	

932.3	660000	Communications, except radio and TV	730109	Other business services
364	780100	U.S. Postal Service	730109	
361.2	630300	Photographic equipment and supplies	730109	
94.4	580600	Magnetic and optical recording media	730109	
48.5	510104	Computer peripheral equipment	730109	
8.1	760101	Motion picture services and theaters	730109	
4.2	560100	Household audio and video equipment	730109	
926.2	660000	Communications, except radio and TV	650500	Air transportation
37.9	760101	Motion picture services and theaters	650500	
3.8	560500	Communication equipment	650500	
900	760101	Motion picture services and theaters	760102	Video tape rental
873.8	560500	Communication equipment	130100	Guided missiles and space vehicles
872.6	780100	U.S. Postal Service	700200	Credit agencies other than banks
715.2	660000	Communications, except radio and TV	700200	
18.2	510104	Computer peripheral equipment	700200	
4.9	560100	Household audio and video equipment	700200	
803.6	660000	Communications, except radio and TV	740000	Eating and drinking places
6.9	560100	Household audio and video equipment	740000	
744.4	630300	Photographic equipment and supplies	991001	State and local government purchases, hospitals an
734.2	630300	Photographic equipment and supplies	730108	Photofinishing labs and commercial photography
732.2	560500	Communication equipment	560500	Communication equipment
35.7	560100	Household audio and video equipment	560500	
715.2	660000	Communications, except radio and TV	770200	Hospitals
356	630300	Photographic equipment and supplies	770200	
286.8	780100	U.S. Postal Service	770200	
189.6	580600	Magnetic and optical recording media	770200	
73.3	620900	Electromedical and electrotherapeutic apparatus	770200	
9.3	760101	Motion picture services and theaters	770200	
701.2	660000	Communications, except radio and TV	750002	Automotive repair shops and services
677.8	780100	U.S. Postal Service	770502	Labor organizations, civic, social, and fraternal
16	760101	Motion picture services and theaters	770502	
674.4	660000	Communications, except radio and TV	980003	State and local government purchases, other education
591.7	660000	Communications, except radio and TV	980002	State and local government purchases, public educational facilities beyond high school
585	630300	Photographic equipment and supplies	980002	
157.1	510104	Computer peripheral equipment	980002	
125.1	560500	Communication equipment	980002	
46.5	560100	Household audio and video equipment	980002	
11.7	760101	Motion picture services and theaters	980002	
9.9	620900	Electromedical and electrotherapeutic apparatus	980002	
4.1	620800	X-ray apparatus and tubes	980002	
587.4	660000	Communications, except radio and TV	720100	Hotels and lodging places
586.2	780100	U.S. Postal Service	770700	Child day care services
99.7	760101	Motion picture services and theaters	770700	

42.1	560100	Household audio and video equipment	770700	
581.8	630300	Photographic equipment and supplies	720203	Portrait photographic studios, and other miscellaneous personal service
466.4	780100	U.S. Postal Service	750001	Automotive rental and leasing, without drivers
179.6	560100	Household audio and video equipment	750001	
453.3	670000	Radio and TV broadcasting	730200	Advertising
452.9	630300	Photographic equipment and supplies	993009	State and local government purchases, other genera
338.4	630300	Photographic equipment and supplies	930000	Change in business inventories
257.6	510104	Computer peripheral equipment	930000	
209.9	560100	Household audio and video equipment	930000	
154.9	560500	Communication equipment	930000	
61.3	580600	Magnetic and optical recording media	930000	
49.6	620900	Electromedical and electrotherapeutic apparatus	930000	
10.9	620800	X-ray apparatus and tubes	930000	
338	780100	U.S. Postal Service	260200	Periodicals
21.4	580600	Magnetic and optical recording media	260200	
325.4	780100	U.S. Postal Service	680100	Electric services (utilities)
180.6	580600	Magnetic and optical recording media	680100	
323.4	780100	U.S. Postal Service	730107	Miscellaneous equipment rental and leasing
113.2	630300	Photographic equipment and supplies	730107	
82.4	580600	Magnetic and optical recording media	730107	
283.3	630300	Photographic equipment and supplies	260501	Commercial printing
27.7	510104	Computer peripheral equipment	260501	
279.7	780100	U.S. Postal Service	770302	Other medical and health services, including veterinarians
261.6	630300	Photographic equipment and supplies	630300	Photographic equipment and supplies
5	620800	X-ray apparatus and tubes	630300	
4.2	620900	Electromedical and electrotherapeutic apparatus	630300	
261.1	780100	U.S. Postal Service	260301	Book publishing
259.5	620900	Electromedical and electrotherapeutic apparatus	991001	State and local government purchases, hospitals an
250.5	780100	U.S. Postal Service	770900	Social services, n.e.c.
249	760101	Motion picture services and theaters	770900	
248.4	780100	U.S. Postal Service	260100	Newspapers
113	630300	Photographic equipment and supplies	260100	
222.3	630300	Photographic equipment and supplies	770402	Colleges, universities, and professional schools
73.6	760101	Motion picture services and theaters	770402	
49.9	580600	Magnetic and optical recording media	770402	
22.5	620900	Electromedical and electrotherapeutic apparatus	770402	
201.2	560100	Household audio and video equipment	560100	Household audio and video equipment
193.5	760101	Motion picture services and theaters	770403	Private libraries, vocational schools, and education
145.2	510104	Computer peripheral equipment	510400	Office machines, n.e.c.

125.4	510104	Computer peripheral equipment	993009	State and local government purchases, other genera
123.4	630300	Photographic equipment and supplies	260806	Platemaking and related services
106.5	580600	Magnetic and optical recording media	560200	Prerecorded records and tapes
106.1	580600	Magnetic and optical recording media	730303	Accounting, auditing and bookkeeping, and miscellaneous
104.6	630300	Photographic equipment and supplies	730303	
12.1	510104	Computer peripheral equipment	730303	

Source: IPPBR

Conclusions

Several interesting predictions are suggested by the input-output data.

First, three important categories of sectors should experience both significant productivity improvements and substantial segmentation of DV-products:

- public non-defense and non-profit services
- information-intensive private industries, such as credit agencies, insurance agencies, brokers, and private detectives.
- the DV-related sectors themselves, including entertainment and broadcasting as well as computing and networking.

Second, two other categories of sectors have a fairly low share of costs for DV-related products, and so are unlikely to experience great productivity gains from the DV transition, as measured in terms of cost shares and at least in the short run. Yet these sectors are very large, and do make significant demands for DV-related products. Therefore we do expect substantial segmentation of DV-related products in these sectors:

- medical specialities
- transportation specialities.

Less interesting results have to do with the large absolute demands that are generated both directly and indirectly by:

- household demands
- defense
- exports
- investment goods.

Since these sectors themselves consist of large aggregates, they can be expected to include a wide variety of DV-related demands. But since these aggregates are relatively non-specific, the input-output data do not provide much information about what those detailed demands are likely to be.

9. A HIERARCHICAL MAP OF POTENTIAL DV APPLICATIONS

This Chapter provides an extensive map of the entire potential DV marketplace, to the extent that it is known from our research. The next chapter refines and analyzes that map so as to provide a much more compact list of markets, including only those that are considered most likely to be directly affected by the ATP DV focus area.

Organization of the map

As noted previously, this map is constructed specifically for the purpose of supporting subsequent research on the economic benefits of the ATP DV focus area. Therefore, areas judged to be peripheral to that task are mapped in correspondingly less detail than other areas. The map consists of four major sections, as follows:

- I. The structure of DV-related human activities
- II. The structure of DV hardware, software, and service components
- III. The structure of specialized uses of DV
- IV. The structure of DV quality scales

Within each structure, substructures are represented in outline style. Links across the five structures are omitted here for brevity, but they are shown in Appendix 5. The network has been truncated at the level of technologies and lower. Also, no attempt was made to map the associated labor markets in full detail; labor markets are closely related to the markets for services provided by labor, and we anticipate that they will not be treated separately in the subsequent impact studies.

In the map, * denotes items judged to be largely outside the scope of the direct effects of the ATP DV focus area. These items do not need to be analyzed further for the purposes of this task, so those parts of the map are generally less well developed than other parts of the map. Also, these items will be omitted from the summary list contained in Chapter 10.

For an explanation of the logic and specialized terms used here for describing these structures, see Chapters 1 and 3, and especially Chapter 2.

I. DV activities
Subdivided by: stage of circulation (creating, viewing, distributing, communicating, and acting)

Activity cluster 1: DV creation
Description: creating video materials, programs, and program streams in a permanent or quasi-permanent and accessible form
Possible specialized uses (market segments):
1.1 by video and audio resolution
6.1 by encoding or format (obsolete technologies may coexist)
6.2 by historic origin of applications (tv/computing)

6.3 by transmission technology
Subdivided by: stage of production (authoring, managing)

Activity 1.1: video authoring
Description: creating original DV materials
Components:?
2.1. Image capture equipment and services
Subdivided by: stage of authoring (capture, record, edit)
* *Activity 1.1.1: video photography*
Description: digitizing real visual material
Possible specialized uses (market segments):
5.1.1a by photographic location
* *Activity 1.1.2: video recording*
Description: in-stream capturing of DV signals
Possible specialized uses (market segments):
2.5 by volatility of memory
5.1.1a by photographic location
5.1.1b by memory location
Activity 1.1.3: simple video processing
Description: authoring and production of video programs
Possible specialized uses (market segments):
5.2.6 by degree of professionalization
Activity 1.1.4: authoring of interactional and animated media
Description: authoring of games, special effects, interactional educational programs
Possible specialized uses (market segments):
5.2.1 by complex authoring application
Activity 1.2: video managing
Description: managing DV materials
Components: ?
1. Creation equipment and services
2. Storage and retrieval equipment and services
Subdivided by: stage of management (compile, encapsulate, preserve, protect)
Activity 1.2.1: video post-production (editing, management, handling, and distribution)
Description: assembling video programs into usable packages or broadcast streams and getting them delivered to manufacturer, retailer, transmitter, or depository
Possible specialized uses (market segments):
5.2.2 by destination of the content
Activity 1.2.2: video storing, cataloging, indexing, and archiving
Description: creating usable video databases, depositories (either real or virtual)
Activity 1.2.3: physical production
Description: creating portable physical memory objects containing individual video program materials
Possible specialized uses:

2.5 by volatility of memory
5.2.3 by size of production run

Activity 1.2.4: protection of intellectual property

Description: producing and implementing rules, enforcement mechanisms, and software for protecting DV ownership (not explored in detail)

Components: 6.2x intellectual property rights software and services

Activity cluster 2: individualized DV utilization

Description: making use of video by end-users at a single location

Components:

5. Viewing equipment and services

* 6.1 keyboard/mouse/data input devices

Possible specialized uses (market segments):

4.5 by commonality of experiences
6.1 by encoding or format (obsolete technologies may coexist)

Subdivided by: what is pre-identified (the desired video object versus the desired information)

Activity 2.1: viewing particular objects

Description: viewing a pre-identified program or object

Possible specialized uses (market segments):

1.4 by degree of image motion

Subdivided by: type of object being viewed (program, computational image, remote view)

Activity 2.1.1: individual video consumption (of an extended program)

Description: viewing a program, playing a game, or taking a lesson (as opposed to obtaining it; see 3.1)

Components:

* 6.1 game/simulation controllers

Possible specialized uses (market segments):

1.1 by video and audio resolution
1.2 by interactivity
2.5 by volatility of memory
3.2a by portability of local viewing equipment
3.2c by portability of local memory
3.3 by viewing location
5.2.4 by individual viewing context or purpose
6.2 by historic origin of applications (tv/computing)
6.3 by transmission technology

Activity 2.1.2: computing, simulating, and scientific imaging

Description: performing high resolution video imaging for input and output of computational, medical, technological, or scientific activities

Possible specialized uses (market segments):

5.1.3 by complex imaging application

Activity 2.1.3: remote viewing, sensing, and controlling

Description: viewing and manipulating inanimate objects at a distance by an individual viewer.
Note: cf 3.3.4, which refers to control of people, not objects.
Components:
2.1 image capture equipment and services
* 6.1x remote actuators
Possible specialized uses (market segments):
2.2 by simultaneity of (conversation or) image capture
5.1.2a by surveillance application area-objects

Activity 2.2: viewing generalized information

Description: viewing selected collections of program or objects so as to obtain pre-identified information.
Note: differs from 2.1.3 remote sensing in that particular remote viewing monitors are not fundamentally required. Rather, some higher level integration and summarization of data occurs.

Components:
3. Storage and retrieval equipment and services

Possible specialized uses (market segments):
3.5 by pricing system for data or content
3.7 by means of search (i.e., different users search different subject fields)

Subdivided by: extent of information stereotyping (random versus fixed requests)

Activity 2.2.1: information search/data surveillance

Description: searching and retrieving randomly varying types of video information (e.g., data on demand).
Note: distinguished from 3.1 program distribution and retrieval because there is no fixed vendor or source for the ultimate information resource (though there may be a fixed vendor for the search/surveillance services themselves.)
Distinguished from 2.1 viewing a program because multiple items are typically considered at the same time.
Possible specialized uses (market segments):
2.4 by timing of a data search

Activity 2.2.2: real-time information monitoring and process control

Description: immediate or continuous remote updating of particular fixed information items
Components:
* 6.1 process controllers
Possible specialized uses (market segments):
5.1.4 by information monitoring area

Activity cluster 3: DV distribution and communication

Description: transmitting video information from source to user
Components:
3. Storage and retrieval equipment and services
4. Distribution equipment and services
5. Viewing equipment and services

Possible specialized uses (market segments):

1.1 by video and audio resolution
1.2 by transmission reliability (Channel access; dropouts; delays)
1.3 by general quality
3.6a by degree of transactions privacy and security
5.3.5 by battle-worthiness
6.1 by encoding or format (obsolete technologies may coexist)
6.3 by transmission technology

Subdivided by: level of interactivity being supported (passive viewing, buying, actively relating)

Activity 3.1: program distribution and retrieval

Description: obtaining a video program from a vendor, library, or other outside source by an individual user with the intent of viewing or using at a single location

Possible specialized uses (market segments):

1.2 by transmission reliability (channel access; dropouts; delays)
2.5 by volatility of memory
3.3 by viewing location
4.1 by degree of interactivity of a program
6.2 by historic origin of applications (tv/computing)
6.5 by legitimacy or legality of copies or signals

Subdivided by: original initiating party (viewer, provider, mutual)

Activity 3.1.1: user-driven program distribution and retrieval

Description: accessing programs as instigated by the user (e.g., video on demand; ads may or may not be attached)

Possible specialized uses (market segments):

2.1 by search technique and access control
4.2 by number of channels (available; simultaneous)
5.2.5 by type of program content

Activity 3.1.2: provider-driven program distribution

Description: direct advertising and other distributing of video materials, instigated by the provider and not connected with user-instigated activities such as video program retrieval (3.1.1) or information search (2.4)

Possible specialized uses (market segments):

6.4 by direct advertising medium

Activity 3.1.3: informal exchange of programs

Description: bilateral sharing of program items, either non-commercial or casual commercial

Possible specialized uses (market segments):

5.2.7 by purpose of informal exchange

Activity 3.2: DV-mediated commerce

Description: DV-assisted financial and commercial transacting, using video data bases as well as personal interaction.

Components:

6.2x financial transactions systems

6.2x home shopping systems
Possible specialized uses (market segments):
3.6b by degree of data privacy
Subdivided by: location (remote, local)
Activity 3.2.1: remote commercial transactions
Description: televideo-mediated exchanging of goods and services
Possible specialized uses (market segments):
5.3.1 by commercial forum
Activity 3.2.2: local commercial transactions
Description: local exchanging of goods and services using video finance (e.g. video smart cards or terminals)
Components:
5.2x video smart cards
Possible specialized uses (market segments):
1.5 by screen size and portability
3.1 by location of financial records
Activity 3.3: non-commercial association
Description: DV-assisted extra-market relating by persons
Possible specialized uses (market segments):
1.5 by screen size and portability
2.2 by simultaneity of conversation or image capture
3.2a by portability of local viewing equipment
3.2b by portability of local photographic equipment
3.3 by viewing location
3.6 by degree of privacy
4.3 by numbers present at the same time
Subdivided by: stages of the relationship (meeting, talking, acting, controlling, terminating)
Activity 3.3.1: virtual personal matching
Description: televideo-mediated matching of individuals and/or situations
Components:
* 6.2x personal matching and alliancing software and services
Possible specialized uses (market segments):
5.3.4 by type of person/situations being matched
Activity 3.3.2: 2-way personal communications (videophone, videomail, video posting, and teleconferencing)
Description: real time and time shifted remote 2-way talking heads
Possible specialized uses (market segments):
2.3 by who made the appointment
4.2 by number of channels (available; simultaneous)

Activity 3.3.3: virtual action
Description: sharing of data as well as 2-way talking heads using video
subdivided by: realm of life (work, play, community participation)+
Activity 3.3.3a: virtual collaboration
Description: sharing of intermediate and final work products between peers using video
Components:
6.2x collaboration-support software and services
Possible specialized uses (market segments):
4.4 by scale of institution
5.3.2 by area of virtual collaboration
Activity 3.3.3b: remote interactive games and recreational interactive data sharing
Description: multi-player gaming and using interactive intelligent toys via video
Components:
* 6.1x keyboard/mouse/data input devices
* 6.1x game/simulation controllers
Possible specialized uses (market segments):
3.4 by auxiliary recreational equipment
Activity 3.3.3c: virtual community participation
Description: contributing to public needs using televideo (e.g. opinion polls)
Components:
6.2x polling software and services
6.2x electronic democracy software and services
Possible specialized uses (market segments):
5.3.3 by type of public need
Activity 3.3.4: virtual command and control
Description: using video to control the behavior of others
Possible specialized uses (market segments):
5.1.2a by surveillance application area-objects
5.1.2b by surveillance application area-people
Possible components:
* 2.1.2x remote imaging equipment
2.2.1x mapping and tracking hardware/software
Subdivided by: military; civilian surveillance; civilian management
* *Activity 3.3.4a: military command and control*
Description: using video to control the behavior of personnel and enemies (e.g. surveillance; automated response systems; managing routine work; military targeting)
Possible specialized uses (market segments): not explored in detail
Activity 3.3.4b: civilian surveillance
Description: using video to observe humans in non-military situations
Components:
6.2x virtual private detective services
Possible specialized uses (market segments):
2.2 by simultaneity of (conversation or) image capture

5.1.2b by surveillance application area-people

Activity 3.3.4c: civilian management

Description: using video to control the behavior of personnel and other civilians

Possible specialized uses (market segments):

5.3.6 by type of management system

Activity 3.3.5: virtual screening, evasion, and countermeasures

Description: making or avoiding unwanted contact and communication, assisted by or in relation to DV

Possible specialized uses (market segments):

5.2.6 by degree of professionalization

Activity 3.3.5a: virtual screening and evasion

Description: avoiding contact and communication with unwanted parties

Components:

4.3.1a screening and evasion equipment and services

6.2x personal recognition equipment

Activity 3.3.5b: screening countermeasures

Description: forcing unwanted contact and communication

Components:

4.3.1b screening and evasion countermeasures

II. Components

1. Related non-DV functions
(Subject matter activities and original computational hardware/software is not included in the relevant realm.)

2. Content creation

2.1 Image capture

2.1.1 image sensors and interpreters

* Cameras/camcorders (180^0, 360^0, 4π steradians, 3D)
* Camera operation
* Lighting equipment-photographic; ambient
* Scanners

Object trackers: Hardware/software functions:

Object identifiers
Range detectors and automated camera focus
Object followers (2D; 3D) and automated camera aiming
Object counters
Terrain describers

People trackers:

Hardware/software functions:

Human ID (cooperative and close; noncooperative and remote)
Human followers
Human counters
Client monitoring systems

Commercial services:

Security services
Surveillance/ private information services
Public information services

2.1.2 image capture support

* playback and recording units
* recording studios: rooms and furniture
* recording media
* remote imaging equipment (camera mounts, panning controls, protection and concealment)

2.2 Image processing

2.2.1 Image and content manipulation

Editing/presentation/authoring

Hardware/software
Editing and post production services

TV bit-stream editing: merging, timing, logic switching hardware/software .

* Automated closed captioning systems .

Virtual reality computation

Modeling languages
Application support hardware/software
Programming and authoring services
TV and advertising content .
Film content .
High art (a niche segment)
Video format conversion services
2.2.2 Metadata creation; image processing support; and management
Automated annotating and metadata creation
Logic switching hardware/software; bitstream management equipment
* analog-digital converters
* video format converters (aspect ratio; frame rate; resolution)
* work stations: rooms and furniture
* 2.3 deliverable content units
games
video greeting cards
video content (e.g. movies)
ads
interactive media content

3. Storage and retrieval functions

3.1 Storage
DV oriented data-base hardware/software
* data-bases of finished programs
* databases of clips and segments
* memory units and media: local
* memory units and media: transportable

3.2 Retrieval
Content-based searching, browsing, and navigation
Image-based hardware/software
Pattern recognition
Indexing and searching
Search results representation software
Automated DV synopsis systems
Services
Program guides
Catalogs and directories
Image-based web crawlers
Recording and messaging equipment

4. Distribution functions

4.1 Sending hardware/software
Broadcasting and narrow casting equipment .

(infrared, radio, wired)
Coders/decoders .
Transcoding equipment
Subcomponents:
Compression technology
* Analog-digital converters
* Cable/fiber optic/copper network equipment
* Program memory unit (e.g. DAT tape) production hardware and software
* Transmission towers

4.2 Receiving hardware/software
Coders/decoders .
Receiving and terminal equipment .

4.3 Message control hardware/software
4.3.1a Image-based screening and evasion
Address secrecy systems
Anonymous remailers
Anti-spamming software and services
Image privacy services
Design of legal rights
Image privacy enforcement systems
Message screeners and scanners
Site blocking software and censorship software; V-chips
4.3.1b Screening and evasion countermeasures
message tracers, address locators
spamming software and services
4.3.2a Video security and property rights enforcement
Authentication, vouching, and watermarking
software (may be integrated with compression)
services
Automated billing, collection, and escrow systems for video
TV stations
VOD systems
Transmission systems
Central storage service systems
Royalties
Use metering software, read-once technology
Video copyright protection
Copyright law design
Copyright law enforcement software and services
Visual encryption software (may be integrated with compression)

4.3.2b Video security and property rights countermeasures

Anti-security and protection-breaking devices (key-breakers and de-encryptors; post-security signal recapture; id emulators; wire tapping and transmission eavesdroppers; etc.)

5. Unified communication services and primary content distributors

5.1 Videophone and conferencing services

Specialized equipment

Answering machines

Video mail hardware/software

Services

Networking, appointments, line quality guarantees, video mail

5.2 Content providers

5.2.1 Scheduled content (broadcast and film)

(See also Image creation, and Distribution functions)

5.2.2 Unscheduled content

Video clipping services .

Data-base management services .

Video program providers

Video rental stores .

VOD .

VOND .

Video-based information services

Searchable DV database services

[See also: medical, expert systems]

5.3 Wearable DV systems .

Hardware/software systems

5.4 Network systems and Internet access services

[see also Distribution functions]

* Broadcasting and narrow casting services

* Transmission services [wired, wireless]

Loss-less data exchange

Security guarantees

Time-valued data transfer

6. Viewing and using

6.1 Viewing space

Personal recognition and equipment locking technology

* Audience room and furniture

* Lighting equipment-ambient

* Theater and auditoriums

* Theater and auditorium construction, operation and marketing

* Billboard space vendors

6.2 Display equipment
Headsets: hardware/software
Head-position and eye position capturing and compensation
Head-position and eye position-responsive controllers and screens
3D glasses
Head-mounted cameras
Adaptive equipment
Tactile analogues of visual field
Visual cuing devices
Eye position-based controllers
Monitors/speakers: stationary
Wall murals/billboards/kiosks
Video smart cards
(Display; camera; memory; processor)
(ID cards; transactions handlers; digital assistants; advertising)
* Monitors/speakers: hand held
Subcomponents
Local image processing
Image memory buffers
Image translators
Screen memory buffers
Screens
6.3 Viewing support
Commercial advertising detectors and trimmers
* Playback units and media
Receivers and decoders

7. Action and commerce
7.1 Physical action and extra-video data capture
[See also image capture; head sets]
* actuators (remote)
* data gloves
* game and simulation controllers
* head-position and eye position-responsive controllers and screens
* keyboard/mouse/data input devices
* process controllers
* touch-sensitive screens
7.2 Social action and commerce (hardware/software, technical support)
Collaboration support systems (i.e. systems to control work products as well as conferencing)
Educational systems
Distance learning support services
Programmed learning systems
Conferencing systems

[See also: medical education]

* Electronic democracy software (for discussion and voting)

Financial transactions systems

Intellectual property rights enforcement (for non-video IPRs)

image-based search and detection software

image-based search and detection services

Home shopping systems

Human positioning and GPS systems and services

Location detection hardware/software

Map and readout hardware/software; databases

Medical systems and services .

Video implant chips (i.e. wearable medical records)

Patient databases and unified records communications

Patient monitoring systems

Distance medicine systems

Medical education systems

Expert diagnostic systems

Searchable information databases

Image manipulation hardware/software

[2D vs. 3D model vs. 3D presentation; static vs. dynamic; real time vs. slow motion; various degrees of magnification; diagnostic versus surgical and intervention monitoring]

Image capture devices

Image display devices

Image recognition, counting, tracking, and interpretation devices

(Cell counters, x-ray scanners, etc.)

Visual treatment systems (biofeedback; mental state exciters; SADD treatment)

Opinion polling systems and services

* Payment and audit systems and services (for non-video industries)

* Personal matching and alliancing software and services (e.g. dating services)

Personal recognition systems

* Scheduling and appointment services

Surveillance services

Technical guides and expert system services (repairs, service, advice; e.g. tele-mechanics)

Video hyper-manuals

True expert systems

Expert system creation

Support systems

Applications

Transportation systems

Object tracking

Vehicles: highway, parking, air, tarmac, rail line, yard, harbor, pipeline

People and cargo

Smart vehicles, vehicle guidance systems
Scheduling and reservations systems: mapping and display
Entertainment in route
Public announcement systems
See also: GPS systems

* Virtual detective services

8. General (implied cross-category upstream support)

* Site, plant, shop equipment, office furnishings for the following
Equipment developers
Equipment producers
Equipment suppliers (wholesale; retail)
Equipment subcomponent suppliers
Equipment operation services
Software developers and producers
Software suppliers
Compliance testing and test equipment
Reviewers and industry journalism
Training and support
Teaching and instruction

9. Unpredictable or unanticipated developments not mapped elsewhere

III. Specialized uses of DV

1. Viewing quality

1.1 by video and audio resolution
- low resolution
- medium resolution
- high resolution (HDTV)
- super high definition (up to 7000 lines)

*1.2 by transmission reliability, i.e., availability and dependability (channel access; dropouts; delays)

1.3 by general video quality (resolution; transmission reliability; number of channels connected; presence)
- household and casual business televideo
- distance learning and teleconferencing
- high-quality (e.g., immersive telepresence)

1.4 by degree of image motion
- still pictures
- translation and magnification of 2D object
- rotation in space of 3D object
- depiction of 4-D object (e.g., 3D objects changing over time)
- rotation in 4-space
- n-D objects

1.5 by screen size and portability
- video card
- hand held video
- head set video
- stationary video

2. Timing conditions for viewing

2.1 by search technique and access control
- unsolicited delivery
- regular scheduled programs (broadcast or narrowcast)
- transmitted by reservation or prior request (push)
- on demand, remote, closed catalog
- on demand, remote, open Internet search
- transfer of physical copy (retail; rental)

2.2 by simultaneity of conversation or image capture
- real-time (e.g., videophone)
- time-shifted (e.g., videomail)
- archived/historical

2.3 by who made the appointment
- joint negotiated (appointment)
- joint unilateral (Public conference, open house)
- one-sided (cold call, home page)

random (chat room, bulletin board)
2.4 by timing of a data search
episodic foreground
continuous background
2.5 by volatility of memory
no record
temporary record (ram)
semipermanent record (VCR)
permanent archives (laser disk)

3. Control of viewing conditions and access
3.1 by location of financial records
local (video account card)
shared (video credit or debit card)
remote (video teller)
3.2a by portability of local viewing equipment
3.2b by portability of local photographic equipment
3.2c by portability of local memory
stationary
local change in aim, focus, zoom
locally mobile
mobile, shoulder or tripod
mobile, hand held
mobile, miniature
personal implant
3.3 by viewing location
home
theater or auditorium
portable
workplace
open public
3.4 by auxiliary recreational equipment
controllers (may be segmented further)
toys (will be segmented further)
3.5 by pricing system for data or content
proprietary resources
free resources supported by advertising
free resources supported by government or non-profits
3.6a by degree of transactions privacy and security
fully encrypted, guaranteed secure keys
encrypted
open
3.6b by degree of data privacy

private
private within small group
private within large group
public

3.7 by means of search (i.e., different users search different subject fields)
visual
audio
text
text embedded in visual

4. Numbers, scale, and interactivity

4.1 by degree of interactivity of a program
passive
local (game or interactive educational program)
single-person multi-site interactive
multi-person multi-site interactive

4.2 by number of channels (e.g., number available; number that can be simultaneously active)

4.3 by numbers of individuals present at the same time
one to none (video mail)
one to one (videophone)
one per location, several points
several to several (video conference)
several to many (teleconference)
many to many (virtual convention)

4.4 by scale of institution
individual
group, team (virtual classroom)
building, school, plant (virtual library)
community, enterprise (virtual corporation, virtual academy)
nation (virtual polity)
world (virtual interpolity)

4.5 by commonality of experiences
mass market
market segment/ subculture
individual

5. Type of application area

5.1 data capture

5.1.1a by photographic location

5.1.1b by memory location
home and casual business
television and portable
studio

on location
surreptitious
public fixed location

5.1.2a by surveillance application area-objects
scientific (likely to be segmented much further)
natural resources
disasters (natural and man-made): oil spills, building fires, forest fires, hazmat releases
earth satellite
process monitoring and control
inventory control

5.1.2b by surveillance application area-people
institutional (monitoring clients)
household
traffic control
surveillance and security (building; outdoors)
remote viewing as a sexual service (legal and illegal)

5.1.3 by complex imaging application
medical imaging; tomography
industrial tomography
computing and modeling output
computing input; data retrieval
specialized data analysis (statistics, biometrics)
scientific data display
animation and special effects
games

5.1.4a by information monitoring area- physical
global positioning
weather
world crop status
land use
natural resource conditions
pollution indices

5.1.4b by information monitoring area-social
programming guides
stock market
news
complex production systems management
complex service systems management
complex inventory systems management
complex distribution systems management
complex financial systems management

5.2 DV processing and distribution

5.2.1 by complex authoring application
- games
- instructional software
- special effects

5.2.2 by destination of the content:
- broadcast stream (real time)
- Repository or store or wholesaler (canned)

5.2.3 by size of production run (physical programs units)
- home and casual business
- mass production

5.2.4 by context or purpose of individual viewing
- leisure
- passive training
- operation simulators (driving, flying)

5.2.5 by type of program content
- entertainment
  - pornography
    - legal
    - illegal
    - twilight (e.g., animated child porn)
  - other entertainment
- information
  - education and scholarly
  - household (news, weather, sports, entertainment)
  - business, by field

5.2.6 by degree of professionalization
- home/casual office
- professional use

5.2.7 by purpose of informal exchange
- videomail
- noncommercial pirating

5.3 action

5.3.1 by commercial forum
- home shopping for goods
- demonstration of services and designs
- shopping for travel locations
- business shopping (may be segmented further)

5.3.2 by area of virtual collaboration
- medicine (subspecialities are Possible)
- science and engineering (may be segmented further)
- business telecommuting, virtual enterprise

distance learning
video and non-video joint authoring and editing

5.3.3 by type of public need
video-encoded surveys
government-citizen interface systems
fund raising

5.3.4 by type of person/situations being matched
forming business or research alliances
legitimate dating services
sexual services (legal and illegal)
educational admissions and scholarships
internship matching
job matching

5.3.5 by battle-worthiness
military
police
civilian security industry
civilian general

5.3.6 by type of management system
project planning and management
production management (by application area)
personnel and resource management (by resource type)
physical security

6. Technology or type of provider

6.1 by encoding or format (obsolete technologies may coexist; e.g.,
VCR vs. DVD
NTSC vs. HDTV
Internet I vs. Internet ii)

6.2 by historic origin of applications (tv/computing)
tv-related equipment
computing and networking equipment

6.3 by transmission technology
physical transfer (disks, tapes, etc.)
Cable
telephone
wireless

6.4 by direct advertising medium
disposable video card
video mail
videophone
physical memory (e.g. DVD diskette)
DV billboards

6.5 by legitimacy or legality of copies or signals
    white market
    black market or pirate
    grey market

IV. Quality improvements

1. Picture and sound quality

Accuracy of transmission [data error rate]
*availability of transmission signal (obtaining channel access, dropouts, delays)
*size and number of monitor screens and speakers
Resolution, video, audio, and touch
    bandwidth [pixels(x)color depth(x)frame rate], [cycles]
    distortion, noise, and artifacts (color fidelity, motion fidelity, latency, data jitter, ...)
Level of presence [simple video; virtual reality/telepresence; immersive telepresence or simulation]
Spatial discrimination (video; audio; touch)
    editing and computation [2D versus 3D modeling]
    viewing [2D, simulated 3D, true binocular/holographic/binaural/multichannel]
Character of virtual reality (availability, quality, control -- e.g., selection of avatars)

2. Quality and diversity of program content and services

Quality of video content
Numbers and variety of video channels (e.g. multicasting)
Size and variety of video content database(s)
*degree of competitivity or monopolization
*locus of market control [e.g., advertiser, end user, non-profit]
*variety of organizations and services accessible
Degree of enhancement of user productivity

3. Control and convenience

Number and variety of editing/presentation functions
    [list]
    integration of tool suites
Certifiability or authentication of images
Convenience of transactions (e.g., payment methods)
Interoperability [incompatible, convertible, interoperable]:
    modularity and interconnectability of Components
    commonalities across specialized markets
    independence between creation, database, transmission, and utilization
      (Signal, memory, and encoding systems)
    seamless merging of tv, computing, teleconferencing, etc.
Degree of local control of picture frame [split screen; picture-in-picture; full windows]
*amount of local storage
Degree of logical control of program stream
    [none; random/dynamic assembly of content]

Degree of adult control over children's access
Degree of (effective or actual) remote control by viewer
    camera point of view [location, aim, focus, zoom]
    other actuators
Degree of other local control over image processing
Level of security and data privacy (storage, transmission, display)
Speed of operations [multi-tasking; real time; offline]
    editing
    searching/retrieving
    converting
    virtual reality computation
Capability of equipment to learn and anticipate user's preferences
Availability of voice control input
User simplicity
Physical comfort and ergonomics of equipment
* head-mounted/wearable display weight
* keyboard/mouse/dataglove
* furniture
* ambient lighting
    voice input
Weight and portability of equipment
Concealment of equipment
*thinness of monitor screen
Rate of content updating
*ugliness and intrusiveness of outdoor antennas and equipment (commercial; household)

4. Connectivity

*number of people with access
*number and variety of people accessible
    [limited coverage; random coverage; universal human interactivity (the video telephone book)]
      geographical coverage
      social coverage
*number of organizations with access
*number and variety of public places that can be viewed on line
*physical ubiquity of transmission service outlets
Effectiveness of searching, indexing, browsing, and pattern recognition capabilities
    navigational aids [hyperlinks,...]
    content-based searching and indexing [rates of type 1 and type 2 errors]
    advanced program guides
Number of contexts in which hypertext is available (e.g., when viewing a tv ad)

5. Technological sophistication

Accuracy and completeness of human perceptual models
Error rates of pattern recognition models
Data compression ratios
Availability of editing and pattern recognition operations on compressed images
Prices and costs [$/unit]
    base price
    per increment per program minute
    per increment per level of resolution (equipment)
    per resolution (transmission), i.e., (Price /bits)*(bits/resolution)
    per increment of signal transmission reliability
    per computational quality
    per features
Cost-risk; resistance to technological obsolescence
Degree of scalability
*degree of redundancy in streaming
*available bandwidth
Maximum manageable size of remote video databases (number of videos; number of accesses per hour)
*wirelessness

10. MARKETS POTENTIALLY AFFECTED BY THE ATP DV PROGRAM

This Chapter interprets and summarizes the map of the DV marketplace presented in Chapter 9.

Purpose

The RFP that led to this research conjectures that there would be "between twenty and fifty markets" likely to be significantly affected by the ATP DV program (Advanced Technology Program, 1997a, p. 2). If markets are very narrowly defined as sets of intercompetitive goods (or market segments), it is apparent that the map contained in Chapter 9 would lead to a much larger number. In particular, some 180 distinct specialized uses are listed; each of them could potentially lead to distinct market segments for every component that is appropriate to that specialized use; and the majority of the specialized uses apply to more than one component. In addition, each of these segments could potentially be further differentiated in terms of quality, using one or more of some 90 listed quality scales. Even if there were only two relevant components per specialized use, only two effective quality scales per component, and only two distinct types per quality scale, the number of distinct possible market segments would easily exceed a thousand.[15] This is simply too many markets for our purposes, for two reasons.

First, remember that market segments listed in Chapter 9 are only *potential* markets; not all of them will be actualized. In fact, the existence of certain market segments will, with high probability, entail the non-existence of others. That is, if a market is segmented along one axis, it becomes less likely to segment along another axis: different principles of segmentation tend to compete with each other. Competition of this type occurs because economies of scale lead to market differentiation rather than complete customization to each individual customer's requirements. In other words, if a product has already been differentiated into segments that have relative low production runs, then additional segmentation may lead to uneconomically high costs. For example, automobiles constitute a very large and highly differentiated industry; yet we observe that optional accessories are often marketed in discrete packages, rather than as a large number of separate choices.

Second, recall that it is intended for future research to track the effects of ATP on the identified markets, and also their spillover effects to other markets. Following thousands of markets individually with any kind of detail would appear to be completely out of the question.

Therefore, the complete map of Chapter 9 will need to be aggregated and selected to form a summarized map.

[15] The true number, which is even larger than that, is not very stable against changes in the map, and could not possibly be calculated without a computer program. We did not write a such a program because the exact number of possible market segments does not appear to be either well defined or useful.

Principles of summarization

The principles of selection for market segments should include:

- domain relevance, e.g. there is a reasonable possibility of funding or direct influence by ATP's DV program. (For example, all military applications have been omitted. More generally, all applications flagged with an * in Chapter 9 have been omitted.)
- the relative likelihood that various competing forms of segmentation will arise. (We have included only the forms of segmentation that seemed most likely to the study team, partly based on statements made at the workshop of consultants and on responses from the survey of experts.)
- the relative likelihood that it will happen within 15 years. (We have included general component markets that were judged to have a subjective probability of at least 1/3 of coming into existence.)
- relative "significance". (We have included markets judged EITHER:
  reasonably likely to be large enough to be directly economically significant - e.g. $100M sales per year- OR
  reasonably likely to be technologically significant - the relevant techniques seem possibly generalizable or seminal.)

The principles of aggregation should include:

- following the same aggregation schemes used in present-day published data, or likely to be used in future.
- aggregating segments that are similar in the types of unpublished data that will need to gathered for impact analysis.
- focusing on "components" (as defined in Chapters 2 and 9), with some segmentation by specialized use. Subcomponents and segmentation by quality scales are largely omitted.

We have followed those principles informally rather than formally; see Chapter 3 for an explanation of our procedures. The results of the summary follow.

Major markets summarized

These markets are organized using the same general scheme that is followed in the discussion of "components" in Section II of Chapter 9. However, less relevant markets have been selected out, and some material on specialized uses taken from Section III has been selected in.

The markets are described using ordinary language. Most of these markets do not correspond very well to existing SIC and NAISC codes, so no attempt has been to provide sector codes.

1. Related non-DV functions

(No relevant markets)

2. Content creation

2.1 Image capture

2.1.1 image sensors and interpreters

Object trackers

[real time services segmented by:

Custom-designed and scientific systems

Industrial process, by process

Warehouse inventory, by type of good (see also: inventory control and resupply systems)

(See also: transportation and medical uses)]

[slow motion and historic ground and satellite imaging services segmented by:

Maintenance monitoring systems

Industrial espionage

Real estate and urban planning

Agricultural, forestry, fishery, mining, environmental

Weather and climate forecasting]

Hardware/software functions:

Object identifiers

Range detectors and automated camera focus

Object followers (2D; 3D) and automated camera aiming

Object counters

Terrain describers

People trackers

[segmented by:

Security systems (indoor; outdoor; e.g border control)

Surveillance systems

TV audience research services

Crowd control systems (indoor; outdoor)

News reporting

(See also: positioning and GPS)]

Hardware/software functions:

Human recognition

Human ID (cooperative and close; noncooperative and remote)

Human followers

Human counters

Client monitoring systems [segmented by institutional type (see also medicine)]

Commercial services:

Security services

Surveillance/ private information services

Public information services

2.1.2 Image capture support

(No relevant markets)

2.2 Image processing
2.2.1 Image and content manipulation
Automated closed captioning systems
Editing/presentation/authoring
Hardware/software
[segmented by:
Low end household
"Prosumer", household and low end professional
Broadcast
Film]
Editing and post production services
[segmented by:
TV advertising
TV primary content [segmented by news, sports, entertainment]
edit suite
On air suite
Film content]
TV bit-stream editing: merging, timing, logic switching hardware/software
Virtual reality computation systems
Modeling languages
Application support hardware/software
2.2.2 Viewpoint customization systems and services
Hardware and software systems
Remote viewpoint customization services
2.2.3 Metadata creation, support, and management
Automated annotating and metadata creation
Logic switching hardware/software; bitstream management equipment
2.3 Deliverable content units
(No relevant markets)

3. Storage and retrieval functions
3.1 Storage
DV oriented data-base hardware/software; asset management systems
3.2 Retrieval
Content-based searching, browsing, and navigation
Image-based hardware/software
Pattern recognition systems
Pattern recognition languages and application generators
Indexing and searching
Search results representation software
Automated DV synopsis systems
Services
Program guides

Catalogs and directories
Image-based web crawlers
Web snapshot and uniform citation systems
Hyperlink standards, metalanguages, and translators
Automated quality-of-link assessment systems

4. Distribution functions

[segmented for countries with differing TV standards]

4.1 Sending hardware/software

Broadcasting and narrow casting equipment; public and private carriers

[segmented by: infrared, radio, wired (cable and telco), satellite or DBS]

Coders/decoders

Transcoding equipment

Subcomponents:

Compression technology

4.2 Receiving hardware/software

Coders/decoders

Receiving and terminal equipment

4.3 Message control hardware/software

4.3.1a Image-based screening and evasion

Design of legal rights to image privacy

Image privacy enforcement systems

Message screeners and scanners

Site blocking software and censorship software; V-chips

Children

Employee

4.3.1b Screening and evasion countermeasures

(No relevant markets)

4.3.2a Video security and property rights enforcement

Authentication, vouching, and watermarking

Software (may be integrated with compression)

Services

Automated billing, collection, and escrow systems for video

TV stations

VOD systems

Transmission systems

Central storage service systems

Royalties

Use metering software, read-once technology

Video copyright protection

Copyright law design

Copyright law enforcement software and services

Visual encryption software (may be integrated with compression)

4.3.2b Video security and property rights countermeasures
(No relevant markets)
4.4 Quality of service control
Measurement hardware and software
Control and guarantee systems

5. Viewing and using
5.1 Viewing space
Personal recognition and equipment locking technology
5.2 Display equipment
Headsets, head-mounted devices (HMDs)
[segmented by
Games
Simulators, trainers
Factory production
WWW and database access metaphors]
Hardware/software
Head-position and eye position capturing and compensation
Head-position and eye position-responsive controllers and screens
3D glasses
Head-mounted cameras
Devices to superimpose DV information on ambient scenes
Adaptive equipment for the handicapped
Tactile and aural analogs of visual fields
Visual cuing devices; virtual seeing-eye dogs
Eye position-based controllers
Monitors/speakers: stationary
Wall murals/billboards/kiosks
Video smart cards
(Display; camera; memory; processor)
(ID cards; transactions handlers; digital assistants; advertising)
5.3 Viewing support
Commercial advertising detectors and trimmers

6. Unified communication services and primary content distributors
6.1 Videophone and conferencing services
[segmented by
Household (CUCME)
Prosumer
Hyper-immersive
Service industries, customized
(See also: medicine, education, transportation, home shopping)]
Specialized equipment

Answering machines
Video mail hardware/software
Services
Line quality guarantees
Video mail
6.2 Content providers
6.2.1 Scheduled content (broadcast and film)
(None; but see Image creation, and Distribution functions)
6.2.2 Unscheduled content
[segmented by: background, on demand]
Video clipping services
Data-base management services
Video program providers
VOD
VOND
Video-based information services; searchable DV database services
[segmented by content:
Generalized
News
Scientific
Entertainment
(See also: medical, expert systems)]
6.3 Wearable DV systems
Hardware/software systems
6.4 Network systems and Internet access services
(No relevant markets; but see Distribution functions.)

7. Integrated systems for action and commerce
7.1 Physical action and extra-video data capture
Robot vision and control
Industrial, segmented by application
Scientific and remote exploration
(See also image capture; head sets)
7.2 Commercial transactions systems (hardware/software, technical support)
Financial transactions systems
Payment and audit services (for non-video industries)
Home and remote shopping systems
[segmented by: type of goods]
Intellectual property rights enforcement (for non-video IPRs)
Image-based search and detection software
Image-based search and detection services
7.3 Service, staff, support, and social action systems (hardware/software, technical support)
Collaboration support systems (i.e. systems to control work products as well as

conferencing)
[segmented by: type of collaboration]
Consumer goods design, simulated display, and customization systems
[segmented by type of good: clothing, interior design, architecture, automobiles, etc.]
Custom end user design
Design for pre-marketing tests
Consumer equipment interfaces
[segmented by: type of equipment--automobiles, kitchen appliances, etc.]
Educational systems
Distance learning support services
Programmed learning systems (e.g. the Video Linguist system)
Conferencing systems
Museum displays (see also: wall murals/billboards/kiosks)
(See also: medical education; teleconferencing)
Human-computer interface (HCI) systems (see also: HCI image computation)
Personal recognition systems
Technical guides and expert system services (repairs, service, advice; e.g. tele-mechanics)
[segmented by difficulty of implementation and use:
Video hyper-manuals
True expert systems]
[segmented by expertise of user:
Consumer guides
Service rep guides
Professional user's handbook]
[segmented by topic (see also: medicine)]
Expert system creation
Support systems
Applications
7.4 Production and distribution systems (hardware/software, technical support)
Construction planning and project management systems
Architectural and engineering planning
Project monitoring (civil and industrial engineering; buildings; landscape)
Acoustical imaging and system installation
Heat distribution imaging and heating/AC system installation
Human positioning and GPS systems
Location detection hardware/software
Map and readout hardware/software; databases
Inventory management and automated resupply systems (see also: object trackers)
[segmented by: type of goods]
Production process control systems [segmented by type of process]
Product testing systems
[segmented by type of good and test]
[segmented by type of sensing: visible, ultrahigh speed, infrared, acoustic, x-ray

tomography]
[segmented by hazardous conditions of the test]
Transportation systems
[segmented by industry]
Object tracking
Vehicles: highway, parking, air, tarmac, rail line, yard, harbor, pipeline
People and cargo
Smart vehicles, vehicle guidance systems
Scheduling and reservations systems: mapping and display
Entertainment in route
Public announcement systems
(See also: GPS systems)

8. General (implied cross-category upstream support for all categories)

Compliance testing and test equipment
Equipment developers
Equipment producers
Equipment suppliers
Equipment subcomponent suppliers
Equipment operation services
Software developers and producers
Software suppliers
Training and support

In addition, complex labor markets are implied for each of these categories.

9. Unpredictable or unanticipated developments not mapped elsewhere

(This category is merely a reminder. When new developments are identified, they should be fit into the first eight categories.)

Conclusion

We will make a few cursory comments on the patterns that emerge in this map.

First, one very important theme that runs throughout this map is pattern recognition. It is not enough for DV to merely capture the images in digital form; to actually use the images, we need to know something about them. If finding out what is in a sequence of images cannot be at least partly automated in various ways, then in an information sense we haven't gained all that much by digitizing them. Consequently, many applications will depend crucially on pattern recognition.

Second, we anticipate that the major part of the action around 8 to 15 years out will lie in adapting DV techniques to particular uses that are relatively specialized. There are only a few basic general

functions that can be performed on or with a DV entity: create it, edit it, transmit it, store it, analyze it, view it, act on it. A collection of techniques and utility routines will be developed that do many of these general tasks in generally efficient and generic ways. Once that has been done, the remaining hard work comes in making those technologies pay off in particular cases. Each of those particular cases has its own quirks, which will require at least partly individualized solutions.

Third, the implications of these DV developments for labor markets will be very significant. By most accounts, pattern recognition software is unlikely to be generic; instead, it will be highly specialized to particular applications. For example, a system that reliably recognizes automobiles and trucks as individual objects on a highway is unlikely to be of much use in tracking changes in land use. That specificity implies that a lot of programmers are going to be engaged in a lot of pattern recognition programming. More generally, a lot of technical personnel are going to be engaged in technical piecework related to particular applications.

Fourth, there will be a countervailing effort to create DV application generators, pattern recognition languages, and other high-level application-oriented DV tools. Since this technology is still undergoing basic research, the time frame and degree of success for those efforts would be rather hard to predict.

11. IMPLICATIONS FOR FUTURE RESEARCH

This Chapter describes some of uses that could be made, both of the specific DV marketplace map constructed here, and also of the mapping methodology in general. These uses could apply not only to our ongoing research on the impacts of DV, but also to other technology assessment studies.

Implications for subsequent tasks in the ATP Digital Video economic impact project

Recursive analysis of markets

We are engaged in a process that maps the future of DV markets. This report provides a snapshot of the map at a particular point in time, but the map is not (and in one sense never will be) "finished". Further stages of research on the economic effects of DV will inevitably uncover new possibilities that suggest revisions in the map. We expect to continue to revise the map in the course of that research. For example, future research on ways of measuring impacts may lead to ideas about data gathering that will cause us to re-examine the aggregation of market segments suggested in Chapter 10.

Uses of the market map

The summarized market map will be a major input to the next research task of the DV impact study. It will be used to help identify pathways to economic benefits from the ATP program. In particular, a pathway is a triple consisting of a directly affected market, a second-round affected market, and a type of effect (such as a spillover across markets). For example, a ATP-funded DV compression technology might be used in "CODECs" (compression-decompression hardware, the directly affected market); then ideas taken from that technology might lead to new ways of compressing non-video data for storage (a knowledge spillover); then these new methods might be incorporated into general purpose memory devices (the second-round market). Research of that type will expand on the map created here by adding spillovers and other pathways; it will also entail creating a more complete picture or mapping for the technology level of the existing hierarchy. The expanded map will then form a basis for the impact studies that follow.

Implications for other research on technology impacts

A methodology for mapping future markets

We would quite naturally do many things differently if we were to repeat this project (and some of them are described below). Nevertheless, we are convinced that the basic features of our approach are sound and would be useful in subsequent projects that attempt to map future technology-driven markets.

- We believe that future markets should be mapped in terms of their abstract functional characteristics. The specific details of market goods change rapidly with technology; it is only

their most general functional purposes that remain sufficiently constant over time as to provide a rational basis for forming beliefs about the future. However, below we raise the question of whether the analysis of those functional characteristics should be based on the demand side (as in this report), or instead on the supply side, of the marketplace.

- In principle, the functional characteristics of products can always be segmented horizontally, in terms of specialized uses, as well as vertically, in terms of qualitative differences. It will usually be important to understand this segmentation in some detail (although that importance will depend on the uses that will be made of the map).

- Consequently, we believe that the map should be organized in a formal hierarchical format. The purpose of the hierarchy is to impose order and control on the mass of relevant data, as well as to reflect the logical structure of the marketplace.

- The map will need to be based on empirical data. At the same time, the map will need to be disciplined by rational organizational principles which include disjointness and exhaustiveness.

- The empirical methods for constructing the map should include iterative comparisons across levels of the hierarchy. Each level of the hierarchy provides a different focus and leads to a different set of ideas; ideas at each level have implications for ideas at the other levels. For example, a new specialized use of DV may suggest a new type of hardware or software component that can assist in that use; a new component may suggest a new quality scale appropriate to that component; a new quality scale may suggest a new specialized use for which that particular form of quality is important.

- The complete map will generally need to be aggregated and selected. The principles of selection will probably include:
  - domain relevance (in our case, likelihood of funding by ATP's DV program)
  - the relative likelihood that various competing forms of segmentation will arise.

  The principles of aggregation will probably include:
  - the same aggregation schemes likely to be used in future published data, and
  - similarities across segments in the types of unpublished data that will need to be gathered.

Of course, a complex method like this one is expensive and time consuming. Such a method would not be appropriate in cases where the future technology is expected to have, at most, narrow effects in a small number of closely related market segments. But the fundamental technology projects that ATP backs are always intended to have broad and far-reaching economic consequences, and mapping those potential consequences will generally be a complex task.

The relative usefulness of data sources

Each effort to map future markets will need to select empirical methods based on individualized costs and opportunities available to the researchers. It may be helpful, however, to provide a subjective

assessment of the relative importance of data sources used in the present report. In order of declining absolute contribution to the report, we would rank the data sources as follows:

1. informal conversation and reflection by the research group, including conversations with on-campus digital video engineers
2. surfing the Internet
3. telephone conversations with off-campus consultants
4. attending the workshop of experts
5. performing the survey of experts
6. reading the non-electronic literature
7. performing the input-output studies
8. performing the focused imaginative review of SIC codes.

A ranking in terms of marginal contribution per cost would not be much different.

Demand side versus supply side

In this report we started from a functional analysis of the demand side of the marketplace ("activities"). According to a theoretical argument, that is the best starting point. However, empirical evidence on the advantages of a supply side ("capabilities") approach could certainly change our views. There is room for additional study as to whether, in practice, functional characteristics of future technology goods are best analyzed in terms of demand-side or supply-side capabilities, or perhaps in terms of both sides of the market simultaneously.

Non-uniqueness of the map

As a matter of design, both the general structure of levels of characteristics, and the particular map of digital video markets, have many elements that are essentially arbitrary. For example, neither vertical segmentation (quality) nor horizontal segmentation (specialized uses) is necessarily higher or lower in the hierarchy than the other. However, either ordering leads to a description that is equivalent to the other, although the links would be drawn differently.

More significantly, constructing the fine structure of distinctions at a given level of the hierarchy depends on imagination as much as it depends on science. Any given instance of a DV map is simply one effort to verbally describe the data on DV possibilities. In other words, we have not tried to propose a methodology that leads to a *unique* map of characteristics.

On the contrary: useful general rules that impose *unconditional uniqueness* on the map are not possible, because the map depends partly on contingent products of imagination on the part of the research team, and partly on other contingent data. If the map is to be empirically based, then each new idea for a potential future product or capability should lead to changes in the map. Therefore, research teams that are able to imagine different possibilities for future goods should, in fact, create different maps. The space of possible ideas about future technology outcomes is simply too large and

unknowable to be completely mapped in advance of experience; therefore, there can be no absolutely best way to form the map.

But what about *conditional* uniqueness? That is, if we make the map as general, as exhaustive, and as disjoint as possible, conditionally on the given data (including the given products of imagination), and force it into the hierarchical form we have defined, would it be unique? We believe it would not. The concept of "data" used here is too soft, and there are simply too many ways to represent a particular set of imaginative ideas. Different research instances applying the same general methodology to the same realm will lead to different results. The best that a systematic method can accomplish is a substantial degree of overlap between different research outcomes.

At the same time, it would certainly be helpful to standardize the form of the map as far as possible. New and additional rules for standardizing the map could potentially have several beneficial effects:

- reducing outright errors and omissions in the map
- reducing the effort needed to construct the map
- increasing the verifiability of maps
- increasing replicability (e.g. reducing uniqueness and increasing overlap) between alternative maps that cover a given realm
- increasing comparability of maps across realms.

Improving the protocols

To some extent we were limited in our empirical methods by the fact that the logical structure of the market map was being developed simultaneously with the data gathering. Consequently, some of our theoretical ideas were not fully reflected in the empirical protocols. In future research, it may be helpful to have protocols that more fully reflect the hierarchical structure. On the other hand, explaining the hierarchical structure itself is rather time-consuming, while it is important to ask survey questions (for example) in ways that don't require too much background information. Reconciling these conflicting aims is a subject for future research.

In particular, some new features of the protocols that might be explored include:

- studying the experts' understanding of the segmentation concept
- conducting directed brainstorming at the workshop, focusing on the particular map as it then exists.

Also, with respect to expert opinion on the likelihood of particular forms of market segmentation, we obtained a somewhat negative result. In particular, there seems to be a wide variance in expert opinion on the likelihood of almost any given form of market segmentation. Therefore, future research should try to find new ways to tighten up this kind of information. One approach would be to ask experts to *rank* the relative probability of each form of segmentation (as opposed to seeking independent and unconditional estimates like those we asked for). That would lead to more clear cut

discrimination between different forms of segmentation on the part of a particular expert. Another approach would be a Delphi panel (in which experts are asked to reconcile their conflicting viewpoints, using a structured procedure).

Additional protocols

We will point out two sources of information that might be fruitful and were under-exploited in our work.

First, the map we constructed did not attempt to distinguish the existing DV market place from the future DV market place. It would be more helpful to create two distinct maps. It might also be helpful to initially subdivide the research team and create two preliminary maps independently, one for the present and one for the future. Merging the two maps could then prove to be a very informative process.

Second, we made no particular effort to focus on science fiction literature as a data source (though some team members were reasonably well acquainted with the genre). In retrospect, that may have been a mistake. It is true that the science fiction literature is vast and that, arguably, much of it lacks any merit except as escapism. At the same time, literary critics such as James E. Gunn have described it as the only fictional genre which focuses on ideas (as opposed to plot or characterization). Whatever the literary merits of particular stories, when taken as a whole that literature can be read as a systematic body of thought about the future (and the only such body of thought we have[16]). Since this literature is fiction and not fact, it is not very well indexed; however, some bibliographic sources do exist that could support some degree of systematic search for ideas about future technologies. Also, it might be helpful to include an expert on science fiction on the study team.

Additional information

A number of additional types of information could be usefully added to the mapping structure used in this report. Some of the possibilities include:

- Additional lower levels. The map presented here is truncated at the level of general technologies; it would be very useful to add that level, and perhaps some lower levels.
- Information on which principles of segmentation are in direct competition with each other; or in other words, lists of segments that probably could not develop in the marketplace simultaneously.
- Summary information on the relative subjective likelihood that each type of market segment will be actualized.
- Information on the expected time when each market or market segment will appear.

[16] In the sense that the "futurology" of George Gilder (Jacobson, 1997) and others is too limited in quantity of work at this stage to be systematic.

We have gathered some information on all of these topics, but it has not been put into a systematic form. Doing so is partly a matter for subsequent stages of the impact research project.

Ex post evaluation of the map

Follow-up research might usefully examine the degree of correspondence between the DV map as constructed, and the actual DV market place as it eventually turns out. The simplest question to answer is whether all segments of the actual marketplace were predicted by the map, at least in general terms. A harder question is, to what extent did the map predict segments that were not actualized? It is not sufficient to merely observe that a possible segment listed in the map did not appear in the marketplace, because the appearance of one segment tends to discourage the appearance of other possible segments; because of economies of scale in production, there is a limit to the number of market segments that can emerge. The deeper question is, what kept a given predicted segment from actually appearing? It is different, for example, to be "crowded out" by segments that *were* predicted in the map, than by segments that were *not* predicted. Also, there is the question of *when*, exactly, a given segment was or should have been predicted to emerge.

And if there is to be some ex post evaluation of the map, it would be helpful if plans for that evaluation were made and taken into account at the time when the original map was being designed and constructed, so that the resulting map would be amenable to ex post evaluation.

Computer models of the hierarchical structure

One could fairly easily construct a simulation model that included the marketplace map and all of its linkages. The model could have various uses. For example, if predicted sizes of total component markets were attached, and if minimum sizes of individual segments could be estimated, then one might try to predict *which* and *how many* segments would actually arise in the marketplace. It might also be interesting to add a new technology into the bottom of the structure and then list all segments at higher levels of the structure that would be indirectly affected by the new competition for "segmentation space." These relationships across levels of the hierarchy could be parametrized in part or whole using formalized subjective methods that have been developed by Saaty (1980). Saaty's work also indirectly influenced the hierarchical representation that was employed in the present study.

APPENDIX 1: WORKSHOP AGENDA AND ATTENDEES

Venue

Workshop on the Coming Digital Video Economy
Friday, December 19, 1997
English Room, Kansas Union
University of Kansas

Agenda

Note: this agenda has been modified after the fact to approximately reflect what took place.

9:30 **Informal Introductions** *(beverages and pastries)*

10:00 **Opening Remarks**

Welcome —*David Burress*

Remarks —*Charles Krider*

10:15 **Presentations I: Technology and Obstacles**

How should we structure a map or taxonomy of today's and tomorrow's DV economy? —*Burress*

Quality improvement scales: What constitutes a real improvement in DV products and services? —*Charles Poynton*

Quality benchmarks: What are the most significant DV milestones of the next 5-15 years? What will they mean to end users? —*Leonard McMillan*

Future DV technology: How will we make it happen? —*John Gauch*

What are the *DV Computing and Networking Markets* of today and tomorrow? —*Gary Minden*

1. Components, products, and services
2. Market segmentation

1:00 **Roundtable: *When will the technology succeed in the laboratory?*** *(box lunch)*

1:30 **Presentations II: Products and Markets**

What are the *DV Broadcasting and Film Markets* of today and tomorrow? —*Merrill Weiss*

1. Components, products, and services
2. Market segmentation

What are the *DV Information Utilization Markets* of today and tomorrow? —*Susan Gauch*

1. Components, products, and services
2. Market segmentation

What will ATP contribute to future DV? —*David Hermreck*

3:00 **Roundtable: *When will products succeed in the marketplace? What are the social impacts?***

3:15 **Concluding Remarks**

Summary and Interpretation —*Patricia Oslund*

Afterward —*Burress*

3:30 **Adjourn**

Speakers

David Burress
Project Director
Research Economist and Associate Scientist, IPPBR
The University of Kansas
Research interests include technology impact analysis

John Gauch
Associate Professor
Electrical Engineering and Computer Science
The University of Kansas
Research interests include multiresolution image shape description; The VISION Digital Video Library

Susan Gauch
Associate Professor
Electrical Engineering and Computer Science
The University of Kansas
ProFusion meta-search engine designer

David Hermreck
Program Manager
Digital Video Program
NIST-Advanced Technology Program

Charles Krider
Director, IPPBR; Professor of Business
The University of Kansas

Leonard McMillan
Assistant Professor, MIT
Department of Electrical Engineering and Computer Science
Research interests include image-based approaches to computer graphics and multimedia.
Previous work experience includes stints at Bell Laboratories and AT&T.

Gary Minden
Associate Professor, Electrical Engineering and Computer Science
Chief Technologist, Information and Telecommunication Technology Center
The University of Kansas

Patricia Oslund
Research Economist, IPPBR
The University of Kansas

Charles Poynton
Consultant in Digital Video
Author, *A Technical Introduction to Digital Video*, 1996
(Attended via teleconference)

S. Merrill Weiss
The Merrill Weiss Group
Engineering Director (Television), Society of Motion Picture and Television Engineers (SMPTE)
Author, *Issues in Advanced Technology*, 1996

Discussants

Norman Clifford
Director of Forecasting and Research
Research Economist, IPPBR
The University of Kansas

Vincent Glaeser
Research Economist, IPPBR
The University of Kansas

Larry Hoyle
Coordinator of Information Processing; Associate Scientist, IPPBR
The University of Kansas

Susan Mercer
Program Assistant, IPPBR
The University of Kansas

Jerry Niebaum
Assistant Vice Chancellor for Information Services; Director, Academic Computing Services
The University of Kansas

Joshua Rosenbloom
Associate Professor, Economics
The University of Kansas

Tom Webb
CEO, Complex/Concept W Corporation
Overland Park, KS

APPENDIX 2: SURVEY PROTOCOL

A description of the general survey procedure can be found in Chapter 6. Below are the supporting technical documents.

Telephone Survey Script

Members of the Survey Research Center staff utilized the following script for the telephone survey designed to identify DV experts.

PHONE SURVEY TO IDENTIFY EXPERTS

[Identify self and University of Kansas Survey Lab.] This survey is part of a scholarly research project on digital video. It will take no more than 5 minutes of your time. May we ask you a few questions?

1) You have been recommended to us as a person who is familiar with some digital video technologies.
Have you worked directly with or used any digital video applications?

[if no or no opinion, thank you and branch out.]

2) What digital video applications have you worked with?

3) How long have you been working with digital video in one form or another?
_____years

4) What is your current occupation?

5) How long have you worked in this field?
_____years

6) Have you written any publications or web pages on video or on digital video?

7) Would you be interested in participating in a subsequent mail survey on uses of digital video? Participants will receive a free copy of our report.
yes, no, no opinion

[if no or no opinion branch out]

What is your mailing address?

fname
lname
mi
street address
city state zip

Can you help us identify other persons who are especially knowledgeable about digital video, and who might be willing to participate in our survey?

fname
lname
mi
occupation or title
company name
telephone number

fname
lname
mi
occupation or title
company name
telephone number

etc.

Thank you for your help.

Letter to mail survey recipients

The following letter was mailed on IPPBR letterhead along with the survey to previously identified DV experts.

December 7, 1997

(inside address)

Dear (title) (lname):

Thank you for agreeing to participate in the University of Kansas Survey on Future Applications of Digital Video in Information Systems. This study is being funded by the Advanced Technology Program at the U.S. National Institute of Standards and Technology.

We are asking for your help because we believe you are knowledgeable about some existing or potential applications of digital video (DV) technology. We need the bit of vision that you can

contribute about the economy of the future from the perspective of your particular position in the economy of the present. The main focus of this survey is on practical DV applications that are likely in the market place, rather than the detailed technology that will make those outcomes possible.

We will compile the answers we receive from you and other knowledgeable persons into a report. In consideration for your assistance, we will send you a copy of the report.

Your response will be completely confidential. We will maintain a list of respondents, but it will be used solely for the purpose of our own follow-up mailing. As you can see, the questions do not request any specific proprietary information about your company. The report will not reveal any information about identifiable persons, products, or companies.

We are asking for about 20 minutes of your time. You may find some of the questions to be difficult or thought provoking; if the survey seems to take too much time, you may want to skip some of the sections. However, please do complete at least sections A, B, and G, and then return the survey in the enclosed postage paid envelope. If you have any questions about the survey, please call me or my associate, Pat Oslund, at the above number.

We also encourage you to pass copies of this survey along to any of your colleagues who may be knowledgeable about some aspects of digital video. We would be pleased to send them copies of our report as well. The purpose of the study is to obtain a variety of viewpoints, rather than a statistical representation of opinions.

Thanks again for your help.

David Burress
Director
University of Kansas Project on the Economic Impacts of Digital Video

Posted advertisement for web user groups

The following was submitted to 12 DV-related Internet Discussion Groups (listed in Table 6.1), requesting interested persons to respond to the online DV survey.

WEB-SITE SURVEY ON THE FUTURE OF DIGITAL VIDEO
expires: 1/12/98

CALL FOR SURVEY RESPONSES

We are requesting all interested persons to fill out our online questionnaire at:

http://lark.cc.ukans.edu/~oslund/dvsurvey.htm

We will send all responders a free report on our findings.

This questionnaire is part of a survey on future economic impacts of Digital Video in Information Systems. The survey is funded by the Advanced Technology Program at the National Institute of Standards and Technology. It is being conducted by the Institute for Public Policy and Business Research at the University of Kansas.

This survey is primarily addressed to persons who are knowledgeable about some existing or potential applications of digital video (DV) technology, but others are welcome to complete it as well. We need the vision that each of you can contribute about the economy of the future from the perspective of your particular position in the DV economy of the present. The survey is technology-driven, but the main focus is on practical DV applications that are likely to be become available in the market place.

All responses will be completely confidential. We will maintain a list of respondents, but it will be used solely for the purpose of our own follow-up communication. The questions do not request any specific proprietary information. The report will not reveal any information about identifiable persons, products, or companies.

We are asking for about 20 minutes of your time. (The full survey could take longer, but you are welcome to answer only a subset of the items.) If you have any questions about the survey, please send them directly to me at the address below.

We also request that you cross post this notice on appropriate newsgroups and discussion lists, or pass it along to any of your colleagues who may be knowledgeable about some aspects of digital video. This subject crosses many lists and newsgroups, most of which we are not knowledgeable about. The purpose of our study is to obtain a variety of viewpoints, rather than a statistical representation of opinions, so sampling bias is not an issue.

Thanks for your help.

David Burress
Director
University of Kansas Project on the Economic Impacts of Digital Video

Keywords: teleconferencing, videomail, virtual collaboration, immersive telepresence, broadcasting, distance learning, binocular video, telecommuting, special effects, holodeck, computational imaging, VR, DV, ATV, HDTV, HMD

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APPENDIX 3: SURVEY INSTRUMENT

Survey on Future Applications of Digital Video in Information Systems

(Note: this version reproduces the original questions but not the original typography and page layout. Different layouts were used in the mail survey, the email survey, and the web-site survey.)

A: Identification of Respondent

Please enter the following information about yourself and your occupation. This information will be kept confidential, and will be used to return a copy of the report to you.

Name
_____

Title
_____

Address1
_____

Address2
_____

City State/Province
_____

Postal Code/ZIP Code
_____

Country
_____

Phone
_____

Internet e-mail address
_____

1. What is your occupation ?

2. How many years have you worked in this field ?

3. What is the name of your employer ?

4. What is the nature of your employing organization ?

5. What is the SIC code of your employer (if known) ?

6. Is your work most closely associated with ?
(check one or more)

a Broadcasting or cable
b Movies or other videos
c Computing or networking
d Other_____

7. Is your work most closely associated with ?
(check one or more)

a Content production
b Transmission or distribution
c Video utilization
d Other_____

8. How would you categorize your main role ?
(check one or more)

a Research and development of technology
b Production or sales of hardware or software
c Service provider
d End user of technology
e Consulting
f Education
g Writing about technology
h Other_____

B: Background and Approach

In the following questionnaire, we will look at DV technology and markets from several different points of view. In particular, we will examine:

1. Market penetration: future milestones in the growth of new DV applications.

2. User-oriented improvements: ways in which DV goods and services can be made more marketable, in terms directly related to the needs and wants of end users.

3. Market segments: various specialized ways in which DV technology can be used.

We will ask you a number of questions about the future of DV. These questions have no right answer -- we are simply asking you to look into your imagination's crystal ball and tell us what seems reasonable to you, all things considered. We do not expect every respondent to be knowledgeable in every aspect of DV technology -- we simply want your perspective on the things that you do know something about.

1. As a starting point, could you briefly list or summarize two or three of the most important developments that you anticipate over the next 5 to 7 years in the market for DV-related goods and services ?

1.1

1.2

1.3

C: Future Milestones in the DV Market Place

The following list includes a number of events which may happen in the future market place for digital video equipment and services. All questions refer to the market place in your country only.

For each possible event, please give your opinion on two scales:

A. When is it most likely to occur?
now, 1-3 years, 4-7 years, 8-15 years, > 15 years, never, no opinion

B. If it happens, how important will the social impacts be?

Please show anticipated impacts on a scale of 1-5, as follows:

1 not important at all
2 slightly important
3 moderately important
4 very important
5 extremely important

(Circle the one item on each scale that you agree most with.)

1. The majority of television broadcast content is in digital format.
now 1-3 years 4-7 years 8-15 years > 15 years never no opinion

(not important at all) 1 2 3 4 5 (very important) no opinion

2. 20% of households are wired for video on demand.
now 1-3 years 4-7 years 8-15 years > 15 years never no opinion

(not important at all) 1 2 3 4 5 (very important) no opinion

3. 20% of households are connected to visual content-searchable DV databases.
now 1-3 years 4-7 years 8-15 years > 15 years never no opinion

(not important at all) 1 2 3 4 5 (very important) no opinion

4. 20% of households subscribe to videomail.
now 1-3 years 4-7 years 8-15 years > 15 years never no opinion

(not important at all) 1 2 3 4 5 (very important) no opinion

5. 20% of households are equipped for videophone.
now 1-3 years 4-7 years 8-15 years > 15 years never no opinion

(not important at all) 1 2 3 4 5 (very important) no opinion

6. 20% of individuals have access at home or work to teleconferencing.
now 1-3 years 4-7 years 8-15 years > 15 years never no opinion

(not important at all) 1 2 3 4 5 (very important) no opinion

7. 20% of individuals are equipped at home or work to communicate using "immersive telepresence" (which provides the illusion of being present with a distant person).

now *1-3 years* *4-7 years* *8-15 years* *> 15 years* *never* *no opinion*

(not important at all) *1* *2* *3* *4* *5* *(very important)* *no opinion*

8. Television and computing video technologies are largely interoperable.

now *1-3 years* *4-7 years* *8-15 years* *> 15 years* *never* *no opinion*

(not important at all) *1* *2* *3* *4* *5* *(very important)* *no opinion*

9. A universal standard for video compression which is scalable in terms of bandwidth has been almost fully implemented.

now *1-3 years* *4-7 years* *8-15 years* *> 15 years* *never* *no opinion*

(not important at all) *1* *2* *3* *4* *5* *(very important)* *no opinion*

10. 20% of households own a DV editor.

now *1-3 years* *4-7 years* *8-15 years* *> 15 years* *never* *no opinion*

(not important at all) *1* *2* *3* *4* *5* *(very important)* *no opinion*

11. Video editing software for home or office is standardized to the point that there are one or two main interchangeable types (which may or may not be brand-named).

now *1-3 years* *4-7 years* *8-15 years* *> 15 years* *never* *no opinion*

(not important at all) *1* *2* *3* *4* *5* *(very important)* *no opinion*

12. A majority of commercial motion pictures are originally created in DV format.

now *1-3 years* *4-7 years* *8-15 years* *> 15 years* *never* *no opinion*

(not important at all) *1* *2* *3* *4* *5* *(very important)* *no opinion*

13. 20% of households own a high resolution binocular or holographic video headset.

now *1-3 years* *4-7 years* *8-15 years* *> 15 years* *never* *no opinion*

(not important at all) *1* *2* *3* *4* *5* *(very important)* *no opinion*

14. 20% of multi-employee businesses have video-based advertisements on the Internet.

now *1-3 years* *4-7 years* *8-15 years* *> 15 years* *never* *no opinion*

(not important at all) *1* *2* *3* *4* *5* *(very important)* *no opinion*

15. 20% of households are wired with incoming bandwidth of at least T1 (or 1.5 Mbps).

now *1-3 years* *4-7 years* *8-15 years* *> 15 years* *never* *no opinion*

(not important at all) *1* *2* *3* *4* *5* *(very important)* *no opinion*

16. 20% of households are wired with outgoing bandwidth of at least T1 (or 1.5 Mbps).

now *1-3 years* *4-7 years* *8-15 years* *> 15 years* *never* *no opinion*

(not important at all) *1* *2* *3* *4* *5* *(very important)* *no opinion*

D: Measurement and Quality Scales for DV Equipment and Services

The following list describes various ways of measuring quality for DV hardware, software and services, in terms that are potentially important to the ultimate user of DV. Each item represents a type of scale or direction along which competing products can be ranked. For example, transmission services could be ranked by error rates; editing systems could be ranked by the presence or absence of operation on compressed data. Some of these scales or directions are specific to broadcast; others to computation; still others creation of program content; while some are more general.

Please indicate the scales along which you think goods and services in the digital video market place will undergo significant changes of quality in the next 5-7 years. Also, please describe any important scales of quality that you think should be added to this list.

y = will undergo significant changes of quality in the next 5-7 years
n = will not undergo significant changes of quality in the next 5-7 years
No-opinion = you have no opinion on this item

1. Picture and Sound Quality

Yes No No-Opinion (significant changes of quality in the next 5-7 years)

____ ____ ____ 1.a. accuracy of transmission (data error rate)
____ ____ ____ 1.b. availability of transmission signal (obtaining channel access, dropouts, delays)
____ ____ ____ 1.c. size and number of monitor screens and speakers
____ ____ ____ 1.d. resolution, video and audio (bandwidth; color depth, distortion, artifacts)
____ ____ ____ 1.e. level of presence (simple video; virtual reality/telepresence; immersive telepresence or simulation)
____ ____ ____ 1.f. degree of spatial discrimination (e.g. 2D vs 3D)
____ ____ ____ 1.g. character of virtual reality (availability, quality, control -- e.g. selection of avatars)

2. Program content quality and diversity

Yes No No-Opinion (significant changes of quality in the next 5-7 years)

____ ____ ____ 2.a. quality of video content
____ ____ ____ 2.b. numbers and variety of video channels
____ ____ ____ 2.c. size and variety of video content database(s)
____ ____ ____ 2.d. degree of competitivity or monopolization
____ ____ ____ 2.e. locus of market control (e.g. advertiser, end user, non-profit)
____ ____ ____ 2.f. other_____

3. Connectivity

Yes No No-Opinion (significant changes of quality in the next 5-7 years)

____ ____ ____ 3.a. number of people with access
____ ____ ____ 3.b. number and variety of people accessible
____ ____ ____ 3.c. number of organizations with access
____ ____ ____ 3.d. number and variety of organizations and services accessible
____ ____ ____ 3.e. number and variety of public places that can be viewed on line
____ ____ ____ 3.f. physical ubiquity of transmission service outlets
____ ____ ____ 3.g. effectiveness of searching, indexing, browsing, and pattern recognition capabilities
____ ____ ____ 3.h. number of contexts in which hypertext is available (e.g. when viewing a TV ad)
____ ____ ____ 3.i. other_____

4. Control and convenience.

Yes No No-Opinion (significant changes of quality in the next 5-7 years)

____ ____ ____ 4.a. number and variety of editing/presentation functions; integration of tool suites
____ ____ ____ 4.b. certifiability or authentication of images
____ ____ ____ 4.c. convenience of transactions (e.g. payment methods)
____ ____ ____ 4.d. interoperability: modularity and interconnectability of components
____ ____ ____ 4.e. interoperability: commonalities across specialized markets
____ ____ ____ 4.f. interoperability: independence between creation, transmission, and utilization
____ ____ ____ 4.g. interoperability: seamless merging of TV, computing, teleconferencing, etc.
____ ____ ____ 4.h. degree of local control of picture (split screen; picture-in-picture; full windows)
____ ____ ____ 4.i. amount of local storage
____ ____ ____ 4.j. degree of logical control of program stream
____ ____ ____ 4.k. degree of adult control over children's access
____ ____ ____ 4.l. degree of remote control of camera point of view by viewer
____ ____ ____ 4.m. level of security and data privacy (storage, transmission, display)
____ ____ ____ 4.n. speed of operations (editing, searching/retrieving, converting, virtual reality computation)
____ ____ ____ 4.o. capability of equipment to learn and anticipate user's preferences
____ ____ ____ 4.p. availability of voice control input
____ ____ ____ 4.q. user simplicity
____ ____ ____ 4.r. physical comfort and ergonomics of equipment
____ ____ ____ 4.s. weight and portability
____ ____ ____ 4.t. thinness of monitor screen
____ ____ ____ 4.u. other_____

5. Technological sophistication

Yes No No-Opinion (significant changes of quality in the next 5-7 years)

____ ____ ____ 5.a. accuracy and completeness of human perceptual models
____ ____ ____ 5.b. error rates of pattern recognition models
____ ____ ____ 5.c. data compression ratios
____ ____ ____ 5.d. availability of editing and pattern recognition operations on compressed images
____ ____ ____ 5.e. prices and costs
____ ____ ____ 5.f. degree of scalability
____ ____ ____ 5.g. degree of redundancy in streaming
____ ____ ____ 5.h. available bandwidth
____ ____ ____ 5.i. maximum manageable size of remote video databases (number of videos; number of accesses per hour)
____ ____ ____ 5.j. wirelessness
____ ____ ____ 5.k. other_____

Instructions for Sections E. and F.

In the market place, similar products may not actually compete with each other because they have different prices and/or other characteristics. For example, Chevrolets in the main do not compete directly with Cadillacs or Mustangs - so the automobile market is said to be differentiated or "segmented" into separate "market segments". The following lists describe various ways in which DV-related products might tend to be differentiated into separate market segments in the future. Of course, different parts of the market are segmented in different ways. For example, at present:

Recording equipment is segmented by volatility of memory; e.g.,
- temporary record (RAM)
- semipermanent record (VCR)
- archivable record (laser disk)

Content distributors and transmission providers are segmented by transmission technology; e.g.
- physical transfer (disks, tapes, etc.)
- cable
- telephone
- wireless.

Post-production equipment is segmented by destination of the content:
- broadcast stream (real time)
- repository or store or wholesaler (canned).

Production of physical recordings is segmented by size of production run:
- home and casual business
- mass production.

Content distribution systems are segmented by pricing system:
- proprietary
- free data resources supported by advertising
- free data resources supported by government or non-profits.

Video viewing equipment for individual viewers is segmented by context or purpose:
- passive entertainment and training
- games
- operation simulators (driving, flying).

Information system equipment is segmented by historic origin of applications:
- TV-related equipment
- computing and networking equipment.

We would like your judgement on which forms of segmentation are likely to be important in the future in at least some parts of the DV market, and which are likely to be unimportant. Please express your opinions on a scale of 1 to 5:

1 *< 5% likely: significant segmentation is very unlikely to occur*
2 *5% to 30% likely: significant segmentation is rather unlikely to occur*
3 *30% to 70% likely: significant segmentation about as likely to occur as not*
4 *70% to 95% likely: significant segmentation is rather likely to occur*
5 *>95% likely: significant segmentation is very likely to occur*

In each case, a range of alternatives is given. The exact alternatives listed are for illustration only. We are not asking if segmentation will take the exact form described; we are asking if there will be some degree of segmentation along the general lines that are indicated.

We would also like your ideas on additional possible ways for equipment, software, and service markets to be segmented.

E: Market Segments for DV Equipment and Services (part 1)

1. Picture and Sound Quality

1.1 Will viewing and transmission systems be segmented by resolution? e.g.,
- low resolution
- high resolution (HDTV)
- super high definition (up to 7000 lines)

Check 1 2 3 4 5, for the degree of likelihood of segmentation, or check "No opinion".

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

1.2 Will transmission services be segmented by availability and dependability (channel access; dropouts; delays)?

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

1.3 Will conferencing services be segmented by general quality (resolution; transmission reliability; number of channels connected; presence)? e.g.,
- household and casual business televideo
- distance learning and teleconferencing
- high-quality (e.g. immersive telepresence)

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

1.4 Will computational imaging be segmented by degree of motion? e.g.,
- translation and magnification of 2D object
- rotation in space of 3D object
- depiction of 4D object
  (e.g. 3D objects changing over time)
- rotation in 4-space
- n-D objects

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

1.5 Are there other possible ways for DV markets to be segmented on viewing quality?

2. Control of viewing conditions and access

2.1 Will interactive video controllers be segmented by degree of interactivity? e.g.,
- local (game/interactive educational program)
- single-person multi-site interactive
- multi-person multi-site interactive

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

2.2 Will video cameras be segmented by portability of local equipment? e.g.,
- stationary
- local change in aim, focus, zoom
- locally mobile
- mobile, shoulder or tripod
- mobile, hand held

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

2.3 Will non-theatrical screens and speakers be segmented by viewing location? e.g.,
- home
- portable
- workplace
- open public

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

2.4 Will content transmission services be segmented by number of channels? (e.g., number available; number that can be simultaneously active)

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

2.5 Will 2-way communications services be segmented by numbers present at the same time ? e.g.,
- one to none (video mail)
- one to one (videophone)
- one per location, several points
- several to several (video conference)
- several to many (teleconference)
- many to many (virtual convention?)

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

2.6 Will 2-way communications services be segmented by degree of privacy? e.g.,
- private
- private within small group
- private within large group
- public

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

2.7 Will virtual collaboration services be segmented by scale of institution? e.g.,
- group, team (virtual classroom)
- building, school, plant (virtual library)
- community, enterprise (virtual corporation, virtual academy)
- nation (virtual polity)
- world (virtual interpolity?)

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

2.8 Will content-based indexing and searching software be segmented by means of the search? e.g., will different users need specializes searches based on:
- visual content
- associated text
- text inside visual field
- audio content

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

2.9 Are there other possible ways for DV markets to be segmented on control and access?

3. Other

3.1 Are there other possible ways for DV markets to be segmented in general?

F: Market Segments for DV Equipment and Services (part 2)

4. Type of Application

4.1 Will complex authoring equipment continue to be differentiated by application? e.g.,
- games
- instructional software
- special effects
- other_____

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

4.2 Will video cameras be increasingly segmented by photographic locations? e.g.,
- home and casual business
- portable
- studio
- on location
- surreptitious
- public fixed location
- other_____

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

4.3 Will monitoring equipment be segmented by application? e.g.,
- scientific (there may be subspecialities)
- institutional (monitoring clients)
- household
- surveillance and security
- process monitoring and control
- inventory control
- traffic control
- other_____

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

4.4 Will commercial matching services be segmented by forum? e.g.,
- home shopping for goods
- demonstration of services and designs
- shopping for travel locations
- business shopping
- dating services
- forming business or research alliances
- other_____

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

4.5 Will virtual collaboration services be segmented by application? e.g.,
- medicine (subspecialities are possible)
- science and engineering (many sub-specialities are possible)
- business telecommuting, virtual enterprise
- distance learning
- video and non-video joint authoring and editing
- other_____

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

4.6 Will complex imaging equipment be segmented by application? e.g.,
- medical imaging; tomography
- industrial tomography
- computing and modeling output
- computing input; data retrieval
- specialized data analysis (statistics, biometrics)
- scientific data display
- animation and special effects
- other_____

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

4.7 Are there other possible ways for DV markets to be segmented on application area?

5. Timing conditions for viewing.

5.1 Will content delivery services be increasingly segmented by search technique and access control? e.g.,
- unsolicited delivery
- regular scheduled programs (broadcast or narrowcast)
- transmitted by reservation or prior request (push)
- on demand, remote, closed catalog
- on demand, remote, open Internet search
- transfer of physical copy (retail; rental)
- other_____

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

5.2 Will 2-way communications systems be segmented by simultaneity? e.g.,
- real-time (e.g. videophone)
- time-shifted (e.g. videomail)
- archived/historical

1 <5% likelihood
2 5% to 30% likelihood
3 30% to 70% likelihood
4 70% to 95% likelihood
5 >95% likelihood
6 No opinion

5.3	Will 2-way communications services be segmented by who made the appointment? e.g., joint negotiated (appointment) joint unilateral (public conference, open house) one-sided (cold call; home page) random (chat room; bulletin board)	1 2 3 4 5 6	<5% likelihood 5% to 30% likelihood 30% to 70% likelihood 70% to 95% likelihood >95% likelihood No opinion
5.4	Will data searching services be segmented by timing of the search? e.g., episodic foreground continuous background	1 2 3 4 5 6	<5% likelihood 5% to 30% likelihood 30% to 70% likelihood 70% to 95% likelihood >95% likelihood No opinion

5.5 Are there other possible ways for DV markets to be segmented on timing?

6. Other

6.1 Are there other possible ways for DV markets to be segmented in general?

G: Wrap-Up

Do you want a copy of the report ? 1 Yes 2 No

(If you said yes, please verify that your mailing address on Page 1

of the survey is complete and correct.)

Have you any additional comments on this survey or on the future of digital video ?

(use the back of this page if necessary)

THANK YOU FOR YOUR HELP.

PLEASE MAIL THE SURVEY IN THE ENCLOSED BUSINESS REPLY ENVELOPE TO, OR Mail the survey to:

David Burress
Institute for Public Policy and Business Research
607 Blake Hall
University of Kansas
Lawrence KS 66045

Questions? call (785)864-3703 and ask for David Burress or Pat Oslund
Or email d-burress@ukans.edu

Thank you for your time and assistance!

APPENDIX 4: SIC MANUAL PROTOCOL

(The following instructions were given to student scanners.)

Purpose

A major goal of the digital video (DV) project is to make a list of possible new uses of DV in the future. That implies using the imagination. In this exercise, you (as a group) will read through the entire SIC manual (at least, if it seems to be helpful) as an aid to imagination.

Main materials

Xeroxed pages of SIC manual
a dictionary
data capture forms
list of identified scales of possible future specialized uses

A *specialized use* is a sub-market related to a particular good or service, in which the items offered for sale are likely to be distinct from, and non-competitive with, goods and services provided in other sub-markets using similar components. Specialized uses always come in sets because something is "specialized" only by comparison or in contrast with something else. A *range of specialized uses* is a set of contrasted alternatives. They are organized into a single range because they generally depend on changes in only a single characteristic of the market.

Other available resources

list of component goods and services - the specific types of things being sold, such as monitors or cameras.
list of identified quality scales - the ways in which one product can be better than another.

Goal

Try to identify new specialized uses for DV. Some may fall into old ranges of specialized uses already identified, while others may lead to the identification of new ranges.

We are also interested in any new commodities and new quality scales you might think of, but that is not the top priority.

Procedure

1. Read the description of an SIC category. Look up any unknown words in the dictionary.

2. Try to think of new specialized uses for DV in this industry. Think about all three aspects of the industry: its relationship with upstream suppliers, its internal processes, and its relationship with downstream users.

3. If you think of one that doesn't seem to be on the list of specialized uses (or on the list of quality scales), write it down on the data capture form. Generally, the information we need is:

- A buzz word or phrase describing the idea (if you can think of one).
- A brief (1 or 2 sentence) description of your idea. (Or longer if absolutely necessary.)
- The SIC code you were reading when you thought of the idea.
- A description or list of other industries where the idea might work.
- Your name and the date.

DATA CAPTURE FORM: DV SIC CODE SEARCH

Name:----------

Date-------
SIC code------
English description of industry------
Description of the idea:

Other industries the idea might apply to (either SIC codes or English description):

Date-------
SIC code------
English description of industry------
Description of the idea:

Other industries the idea might apply to (either SIC codes or English description):

Date-------
SIC code------
English description of industry------
Description of the idea:

Other industries the idea might apply to (either SIC codes or English description):

APPENDIX 5: SUMMARY OF DOWNWARD LINKS IN THE HIERARCHICAL MODEL

In this model, we have attached all links at the level of human activities. Consequently, specialized uses and quality scales attached to a given activity are assumed to apply equally to all of its components, except as otherwise noted. This model leads to a more compact representation, but it also places some limits on generality. Those limits do not seem important for our purposes. For other applications of the hierarchical market model, a more detailed linking structure might be appropriate.

Links are shown by listing the components, ranges of specialized use, and quality scales that are most appropriate to each DV-related human activity.

DV-related human activities

Activity cluster 1: DV creation
Description: creating video materials, programs, and program streams in a permanent or quasi-permanent and accessible form
Possible specialized uses (market segments):
1.1 by video and audio resolution
6.1 by encoding or format (obsolete technologies may coexist)
6.2 by historic origin of applications (TV/computing)
6.3 by transmission technology
Subdivided by: stage of production (authoring, managing)

Activity 1.1: video authoring
Description: creating original DV materials
2.1. Image capture equipment and services
Subdivided by: stage of authoring (capture, record, edit)
* *Activity 1.1.1: video photography*
Description: digitizing real visual material
Possible specialized uses (market segments):
5.1.1a by photographic location
* *Activity 1.1.2: video recording*
Description: in-stream capturing of DV signals
Possible specialized uses (market segments):
2.5 by volatility of memory
5.1.1a by photographic location
5.1.1b by memory location
Activity 1.1.3: simple video processing
Description: authoring and production of video programs
Possible specialized uses (market segments):
5.2.6 by degree of professionalization

Activity 1.1.4: authoring of interactional and animated media
Description: authoring of games, special effects, interactional educational programs
Possible specialized uses (market segments):
5.2.1 by complex authoring application

Activity 1.2: video managing
Description: managing DV materials
Components:
2. Creation equipment and services
3. Storage and retrieval equipment and services
Subdivided by: stage of management (compile, encapsulate, preserve, protect)

Activity 1.2.1: video post-production (editing, management, handling, and distribution)
Description: assembling video programs into usable packages or broadcast streams and getting them delivered to manufacturer, retailer, transmitter, or depository
Possible specialized uses (market segments):
5.2.2 by destination of the content

Activity 1.2.2: video storing, cataloging, indexing, and archiving
Description: creating usable video databases, depositories (either real or virtual)

Activity 1.2.3: physical production
Description: creating portable physical memory objects containing individual video program materials
Possible specialized uses:
2.5 by volatility of memory
5.2.3 by size of production run

Activity 1.2.4: protection of intellectual property
Description: producing and implementing rules, enforcement mechanisms, and software for protecting DV ownership (not explored in detail)
Components: 4.3.2a Video security and property rights enforcement

Activity cluster 2: individualized DV utilization
Description: making use of video by end-users at a single location
Components:
5. Viewing equipment and services
* 7.1 keyboard/mouse/data input devices
Possible specialized uses (market segments):
4.5 by commonality of experiences
6.1 by encoding or format (obsolete technologies may coexist)
Subdivided by: what is pre-identified (the desired video object versus the desired information)

Activity 2.1: viewing particular objects
Description: viewing a pre-identified program or object
Possible specialized uses (market segments):
1.4 by degree of image motion
Subdivided by: type of object being viewed (program, computational image, remote view)

Activity 2.1.1: individual video consumption (of an extended program)

Description: viewing a program, playing a game, or taking a lesson (as opposed to obtaining it; see 3.1)

Components:

* 7.1 game/simulation controllers

Possible specialized uses (market segments):

1.1 by video and audio resolution
1.2 by interactivity
2.5 by volatility of memory
3.2a by portability of local viewing equipment
3.2c by portability of local memory
3.3 by viewing location
5.2.4 by individual viewing context or purpose
6.2 by historic origin of applications (TV/computing)
6.3 by transmission technology

Activity 2.1.2: computing, simulating, and scientific imaging

Description: performing high resolution video imaging for input and output of computational, medical, technological, or scientific activities

Possible specialized uses (market segments):

5.1.3 by complex imaging application

Activity 2.1.3: remote viewing, sensing, and controlling

Description: viewing and manipulating inanimate objects at a distance by an individual viewer
Note that 3.3.4 refers to control of people, not objects.

Components:

2.1 image capture equipment and services

* 7.1x remote actuators

Possible specialized uses (market segments):

2.2 by simultaneity of (conversation or) image capture
5.1.2a by surveillance application area-objects

Activity 2.2: viewing generalized information

Description: viewing selected collections of program or objects so as to obtain pre-identified information

Note: differs from 2.1.3 remote sensing in that particular remote viewing monitors are not fundamentally required. Rather, some higher level integration and summarization of data occurs.

Components:

3. Storage and retrieval equipment and services

Possible specialized uses (market segments):

3.5 by pricing system for data or content
3.7 by means of search (i.e., different users search different subject fields)

Subdivided by: extent of information stereotyping (random versus fixed requests)

Activity 2.2.1: information search/data surveillance

Description: searching and retrieving randomly varying types of video information (e.g., data on demand)

Note: distinguished from 3.1 program distribution and retrieval because there is no fixed vendor or source for the ultimate information resource (though there may be a fixed vendor for the search/surveillance services themselves.)

Distinguished from 2.1 viewing a program because multiple items are typically considered at the same time.

Possible specialized uses (market segments):

2.4 by timing of a data search

Activity 2.2.2: real-time information monitoring and process control

Description: immediate or continuous remote updating of particular fixed information items

Components:

* 7.1 process controllers

Possible specialized uses (market segments):

5.1.4 by information monitoring area

Activity cluster 3: DV distribution and communication

Description: transmitting video information from source to user

Components:

3. Storage and retrieval equipment and services
4. Distribution equipment and services
5. Viewing equipment and services

Possible specialized uses (market segments):

1.1 by video and audio resolution
1.2 by transmission reliability (Channel access; dropouts; delays)
1.3 by general quality
3.6a by degree of transactions privacy and security
5.3.5 by battle-worthiness
6.1 by encoding or format (obsolete technologies may coexist)
6.3 by transmission technology

Subdivided by: level of interactivity being supported (passive viewing, buying, actively relating)

Activity 3.1: program distribution and retrieval

Description: obtaining a video program from a vendor, library, or other outside source by an individual user with the intent of viewing or using at a single location

Possible specialized uses (market segments):

1.2 by transmission reliability (channel access; dropouts; delays)
2.5 by volatility of memory
3.3 by viewing location
4.1 by degree of interactivity of a program
6.2 by historic origin of applications (TV/computing)
6.5 by legitimacy or legality of copies or signals

Subdivided by: original initiating party (viewer, provider, mutual)

Activity 3.1.1: user-driven program distribution and retrieval

Description: accessing programs as instigated by the user (e.g., video on demand; ads may or may not be attached)

Possible specialized uses (market segments):

2.1 by search technique and access control

4.2 by number of channels (available; simultaneous)

5.2.5 by type of program content

Activity 3.1.2: provider-driven program distribution

Description: direct advertising and other distribution of video materials, instigated by the provider and not connected with user-instigated activities such as video program retrieval (3.1.1) or information search (2.4)

Possible specialized uses (market segments):

6.4 by direct advertising medium

Activity 3.1.3: informal exchange of programs

Description: bilateral sharing of program items, either non-commercial or casual commercial

Possible specialized uses (market segments):

5.2.7 by purpose of informal exchange

Activity 3.2: DV-mediated commerce

Description: DV-assisted financial and commercial transacting, using video data bases as well as personal interaction

Components:

7.2x financial transactions systems

7.2x home shopping systems

Possible specialized uses (market segments):

3.6b by degree of data privacy

Subdivided by: location (remote, local)

Activity 3.2.1: remote commercial transactions

Description: televideo-mediated exchanging of goods and services

Possible specialized uses (market segments):

5.3.1 by commercial forum

Activity 3.2.2: local commercial transactions

Description: local exchanging of goods and services using video finance (e.g. video smart cards or terminals)

Components:

5.2x video smart cards

Possible specialized uses (market segments):

1.5 by screen size and portability

3.1 by location of financial records

Activity 3.3: non-commercial association

Description: DV-assisted extra-market relating by persons

Possible specialized uses (market segments):

1.5 by screen size and portability

2.2 by simultaneity of conversation or image capture

3.2a by portability of local viewing equipment

3.2b by portability of local photographic equipment
3.3 by viewing location
3.6 by degree of privacy
4.3 by numbers present at the same time

Subdivided by: stages of the relationship (meeting, talking, acting, controlling, terminating)

Activity 3.3.1: virtual personal matching

Description: televideo-mediated matching of individuals and/or situations

Components:

* 7.3x personal matching and alliancing software and services

Possible specialized uses (market segments):

5.3.4 by type of person/situations being matched

Activity 3.3.2: 2-way personal communications (videophone, videomail, video posting, and teleconferencing)

Description: real time and time shifted remote 2-way talking heads

Possible specialized uses (market segments):

2.3 by who made the appointment
4.2 by number of channels (available; simultaneous)

Activity 3.3.3: virtual action

Description: sharing of data as well as 2-way talking heads using video

Subdivided by: realm of life (work, play, community participation)

Activity 3.3.3a: virtual collaboration

Description: sharing of intermediate and final work products between peers using video

Components:

7.3x collaboration-support software and services

Possible specialized uses (market segments):

4.4 by scale of institution
5.3.2 by area of virtual collaboration

Activity 3.3.3b: remote interactive games and recreational interactive data sharing

Description: multi-player gaming and using interactive intelligent toys via video

Components:

* 7.1x keyboard/mouse/data input devices
* 7.1x game/simulation controllers

Possible specialized uses (market segments):

3.4 by auxiliary recreational equipment

Activity 3.3.3c: virtual community participation

Description: contributing to public needs using televideo (e.g. opinion polls)

Components:

7.3x polling software and services

* 7.3x electronic democracy software and services

Possible specialized uses (market segments):

5.3.3 by type of public need

Activity 3.3.4: virtual command and control

Description: using video to control the behavior of others

Possible specialized uses (market segments):

5.1.2a by surveillance application area-objects
5.1.2b by surveillance application area-people
Possible components:
* 2.1.2x remote imaging equipment
2.2.1x mapping and tracking hardware/software
Subdivided by: military; civilian surveillance; civilian management
* *Activity 3.3.4a: military command and control*
Description: using video to control the behavior of personnel and enemies (e.g. surveillance; automated response systems; managing routine work; military targeting)
Possible specialized uses (market segments): not explored in detail
Activity 3.3.4b: civilian surveillance
Description: using video to observe humans in non-military situations
Components:
7.3x virtual private detective services
Possible specialized uses (market segments):
2.2 by simultaneity of (conversation or) image capture
5.1.2b by surveillance application area-people
Activity 3.3.4c: civilian management
Description: using video to control the behavior of personnel and other civilians
Possible specialized uses (market segments):
5.3.6 by type of management system
Activity 3.3.5: virtual screening, evasion, and countermeasures
Description: making or avoiding unwanted contact and communication, assisted by or in relation to DV
Possible specialized uses (market segments):
5.2.6 by degree of professionalization
Activity 3.3.5a: virtual screening and evasion
Description: avoiding contact and communication with unwanted parties
Components:
4.3.1a screening and evasion equipment and services
7.3x personal recognition equipment
Activity 3.3.5b: screening countermeasures
Description: forcing unwanted contact and communication
Components:
4.3.1b screening and evasion countermeasures

REFERENCES

Advanced Technology Program. 1994. *Advanced Technology Program Proposal Preparation Kit,* Gaithersburg MD: National Institute of Standards and Technology, November

Advanced Technology Program. 1997a. "Task Statement of Work -- Pathways to Economic Benefit for the ATP Digital Video Program," Gaithersburg MD: National Institute of Standards and Technology, dated August 13

Advanced Technology Program. 1997b. "Digital Video in Information Networks '1997 White Paper'", Gaithersburg MD: National Institute of Standards and Technology, draft of August 11(revised)

Advanced Television Systems Committee. 1998. http://www.atsc.org/http://www.atsc.org/ (last modified 1/28/98; accessed 1/28/98)

Auerbach, A. J., and Martin Feldstein, eds. 1987. *Handbook of Public Economics, Volume II,* New York: North Holland

Balakrishnan, Mahesh, Basile Carlo, Also Cugnini, and Richard Shen. 1996. "Digital Video and the National Information Infrastructure," *Phillips Journal of Research* 50, pp. 105-129

Brinkley, Joel. 1997. *Defining Vision: The Battle for the Future of Television*. New York, San Diego, and London: Harcourt Brace & Company

Business Week. 1997. "Digital Divide," April 21, pp. 50-51

Community of Science. 1998. "Search the U.S. Patent Database," http://muscat.gdb.org/repos/pat/pat.html (accessed 1/28/98)

Current Online. 1997a. "Public TV and the Transition to Digital Broadcasting." http://www.current.org/atv1.html (last modified 12/2/97; accessed 1/28/98)

Current Online. 1997b. "Engineers lobby manufacturers to build DTV gear they'll need," http://www.current.org/tech/tech741d.html/

Dielectric Communications. 1997. http://www.dielectric.com (last modified 12/2/97; accessed 1/28/98)

Drèze, J., and N. Stern. 1987. "The Theory of Cost-Benefit Analysis", Chapter 14 in A. J. Auerbach and M. Feldstein, eds. (1987)

DTV Team. 1998. http://www.dtv.org/agenda.html (accessed 1/30/98)

Economist. 1997. "Is it Tellynet or Netelly?," December 13, p. 10

Electronic Business Today. 1998. http://www.ebtmag.com/ (accessed 1/28/98)

European Broadcasting Union & Society of Motion Picture and Television Engineers, Task Force for Harmonized Standards for the Exchange of Programme Material as Bit Streams. 1997a. "First Report: User Requirements -- April 1977," *SMPTE Journal*, June 1997, pp. 345-405

European Broadcasting Union & Society of Motion Picture and Television Engineers, Task Force for Harmonized Standards for the Exchange of Programme Material as Bit Streams. 1997b. *Request for Technology: 'System Management Services'*, v1.00, November 6

Forrest, J. R. 1996. "Convergence in the Industry," International Broadcasting Convention, *IEEE Conference Publication, no. 428*, pp. 1-6

Hayes, David. 1998. "Image-enhancing invention wins Academy Award", *The Kansas City Star*, Saturday, January 31, pp. B1, B10

HDTV Newsletter. 1998. http://web-star.com/hdtv/hdtvnews1.html (accessed 1/28/98)

Jacobson, Gordon. 1997. "Gilder Articles Index", http://heyday.seas.upenn.edu/~gaj1/ggindex.html (last modified September 23, 1997; accessed January 30, 1998)

Kerber, Ross. 1998. "When Is a Satellite Photo An Unreasonable Search?", *The Wall Street Journal* CI(18), Tuesday, January 27, pp. B1, B4

Lancaster, K. J. 1971. *Consumer Demand: a New Approach*, New York: Columbia University Press

Laven, P. A. 1996. "Convergence in Action?" International Broadcasting Convention, *IEEE Conference Publication, no. 428*, pp. 7-10

Li, L. C. 1996. "The Future of Media Servers in Broadcasting." International Broadcasting Convention, *IEEE Conference Publication, no. 428*, pp. 17-22

Media Lab. 1998. http://www.media.mit.edu/MediaLab/groups/ic (accessed 1/28/98)

Mediaweek. 1997. "The Resolution Will Not be Televised," April 14, pp.12-16

Mentley, David E.; and Joseph A. Castellano. 1996. "Forecast of the HDTV Market", http://web-star.com/hdtv/marketforecast.html (accessed 8/20/97)

Multimedia Research Center. 1998. http://bmrc.berkeley.edu/info/aboutbmrc1.html (accessed 1/28/98.)

Nielson, Jakob. 1988. *Multimedia and Hypertext -- the Internet and Beyond*, Boston: Academic Press

Owen, Bruce M. And Steven S. Wildman. 1992. *Video Economics*, Cambridge, MA and London: Harvard University Press

PC Magazine. 1997a. "The Complete Video Desktop," 16(17), Oct. 17, pp. 159-212

PC Magazine. 1997b. "Desktop Video Conferencing," 16(17), Oct. 17, pp. 219-29

Poynton, Charles. 1996. *A Technical Introduction to Digital Video*, New York NY: John Wiley & Sons

Richelson, Jeffrey T. 1998. "Scientists in Black", *Scientific American* 278(2), February, pp. 48-55

Saaty, Thomas L. 1980. *The Analytic Hierarchy Process (Planning, Priority Setting, Resource Allocation)*. New York: McGraw Hill

Scherer, F. M. 1998. "The Size Distribution of Profits from Innovation", Cambridge MA: Kennedy School of Government (mimeo)

Software Devices and Systems Group. 1998. http://www.sds.lcs.mit.edu/InfoAppl/start.html (accessed 1/28/98)

Sudalnik, James E. And Victoria A. Kuhl. 1994. *High Definition Television: An Annotated Multidisciplinary Bibliography, 1981-1992*. Westport, CT and London: Greenwood Press

Turner, S. R. 1996. "Interactivity and the Convergence of TV and PC--Real or Imagined?" International Broadcasting Convention, *IEEE Conference Publication, no. 428*, pp. 200-203

U.S. Patent and Trademark Office. 1998. "U.S. PTO Patent and Trademark Databases." http://patents.uspto.gov/

Wall Street Journal. 1998. "HDTV Sets: Too Pricey, Too Late?" January 7, p. B1

Weiss, S. Merrill. 1998. *Issues in Advanced Television Technology*, Boston: Focal Press

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