CONSUMER MULTIMEDIA SEMICONDUCTORS AND APPLICATIONS WORLDWIDE 1996
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Dataquest ALERT

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Digital Satellite Price War Boosts Chip Opportunity

The full-scale price war that broke out this week among makers of digital direct broadcast satellite (DBS) set-top boxes (STBs) reflects a new competitive dynamic in the STB market that will grow sales and result in increased demand for cost-effective application-specific standard products (ASSPs), demodulators, decoders, and other chips.

Thomson Consumer Electronics cut the cost of its Digital Satellite System (DSS) subscriber system to $199, down from $499. Thomson achieved the price cut through a combination of a $100 discount and a $200 rebate. To qualify for the deal, consumers must subscribe to one year's worth of DBS television programming service from DirecTV at a minimum price of $360. Thomson's move, which had been expected for several weeks, came in response to a price cut by EchoStar Communications Corporation, which in early August reduced the cost of its STB equipment to $199, down from $600.

Thomson is the leading maker of digital STBs, with 47.3 percent of worldwide revenue in 1995. The company sells its DSS STBs under brand names that include RCA and General Electric.

Since it began broadcasts in 1994, more than 1.7 million customers have signed up for DirecTV, a DBS television service that works with the Thomson DSS boxes. In contrast, EchoStar—which sells both services and STBs—has signed about 115,000 subscribers since it began broadcasts in April.

Thus, Thomson's price cuts are expected to have much more far-reaching effects on the market than EchoStar's. Thomson executives predict the move will significantly expand the market for digital satellite at the expense of analog cable.

Dataquest Perspective

The digital DBS STB price declines are dramatic, but they are even more remarkable when viewed in comparison with the analog STB market. The average price of an analog cable STB has been stuck at $105 for the last 10 years. This is because of the tight control analog cable service providers have had over the distribution of their equipment. Analog cable service providers rent their STBs to consumers rather than sell them. When customers no longer needs an analog cable box, they return it to the service provider, who then rents it to someone else, increasing the life span of that equipment and depressing sales of new STBs. Analog STBs tend to be proprietary to the service provider, eliminating the possibility of consumers choosing which box they want to use.

What a difference standards make! In the DBS market, STB OEMs are building systems that comply with the DSS standard, which is licensed out by DirecTV, or the Digital Video Broadcasting (DVB) standard, an open specification published by a Europe-based group of companies. The emergence of digital STB standards has allowed STB vendors for the first time to compete on price and technology. Some digital STBs—including the Thomson-manufactured boxes—now are sold in retail outlets, allowing customers to compare products from numerous manufacturers and make choices based on price, features, and brand name.

Besides Thomson, manufacturers that have introduced DSS-compatible receivers or that plan to enter the market include Sony, Toshiba America Consumer Products Inc., Uniden America Corp., Hughes Network Systems, Sanyo Electric Co. Ltd., Samsung Electronics Co. Ltd., Daewoo Electronics Co. Ltd., and Matsushita Consumer Electronics Co. Companies offering DVB-compatible systems include EchoStar (with the manufacturing done by Groupe Sagem and SCI Systems Inc.), Tee-Com, and Pace Micro Technology.

The advent of standards combined with healthy competition has created a new dynamic in the STB market that will help boost production of digital satellite STB sales to more than 20 million units by the year 2001, up from 2.8 million in 1995.

The round of price cuts indicates how far digital DBS providers are willing to go to attract new subscribers. At a selling price of $199, Thomson would lose money on each box it sells. A Dataquest teardown of a first-generation Thomson-manufactured DSS STB revealed that the manufacturing cost was about $283.82 and the electronics cost alone was $242.93! Even though Thomson's second-generation box, introduced earlier this year, achieved some cost reduction by using more highly integrated silicon, the company would still lose money at a sales price of $199.

However, Thomson is able to offer consumers the $199 deal using a subsidy by DirecTV, which provides programming for Thomson's STBs. To get the $199 deal, customers must subscribe to DirecTV's Total Choice television service for one year at a cost of at least $360.

This indicates that the real money in the DBS business is made in selling the services and not the equipment. Thus, OEMs will be looking to reduce the cost of building their STBs in every way possible to minimize losses. This rush to cut costs will lead equipment makers to use the cheapest, most highly integrated silicon available. ASSP solutions like LSI Logic Corporation's Integra chipset, which provides most required STB functions at a price of just $75 in high volume, will become more attractive. As OEMs turn to ASSPs, they will eschew their present approach to building set top boxes, which uses a combination of ASICs and general-purpose standard parts.

The Thomson price cut also is contributing to the trend of digital STBs becoming more of a commodity product. To cut costs, most OEMs will sacrifice differentiated features. However, in the longer term, digital STBs may incorporate more value-added features, as other delivery systems, such as digital cable and hybrid fiber coax, promote a higher degree of interactivity than is possible with DBS.
By Jonathan Cassell

Dataquest ALERT

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Philips and Sony Start Licensing DVD Prematurely

Both Split from DVD Consortium before Group Finalizes Royalty Structure

Frustrated with the lack of serious progress on finalizing the royalty structure for DVD, Philips and Sony announced on August 2nd that that the two companies will begin licensing its patented technologies for DVD players and discs. In spite of impending self-imposed deadlines to ship the first DVD players by the end of 1996, discussions within the DVD consortium have failed to be conclusive, and Philips and Sony have decided to move forward in order to avoid additional delays. Sony has authorized Philips to execute the licensing program on behalf of the two companies.

In late 1995, the rival DVD format camps led by Sony/Philips (MMCD) and Toshiba/Matsushita (SD) decided to end their battle and form one DVD standard. Although they continue to stress their ongoing support for the DVD format and consortium, this is a serious break from the unified approach which the DVD industry has pursued for the last eight months.

The DVD Consortium was formed after the unification of the standard with one of the objectives of the Consortium being the pooling of patents to provide the industry with the benefits of a one-stop-shop approach to licensing. However, one of the implicit objectives of the Consortium was to establish a reasonable total royalty for DVD. Why? Because the market success of DVD could be seriously inhibited if the total licensing fees force the cost of the players above alternative technologies such as CD-ROM and video tape. By bringing all patent holders under one committee to hammer out a unified and hopefully reasonable licensing structure ,all Consortium members hoped to create a win-win situation for all.

However, essential to a unified structure is the fact that every party has to take less for the greater good. In reality, not everyone wanted to take less and the Consortium has become stalemated. Because the Consortium hasn't been able to agree on a unified licensing structure, there is serious jeopardy that none of the DVD vendors will make their projected end of 1996 delivery. So, rather than wait for the committee to settle on a licensing structure, Philips and Sony have broken ranks and are licensing their patents on their own.

DVD shipments will still not get off the ground any faster unless other patent holders also move forward on their own or the Consortium finally comes to agreement. Philips and Sony do not own all of the patents needed to manufacture and market a DVD player and discs according to the existing standard. Any vendor looking to market DVD players will need to obtain licenses from Sony and Philips and from the other individual patent holders as well. This would result in a departure from the one-stop-shopping objective of the DVD Consortium.

Dataquest Perspective

The positive outcome of the Philips and Sony action is that it may end the DVD Consortium stalemate and get all of the patent holders to finally agree on a unified royalty package. The scenario with the least negative implication for DVD would be that it becomes even more expensive because of the free-for-all licensing structure and therefore take longer to be accepted by the very price elastic consumer market. In the worst case, we may revert to the two-standard scenario that existed prior to December 1995. This scenario could develop as Philips and Sony look to other nonstandard patent holders to complete the manufacturing patent package. While the latter seems less likely to develop because of Philips and Sony's stated objective to continue to support the work of the DVD Consortium, it still remains a possibility as the pressure mounts to deliver DVD product sooner rather than later.

There is a very strong probability that the Sony/Philips action will prevent the creation of a unified standard for writable and rewritable DVD products. Work on developing standards for the next generation of DVD products, which will allow write and erase capability, is in the early stages. Two competing camps have already formed in this arena based on the use of magneto-optical (MO) and phase change (PD) optical disc technology. Once again, Toshiba/Matsushita is leading one camp (PD) while Sony/Philips is leading the other camp (MO). Based on the apparent frustrations that have developed over DVD and the inability to reach negotiated agreements on critical patent and royalty issues, both camps may decide to try the old VHS/Beta route and let the market decide the future winners in this competition.

It is Dataquest's view that an underlying objective of Philips and Sony is an attempt to control the destiny of the royalty revenue stream of DVD in the same way the two companies controlled the royalty revenue stream of CD technology. As publicly traded corporate giants in the multimedia market, based in a large part on the success of CD Audio and CD-ROM technology, the two can ill afford to take less revenue for DVD than for CD technology in the market. This is especially important in the long term as DVD replaces CD technology. Both companies have experienced very costly and highly embarrassing efforts to develop other standards such as MiniDisc, CD-i, and Digital Compact Cassette (DCC). It thus becomes mandatory for these two companies to ensure that they are revenue winners in the next generation of audio and video media technology. However, the inability of Philips and Sony to reach negotiated agreements with the other members of the DVD Consortium may result in creating impediments to long-term growth and leave a smaller pie to split between the different competitors over the next five to ten years.

By Bruce Ryon, Mary Bourdon, Dale Ford

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February 1996

Dear Dataquest Client,

By now, you should have received the 1996 Dataquest research program binders for filing the newsletters and reports that will be sent to you throughout the year.

To let you know what documents you can expect to receive as part of your subscription, enclosed please find the 1996 datasheet for the research program to which you subscribe. The back side of the datasheet lists the Dataquest Perspectives, Market Trends reports, Market Statistics books, reports, and electronic newsletters that are included in this year's research portfolio.

If you have any questions about the research schedule, please contact your Dataquest research analyst or client services representative.

Sincerely,

Jeffrey A. Byrne
Vice President
Worldwide Marketing

December 1995

Dear Dataquest Client:

In 1996, Dataquest will celebrate its 25th year as the leading global supplier of market intelligence to the IT vendor and financial communities. I would like to thank you, on behalf of all Dataquest associates worldwide, for your support. We are proud to be your information partner by providing the IT market insight and analysis you need to make crucial business and planning decisions.

The enclosed binder is for filing and storing the printed market research newsletters and reports that you will receive on an ongoing basis throughout 1996 as part of your subscription to Dataquest. You may notice that we've streamlined the binder tab and document filing structure this year. We hope that this 5-tab scheme increases your efficiency in filing and locating documents.

You probably know that in addition to paper-based delivery, Dataquest is also committed to delivering our market statistics and analysis electronically. We expect that our electronic products, known collectively as *Dataquest on the Desktop*, will play an increasing role in our ability to deliver information to you in a timely, efficient way. For your information, our electronic tools include:

- *Dataquest on Demand*—Our monthly CD-ROM containing a rolling 13 months of Dataquest's printed documents
- *MarketView*—A data analysis tool containing many of Dataquest's market statistics databases
- *Electronic NewsTakes and Dataquest Alerts*—Weekly/event-driven summary and analysis of top IT news, published via e-mail or fax by most Dataquest research groups
- *Dataquest Interactive*—Our Internet-based electronic delivery system that you are invited to preview at this URL: http://www.dataquest.com

One last note: an optional binder called *Electronic News* is available on request for clients who wish to file their electronic newsletters and Dataquest Alerts. To order your copy, please fill out the FaxBack form found in the binder pocket and fax it back to us.

We look forward to working with you in our continuing process to improve the content, quality, and timeliness of our products and services. I encourage you to share with us your comments about our publications and electronic delivery tools.

Sincerely,

Jeffrey A. Byrne
Vice President, Worldwide Marketing

CONSUMER MULTIMEDIA SEMICONDUCTORS AND APPLICATIONS WORLDWIDE

Dataquest's newest applications market program focuses on semiconductor opportunities in the multimedia and consumer electronics markets, with emphasis on interactive, video, audio, and home convenience technologies.

The New Generation of Consumer Electronics

Semiconductors are not only driving the development of a new generation of consumer electronics, they are also changing the way consumers will purchase and access information and entertainment hardware and services. Products and strategies developed by consumer electronics manufacturers and semiconductor suppliers are being shaped by competing standards and technologies. In this very dynamic environment, manufacturers will need to be keenly aware of shifting market trends and rapidly advancing technologies.

Dataquest has developed a program that focuses specifically on semiconductor directions in consumer electronics and home multimedia products.

Who Can Benefit from This Program?

Semiconductor companies will value the in-depth coverage of emerging markets for their products in consumer electronics, such as next-generation video games, interactive set-top boxes, HDTV, and digital cameras. This service provides coverage of these markets from a semiconductor perspective and presents analysis of new architectures and technologies, competitive product information, and forecasts of growth for semiconductors employed in consumer and home multimedia products.

Consumer electronic OEMs, passive component companies, and design tool and test equipment companies will all need this information to lay market plans, characterize emerging markets, prioritize investments, and reduce decision risk.

Market Coverage

This program provides a comprehensive view of the products, applications, and semiconductor suppliers for the consumer electronics and home multimedia markets. Statistics include:

- Electronic equipment production estimates
- Semiconductor consumption by application market
- Market share and competitive analysis of multimedia/consumer IC manufacturers
- Consumer electronics-specific IC forecasts

Application and Device Coverage

Market and production information for systems and semiconductors includes:

- Set-top boxes (Cable/DBS)
- Video game controllers, cable adapters, and cartridges
- Digital Video/Versatile Disc (DVD)
- Digital cameras
- Televisions (HDTV)
- VCRs
- Camcorders
- Personal portable stereos (boomboxes, MD, DCC)
- CD players
- Stereo components
- Multimedia PC (top-level data only)
- Appliances
- Video and graphics ASICs
- Compression chips (e.g., MPEG)
- Media engines
- 2-D CCDs

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WHAT YOU WILL RECEIVE AS A CLIENT

CONSUMER MULTIMEDIA SEMICONDUCTORS AND APPLICATIONS WORLDWIDE

Perspectives

Dataquest Perspectives present analysis and commentary on key technologies, companies, market opportunities, trends, and issues in the semiconductor market. A minimum of six Perspectives will be published on an event-driven basis throughout the year. Scheduled Perspectives for 1996 include:

Market and Product Analysis: Comprehensive newsletters presenting analysis and commentary on new products or applications that will impact the market for semiconductors in consumer/multimedia electronics. Potential topics include: reports on major industry shows, interactive set-top boxes, HDTV, video game controllers, compression technology, audio technology, and video and graphics chips.

Two Issues per Year

Market Analysis: Concise summary of significant events or announcements in the semiconductor industry or consumer electronics markets.

Two Issues per Year

Vendor Analysis: These reports will provide a series of brief analyses covering topics such as product offerings, financial results, organizational structures, and strategic direction of key players in the industry.

Four Issues per Year

Market Trends

Consumer Applications Markets: Market size and forecasts for principal consumer interactive and multimedia, video, audio, and appliance markets. This report provides basic information about the semiconductor opportunity offered by particular applications. Information provided includes system market size (in production terms) in revenue, units, and average selling price; system market and product feature trends; hardware architecture trends; semiconductor content and market forecasts; and a listing of key OEMs.

Available in the Third Quarter 1996

Market Statistics

Competitive Trends: Consumer Electronics Semiconductor Supplier Analysis - Examines the competitive landscape of the consumer electronics and home multimedia semiconductor markets. Market share for companies supplying consumer electronics-specific chips and supplier matrices are provided for major product areas.

Available in the Third Quarter 1996

Consumer Semiconductor Consumption Forecast: Five-year forecasts for consumer electronics-specific semiconductor consumption in approximately 15 categories and major subcategories of consumer electronics equipment. Forecasts for multimedia and interactive products are closely tied to electronic equipment product forecasts produced by Dataquest's Multimedia research group.

Available in the Fourth Quarter 1996

Reports

Digital Video/Versatile Disc Technology and Semiconductors: In-depth analysis of the competing standards, critical technologies, and innovative semiconductor products shaping the emerging DVD market. The report will deliver a forward-looking assessment of the DVD market and predict the semiconductor opportunity it will drive. Information and analysis of the market will support tactical and strategic planning needs.

Available in the First Quarter 1996

Electronic News

Dataquest Alerts: News and analysis, delivered by fax, for fast-breaking events. Dataquest Alert bulletins are published throughout the year on an event-driven basis.

Event-driven

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Program Code: MSAM-WW MKTG 1/96 (JCG)

1996 RESEARCH PROGRAMS

From semiconductors to systems, software to services, telecommunications to document management, Dataquest's scope of expertise provides clients with a clear view of the relationships among information technology segments – relationships that can have a profound impact on making strategic business decisions.

Computer Systems and Peripherals

Computer Systems
- Client/Server Computing *Worldwide*
- Computer and Client/Server Systems *Europe*
- Servers *Europe*
- UNIX and Open Systems *Europe*

Workstations
- Advanced Desktop and Workstation Computing *Worldwide*
- Workstations *Europe*

Computer Storage
- Removable Storage *Worldwide*
- Optical Disk Drives *Worldwide*
- Optical Disk Drives *Europe*
- Rigid Disk Drives *Worldwide*
  - RAID Storage Systems *Worldwide*
- Rigid Disk Drives *Europe*
- Tape Drives *Worldwide*
- Tape Drives *Europe*

Graphics
- Graphics and Displays *Worldwide*

Personal Computing
- Personal Computers *Worldwide*
- Personal Computers Strategic Service *Europe*
- Personal Computers *Asia/Pacific*
- Mobile Computing *Worldwide*
- PC Distribution Channels *Worldwide*
- PC Distribution Channels *Europe*
- Desktop PC Technology Directions *Worldwide*
- Mobile PC Technology Directions *Worldwide*
- Personal Computers *Central and Eastern Europe*

Quarterly Statistics
- Advanced Desktop and Workstation Quarterly Statistics *Worldwide*
- Workstation Quarterly Statistics *Europe*
- Server Quarterly Statistics *North America*
- Server Quarterly Statistics *Europe*
- PC Quarterly Statistics *United States*
- PC Quarterly Statistics *Europe*
- PC Quarterly Statistics *Japan*
- PC Quarterly Statistics *Asia/Pacific*
- PC Quarterly Statistics *Worldwide by Region*

Online, Multimedia, and Software

Emerging Technologies
- Multimedia *Worldwide*
- Multimedia *Europe* (Module)
- Online Strategies *Worldwide*
- Online Strategies *Europe* (Module)

Productivity/Development Tools
- Client/Server Software *Worldwide*
- Workgroup Computing *Worldwide*
- Workgroup Computing *Europe* (Module)
- Personal Computing Software *Worldwide*
- Personal Computing Software *Europe* (Module)

Technical Applications
- AEC and GIS Applications *Worldwide*
- Electronic Design Automation (EDA) *Worldwide*
- Mechanical CAD/CAM/CAE *Worldwide*
- CAD/CAM/CAE/GIS *Europe* (Module)
- CAD/CAM/CAE *Asia/Pacific* (Module)

Services

Customer Services
- Customer ServiceTrends *North America*
- Customer Services and Management Trends *Europe*

Professional Services
- Professional Service Trends *North America*
  - Systems Integration and Applications Development
  - Consulting and Education
  - Systems Management
- Vertical Market Opportunities *North America*
- Professional Services *Europe*
  - Systems Integration
  - Consulting and Education
  - Systems Management
- Professional Services Vertical Market Opportunities *Europe*
- Professional Service Trends *Asia/Pacific*

Sector Programs
- System Services *North America*
  - Desktop Services
  - Notebook Services
  - Server Services
- User Computing Services *Europe*
- Network Integration and Support Services *North America*
- Network Integration and Support Services *Europe*
- Software Services *North America*
- Strategic Service Partnering *North America*

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1996 RESEARCH PROGRAMS

Document Management

Copiers
- Copiers *North America*
- Copiers *Europe*

Facsimile
- Facsimile *North America*

Printers
- Printers *North America*
- Printers *Europe*
- Colour Products *Europe* (Module)
- Printer Quarterly Statistics *Europe*
- Printer Distribution Channels *Europe*
- Printers *Asia/Pacific*
- Printer Quarterly Statistics *Asia/Pacific*

Semiconductors

Regional Markets
- Semiconductors *Worldwide*
- Semiconductors *Europe*
- Semiconductors *Japan*
- Semiconductors *Asia/Pacific*
  - China/Hong Kong
  - Taiwan
  - Korea
  - Singapore

Devices
- ASICs *Worldwide*
- ASIC Applications *Europe*
- Memories *Worldwide*
- Memory Applications *Europe*
- Memory IC Quarterly Statistics *Worldwide*
- Embedded Microcomponents *Worldwide*
- Microcomponent Applications *Europe*
- DRAM Quarterly Supply/Demand Report

User Issues
- Semiconductor Supply and Pricing Worldwide

Application Markets
- Semiconductor Application Markets *Worldwide*
- Semiconductor Application Markets *Europe*
- Semiconductor Application Markets *Asia/Pacific*
- Communications Semiconductors & Applications *WW*
- Consumer Multimedia Semiconductors & Applications *Worldwide*
- Semiconductor Directions in PCs & PC Multimedia *WW*
- PC Teardown Analysis
- PC Watch *Europe*
- Electronic Equipment Production Monitor *Europe*
- Electronic Application Markets *Europe* —Automotive
- Electronic Application Markets *Europe* —Communications
- Electronic Application Markets *Europe* —Consumer
- Electronic Application Markets *Europe* —EDP

Manufacturing
- Semiconductor Equipment, Manufacturing, & Materials *Worldwide*
- LCD Industry *Worldwide*
- Semiconductor Contract Manufacturing *Worldwide*

Telecommunications

Networking
- Networking *North America*
  - Local Area Networks *North America*
  - Wide Area Networks *North America*
  - Modems *North America*
- Networking *Europe*
  - Asynchronous Transfer Mode *Europe*
  - ISDN *Europe*
  - Modems *Europe*
  - Local Area Networks *Europe*
  - WANs *Europe*
- Quarterly Market Watch *North America*
  - Intelligent Hubs & Switches
  - Network Interface Cards
- Network Distribution Channels *Europe*

Voice
- Voice Communications *North America*
  - Voice Processing *North America*
  - Computer-Integrated Telephony & Automatic Call Distributors *North America*
  - Premise Switching Systems *North America*
- Voice Communications *Europe*
  - Voice Processing *Europe*
  - Call Centres *Europe*
  - Telephones *Europe*
  - PBX/KTS Systems *Europe*

Public
- Public Network Equipment & Services *North America*
  - Public Network Equipment *North America*
  - Public Network Services *North America*
- Public Network Equipment & Services *Europe*
  - Public Network Equipment *Europe*
  - Public Network Services *Europe*

Personal
- Cellular Telephony *Worldwide*
- Personal Communications *North America*
- Personal Communications *Europe*
  - Infrastructure and Services *Europe*
  - Terminals *Europe*
- Personal Communications Distribution Europe

Cross-Technology Programs

Technology Insights for:
- Financial Services
- Government Agencies
- Publishing, Media, and Consulting Firms
- IT Business Development for Financial Organizations
- IS and Purchasing Organizations
- IT Supporting Industries

Emerging IT Markets

Central and Eastern Europe
- Personal Computers
- Telecommunications

Latin America
- Personal Computers
- Printers

Asia/Pacific
- IT Market Insight *Asia/Pacific*
- Personal Computers *Asia/Pacific* & Quarterly Statistics
- Printers *Asia/Pacific* & Quarterly Statistics
- Professional Service Trends *Asia/Pacific*
  - Country-level reports on Asia/Pacific IT markets

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Program Code: NONE-WW MKTG 1/96 (PSB)

DATAQUEST 1996 CONFERENCES

Dataquest sponsors an on-going series of conferences and invitational events focusing on trends and issues in information technology and IT services. These conferences are the preeminent source of insight and analysis of global IT market dynamics.

North America	January 24	Capitalizing on the Wireless Phenomenon	San Jose, California
	January 30	Dataquest Predicts	Boston, Massachusetts
	February 20	Dataquest Predicts	San Jose, California
	March 7	Channel Trends Conference	San Jose, California
	April 1-2	ServiceTrends Conference	Orlando, Florida
	April 1 *	Mining the Internet	Boston, Massachusetts
	May 6-7	Personal Computer Conference	San Jose, California
	May 13-14	Copier Conference	Boston, Massachusetts
	June 26-27	Storage Track Conference	Monterey, California
	July 1 *	SEMICON/West	San Francisco, California
	September 25-26 *	Multimedia	San Jose, California
	October 24-25	Semiconductors '96	Palm Desert, California
	December 1 *	Mining the Internet	San Jose, California
Europe	January 24	Computer Storage	Munich, Germany
	May 22-23	Semiconductors '96	Frankfurt, Germany
	September 10	Computer Storage	London, England
Japan	May 13-14	Semiconductors '96	Tokyo, Japan
	September 10-12	Computers and Peripherals	Tokyo, Japan
	December 6	Telecommunications	Tokyo, Japan
Dataquest Invitational Computer Conferences	December 1 *	Asia/Pacific Series	Tokyo, Japan
	December 1 *	Asia/Pacific Series	Seoul, Korea
	December 1 *	Asia/Pacific Series	Beijing, PRC
	December 1 *	Asia/Pacific Series	Shanghai, PRC
	December 1 *	Asia/Pacific Series	Xi'an, PRC
	December 1 *	Asia/Pacific Series	Guangzhou, PRC
	March 5	Dataquest Storage Solutions Series - USA	San Jose, California
	April 10	Dataquest Storage Solutions Series - USA	Irvine, California
	April 24	Dataquest Storage Solutions Series - USA	Nashua, New Hampshire
	September 24	Dataquest Storage Solutions Series - USA	Newton, Massachusetts
	April 1	Mediterranean Series	Dubai, UAE
	May 21	Mediterranean Series	Athens, Greece
	October 30	Mediterranean Series	Tel Aviv, Israel
	November 6	Mediterranean Series	Istanbul, Turkey

** Date tentative/may change*

Dataquest

Dataquest Invitational Computer Conferences *(continued)*

January 17	Dataquest Storage Solutions Series-Europe	Paris, France
January 23	Dataquest Storage Solutions Series-Europe	Munich, Germany
January 30	Dataquest Storage Solutions Series-Europe	Milan, Italy
February 1	Dataquest Storage Solutions Series-Europe	Rome, Italy
June 10	Dataquest Storage Solutions Series-Europe	Budapest, Hungary
June 12	Dataquest Storage Solutions Series-Europe	Prague, Czech Republic
June 21	Dataquest Storage Solutions Series-Europe	St. Petersburg, Russia
June 25	Dataquest Storage Solutions Series-Europe	Moscow, Russia
July 1	Dataquest Storage Solutions Series-Europe	Warsaw, Poland
September 1	Dataquest Storage Solutions Series-Europe	Amsterdam, Holland
September 5	Dataquest Storage Solutions Series-Europe	Stockholm, Sweden
September 11	Dataquest Storage Solutions Series-Europe	London, England
September 19	Dataquest Storage Solutions Series-Europe	Frankfurt, Germany
October 1 *	Latin America Series	Caracas, Venezuela
October 1 *	Latin America Series	Mexico City, Mexico
October 1 *	Latin America Series	São Paulo, Brazil
October 1 *	Latin America Series	Buenos Aires, Argentina
October 1 *	Latin America Series	Santiago, Chile
October 1 *	Latin America Series	Bogotà, Columbia
October 1 *	Latin America Series	Lima, Peru
February 19	South Africa Series	Capetown, South Africa
February 22	South Africa Series	Johannesburg, South Africa
April 11	LINK Series - North America	Orlando, Florida
April 30	LINK Series - North America	Austin, Texas
May 1	LINK Series - North America	Philadelphia, Pennsylvania
May 9	LINK Series - North America	Charlotte, North Carolina
May 14	LINK Series - North America	Denver, Colorado
May 21	LINK Series - North America	Portland, Oregon
November 1 *	LINK Series - North America	Montréal, Québec
November 1 *	LINK Series - North America	Ottawa, Ontario
November 1 *	LINK Series - North America	Calgary, Alberta
November 1 *	LINK Series - North America	Vancouver, BC
November 1 *	LINK Series - North America	Toronto, Ontario

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**Date tentative/may change*

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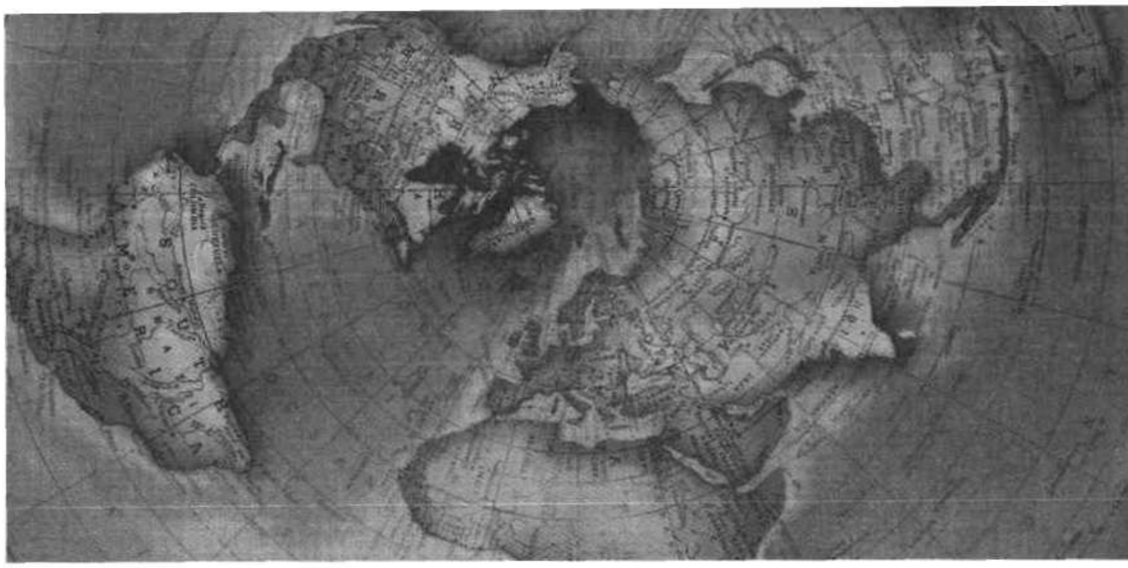

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Vendor Analysis

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Standard Logic, Linear	2.72	2.60	-4.3
MPU, Graphics/Video	63.67	60.49	-5.0
Active Discrete Components	0.78	0.77	-1.9
Passive Components	8.02	7.94	-1.1
Systems, Modules, and Batteries	21.10	21.10	0.0
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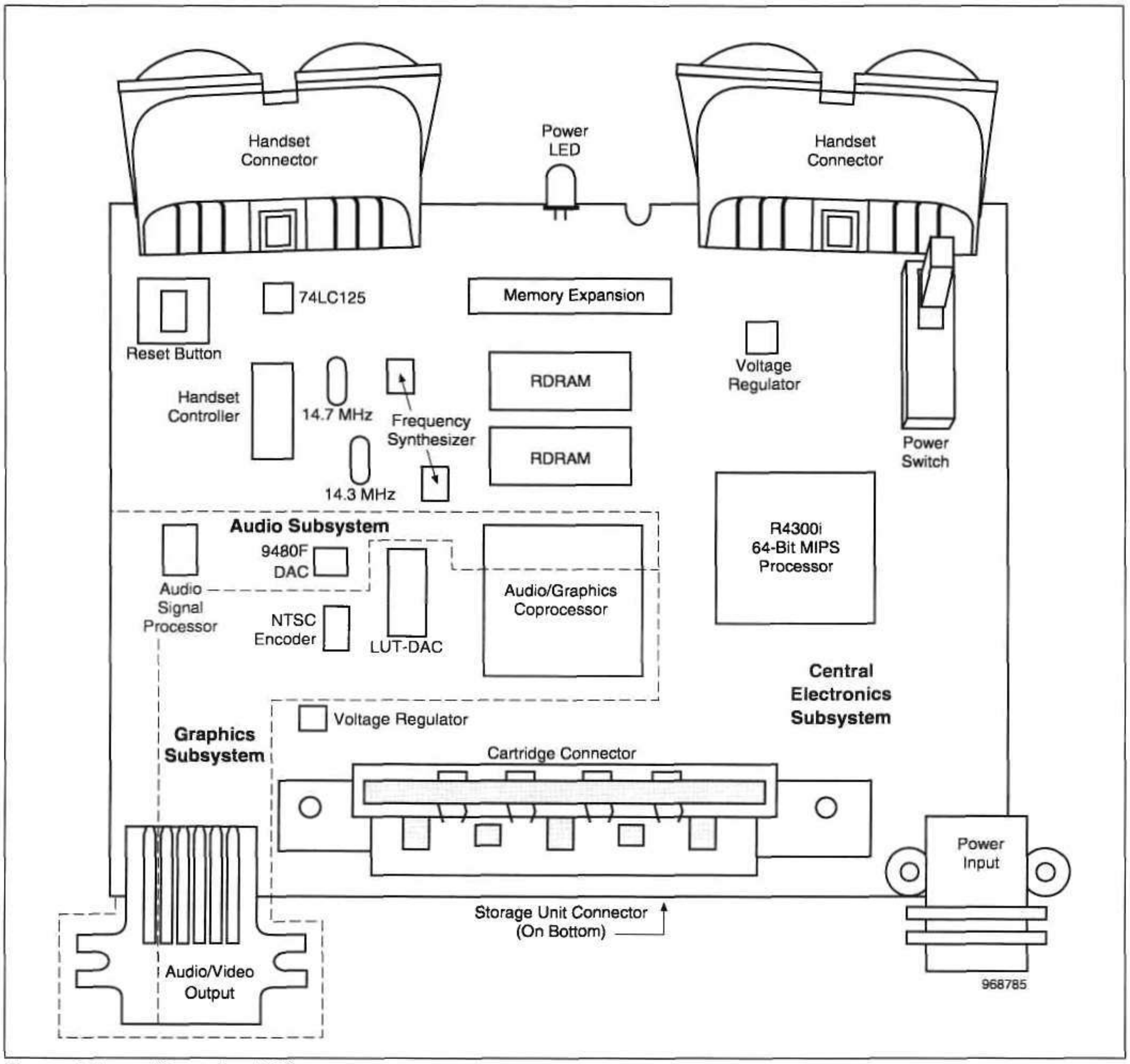
Nintendo 64 System Card



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The departure of Atari and 3DO has narrowed the video game console industry to three principal players: Sega, Sony, and Nintendo. In addition to this trio, the multimedia PC has become a very popular gaming platform competing with the video game console segment. Based on the cost analysis of the Sega Saturn, Sony PlayStation, and Nintendo 64 shown in Table 4, Nintendo holds a significant advantage in system production costs, with an estimated cost of $162 for 1997. The production costs for the Sony PlayStation are $50 higher, and the Sega Saturn costs almost $90 more than the Nintendo 64 to produce. This difference in production costs allowed Nintendo to easily match the $199 retail prices of the PlayStation and Saturn and eliminate cost as a factor in a customer's purchase decision. It appears

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Table 4
Total Production Cost Summary for 32/64-Bit Video Game Consoles (Dollars)

	1995	1996	1997
Sega Saturn			
Total Semiconductor Cost	261.61	199.92	121.00
Passive Components	13.66	13.29	12.92
Systems, Modules, and Batteries	76.46	39.32	38.14
Printed Circuit Boards	23.00	22.54	22.09
Mechanical Components	16.46	16.48	16.51
Labor and Freight	36.81	38.04	39.32
Total Cost	428.01	329.60	249.97
Sony PlayStation			
Total Semiconductor Cost	196.45	166.19	118.65
Passive Components	18.12	17.70	17.29
Systems, Modules, and Batteries	27.04	26.52	26.00
Printed Circuit Boards	12.50	12.25	12.01
Mechanical Components	11.73	11.80	11.87
Labor and Freight	23.10	23.78	24.49
Total Cost	288.95	258.24	210.30
Nintendo 64			
Total Semiconductor Cost	-	107.37	98.93
Passive Components	-	8.02	7.94
Systems, Modules, and Batteries	-	21.10	21.10
Printed Circuit Boards	-	2.60	2.55
Mechanical Components	-	19.00	18.94
Labor and Freight	-	12.05	12.53
Total Cost	-	170.14	161.99

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Sega and Sony have both responded to the Nintendo 64 introduction with renewed sales campaigns for their own machines. At the end of November, Sega began a promotion in which it bundles three free titles and a coupon for $15 off any two additional titles with the purchase of a Sega Saturn. This promotion will run through December 31, 1996. Sega claims that by September 1996, sales of the Sega Saturn had reached 5.75 million cumulative units. The company is targeting 7.75 million cumulative unit shipments worldwide by the end of March 1997. Sony claims that it had shipped a total of 9 million PlayStations by October 31, 1996. Sony has also claimed that demand is exceeding supply for the PlayStation and announced

plans to increase production to 1 million units per month in November and December.

Dataquest Perspective

Nintendo has hit a grand slam with the Nintendo 64 and delivered a new surge of energy to the overall video game market. At one point, it appeared that the multimedia PC might spell the demise of the video game console industry. Not only has the Nintendo 64 leapfrogged its competitors, it has demonstrated the awesome potential that still exists to deliver an incredible gaming experience in a box that costs less than $200. Future possibilities for the video game console are brighter than ever, but the multimedia PC will continue to place pressure on this industry to stay one step ahead. Of course, at the heart of all of this lies advanced semiconductor technology from Silicon Graphics and Rambus, and they will reap the rewards for their contribution. If Nintendo can successfully ride the tidal wave it has created, sales of the Nintendo 64 could surpass both Sega and Sony by Christmas 1997.

For More Information...

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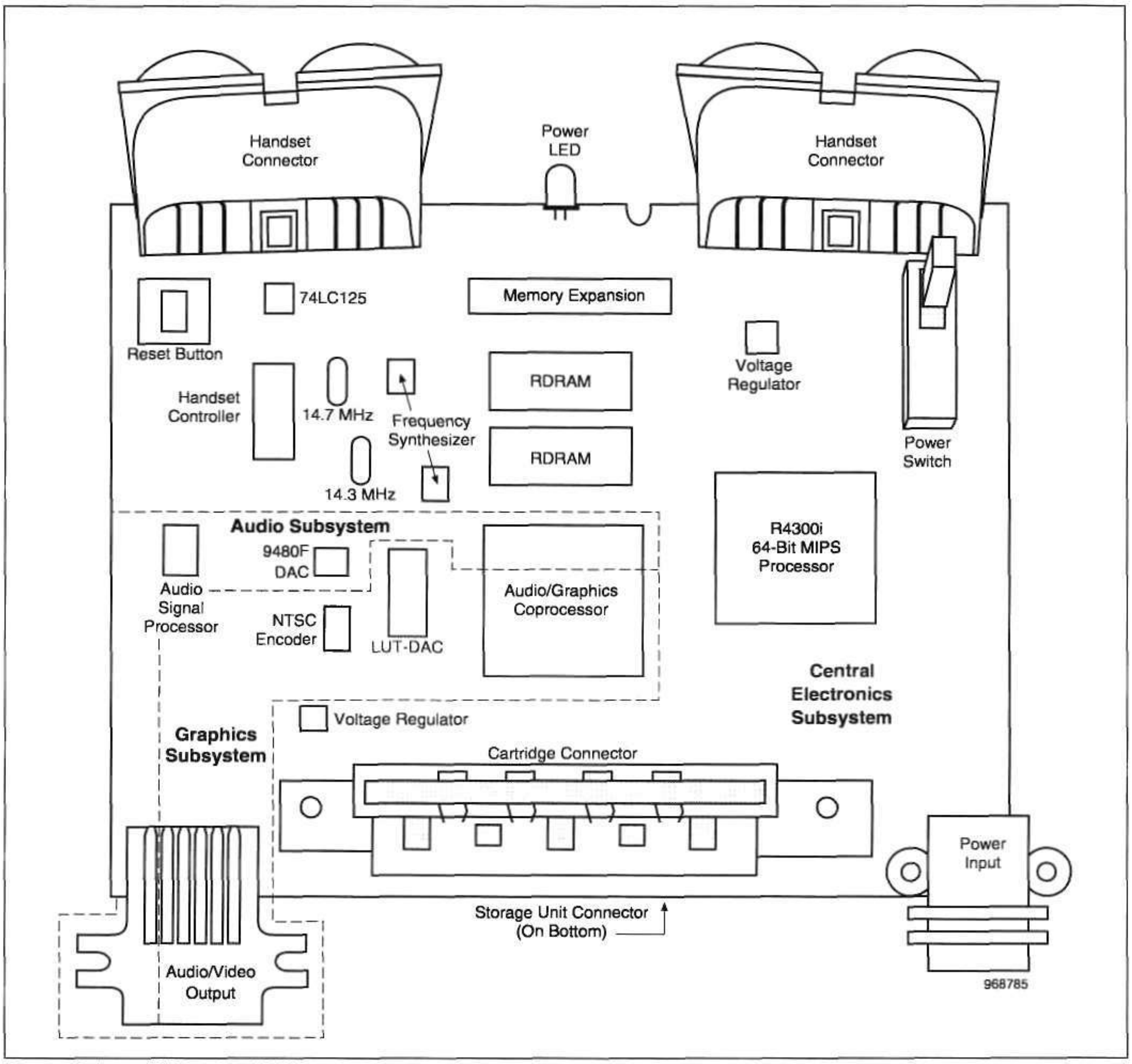

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Systems, Modules, and Batteries	76.46	39.32	38.14
Printed Circuit Boards	23.00	22.54	22.09
Mechanical Components	16.46	16.48	16.51
Labor and Freight	36.81	38.04	39.32
Total Cost	428.01	329.60	249.97
Sony PlayStation			
Total Semiconductor Cost	196.45	166.19	118.65
Passive Components	18.12	17.70	17.29
Systems, Modules, and Batteries	27.04	26.52	26.00
Printed Circuit Boards	12.50	12.25	12.01
Mechanical Components	11.73	11.80	11.87
Labor and Freight	23.10	23.78	24.49
Total Cost	288.95	258.24	210.30
Nintendo 64			
Total Semiconductor Cost	-	107.37	98.93
Passive Components	-	8.02	7.94
Systems, Modules, and Batteries	-	21.10	21.10
Printed Circuit Boards	-	2.60	2.55
Mechanical Components	-	19.00	18.94
Labor and Freight	-	12.05	12.53
Total Cost	-	170.14	161.99

Source: Dataquest (December 1996)

Sega and Sony have both responded to the Nintendo 64 introduction with renewed sales campaigns for their own machines. At the end of November, Sega began a promotion in which it bundles three free titles and a coupon for $15 off any two additional titles with the purchase of a Sega Saturn. This promotion will run through December 31, 1996. Sega claims that by September 1996, sales of the Sega Saturn had reached 5.75 million cumulative units. The company is targeting 7.75 million cumulative unit shipments worldwide by the end of March 1997. Sony claims that it had shipped a total of 9 million PlayStations by October 31, 1996. Sony has also claimed that demand is exceeding supply for the PlayStation and announced

plans to increase production to 1 million units per month in November and December.

Dataquest Perspective

Nintendo has hit a grand slam with the Nintendo 64 and delivered a new surge of energy to the overall video game market. At one point, it appeared that the multimedia PC might spell the demise of the video game console industry. Not only has the Nintendo 64 leapfrogged its competitors, it has demonstrated the awesome potential that still exists to deliver an incredible gaming experience in a box that costs less than $200. Future possibilities for the video game console are brighter than ever, but the multimedia PC will continue to place pressure on this industry to stay one step ahead. Of course, at the heart of all of this lies advanced semiconductor technology from Silicon Graphics and Rambus, and they will reap the rewards for their contribution. If Nintendo can successfully ride the tidal wave it has created, sales of the Nintendo 64 could surpass both Sega and Sony by Christmas 1997.

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Perspective

Consumer Multimedia Semiconductors and Applications Worldwide

Vendor Analysis

Nintendo Delivers the Machine of the Year

Abstract: *This document provides information on Nintendo's introduction of its next-generation platform, the Nintendo 64 (N64). A cost analysis of the Nintendo 64, along with semiconductor content information, is presented. Also, an updated forecast for 32/64-bit video game console production is provided. Finally, a competitive cost comparison of the Sony PlayStation and Sega Saturn systems is presented.*
By Dale Ford

All I Want for Christmas Is a Nintendo 64

As the Christmas holidays approach, children and teenagers are euphoric over the new Nintendo 64 system and the unprecedented level of game play that it delivers. With requests for Nintendo's new system at the top of millions of letters to Santa Claus, parents are panic-stricken as they find barren retail store shelves and long waiting lists for deliveries. Some parents have turned to placing want ads in the newspaper promising amazing sums for the chance to buy the box that *Time* magazine selected as Machine of the Year for 1996. The Nintendo 64 won this distinction over other exciting products such as digital satellite set-top boxes, WebTV systems, the latest cellular telephone products, digital cameras, and even 200-MHz Pentium PCs. With a seeming chorus of praises already ringing from video game industry publications to daily newspapers, Nintendo continues to fuel demand using joint promotions with Blockbuster Video, Nickelodeon, and Kellog's and a "Change the System" ad campaign. However, the company's greatest challenge now is to deliver systems and software to meet the demand it has already created.

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The Nintendo 64 was first released in Japan on June 23, and within 10 weeks, over 1 million units had been sold. Early reports in the Japanese press claimed that Japanese retailers were holding high levels of inventory because of poor consumer demand and a failure of the systems to sell through to the market. Nintendo disputed these claims and met with the press to provide information showing that over 90 percent of the systems had already been sold to consumers. Nintendo continues to be aggressive in addressing persistent news reports in the Japanese press that the Nintendo 64 is not meeting sales projections for Japan. The company insists that it is continuing to meet its sales targets.

Within three days of the September 29 launch in North America, the initial shipment of 350,000 units was completely sold out. Consumers bought more than 50 percent of the software and systems before they reached the shelves. Responding to the wave of consumer demand, Nintendo has announced that it will increase shipments of the Nintendo 64 to the North American market from 500,000 to 1.2 million by Christmas. However, the demand for Nintendo 64 is somewhere between 1.5 million to 2 million units. In an attempt to respond to the short supply, Nintendo has now established a rain check policy, with major retailers guaranteeing a system by the end of January 1997. By early December, 900,000 units had reached the market. Originally, Nintendo had projected that it would sell 5 million Nintendo 64 systems by the end of its fiscal year on March 31, 1997. The most recent comments now indicate that it expects to sell 6 million units by then.

The Name of the Game Is Fun (and Profit)

Perhaps the most important challenge that Nintendo faces is delivering software titles for the Nintendo 64. Nintendo has set very high quality standards for the titles that it approves for the Nintendo 64, which has limited the early availability of software. As a result, there were only two titles available when the system was launched, Super Mario 64 and PilotWings 64. The quality of the games is evidenced from numerous reviews calling Super Mario 64 the best video game ever produced. Industry analysts and press representatives who viewed a demonstration of the Nintendo 64 at the E3 show gave it a standing ovation. There are a total of eight titles available for the Nintendo 64 during the 1996 holiday season. At the Shoshinkai trade show in Japan in November, there were nearly 40 new titles demonstrated for the Japanese market, and there should be at least 20 titles available for the North American market by the end of March 1997. The bottom line from Nintendo's perspective is that the system must be fun and create a new surge of excitement among its players. The company feels that if it accomplishes this, the profit will follow.

The availability of software is critical because this is where the profit is derived. Nintendo competitors point to the hundreds of titles available for the Sony PlayStation and Sega Saturn as evidence of a key advantage they have over Nintendo. However, a high percentage of these titles are so similar that it is hard to distinguish among them. This has created a situation where many companies struggle to differentiate their product and earn a profit. The challenge of developing titles for the Nintendo 64 and the business

development plan implemented by Nintendo will create a barrier too high for smaller companies and limit the number of developers supporting the platform. By pushing the technology envelope, Nintendo is creating an environment in which only the fittest will survive.

The record-setting sales of the Nintendo 64 system provide a solid foundation for Nintendo to turn its financial picture around from the declining revenue it has earned since 1993, as shown in Table 1. The success of the Nintendo 64 system will provide additional fuel to the growth of the overall 32/64-bit video game market forecast, shown in Table 2. Again, it must be remembered that video game manufacturers actually lose money on the sales of hardware. However, the hardware sales enable profit from the sale of software, and video game manufacturers have to work to create an installed base of users for their software.

Table 1
Nintendo Financial Data, Year Ending March 31 (Millions of Dollars)

	1992	1993	1994	1995	1996
Revenue	5,300	5,987	4,581	3,917	3,337
Gross Margin (%)	16	14	11	10	17
Net Income	822	836	497	393	565

Note: Revenue in dollars is based on a rate of ¥106 = $1.
Source: Nintendo

Table 2
Worldwide 32/64-Bit Video Game Controller Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Unit Shipments (K)	100	1,570	5,123	10,928	12,387	16,442	19,510	20,536	32.0
Factory Value ($)	328	320	335	270	235	205	197	187	-11.0
Factory Revenue ($M)	33	502	1,716	2,950	2,911	3,371	3,843	3,840	17.5
Semiconductor Content ($)	205	200	225	175	142	130	125	118	-12.1
Semiconductor TAM ($M)	21	314	1,153	1,912	1,759	2,137	2,439	2,423	16.0

Source: Dataquest (December 1996)

Looking under the Hood

After the introduction of the Nintendo 64 in Japan, Dataquest acquired a system and performed a detailed cost and production analysis. A summary of the system cost and semiconductor content is presented in Table 3 and an illustration of the system board layout is shown in Figure 1. The complete analysis of the Nintendo 64 has been published in a Focus Report titled *A Teardown Analysis of the Nintendo 64* (TRDN-WW-FR-9610).

The Nintendo 64 represents an impressive accomplishment in system design and the use of advanced chip technology. The entire system centers around four main chips, two processor chips based on Silicon Graphics technology

and the MIPS architecture and two Rambus DRAMS. All four of these chips are manufactured by NEC. The design of this system enables it to deliver the highest level of performance ever in a video game console while achieving a low production cost that minimizes the losses from selling it at $199.

Table 3
Nintendo 64 System Cost Summary and Semiconductor Content (Dollars)

	1996	1997	Change (%)
Total System Production Cost	170.14	161.99	-4.8
Total Semiconductor Cost	107.37	98.93	-7.9
ICs	106.58	98.16	-7.9
Memory	31.05	26.39	-15.0
DRAM/VRAM/SDRAM/RDRAM	31.05	26.39	-15.0
Audio	9.15	8.69	-5.0
Standard Logic, Linear	2.72	2.60	-4.3
MPU, Graphics/Video	63.67	60.49	-5.0
Active Discrete Components	0.78	0.77	-1.9
Passive Components	8.02	7.94	-1.1
Systems, Modules, and Batteries	21.10	21.10	0.0
Printed Circuit Boards	2.60	2.55	-2.0
Mechanical Components	19.00	18.94	-0.3
Labor and Freight	12.05	12.53	4.0

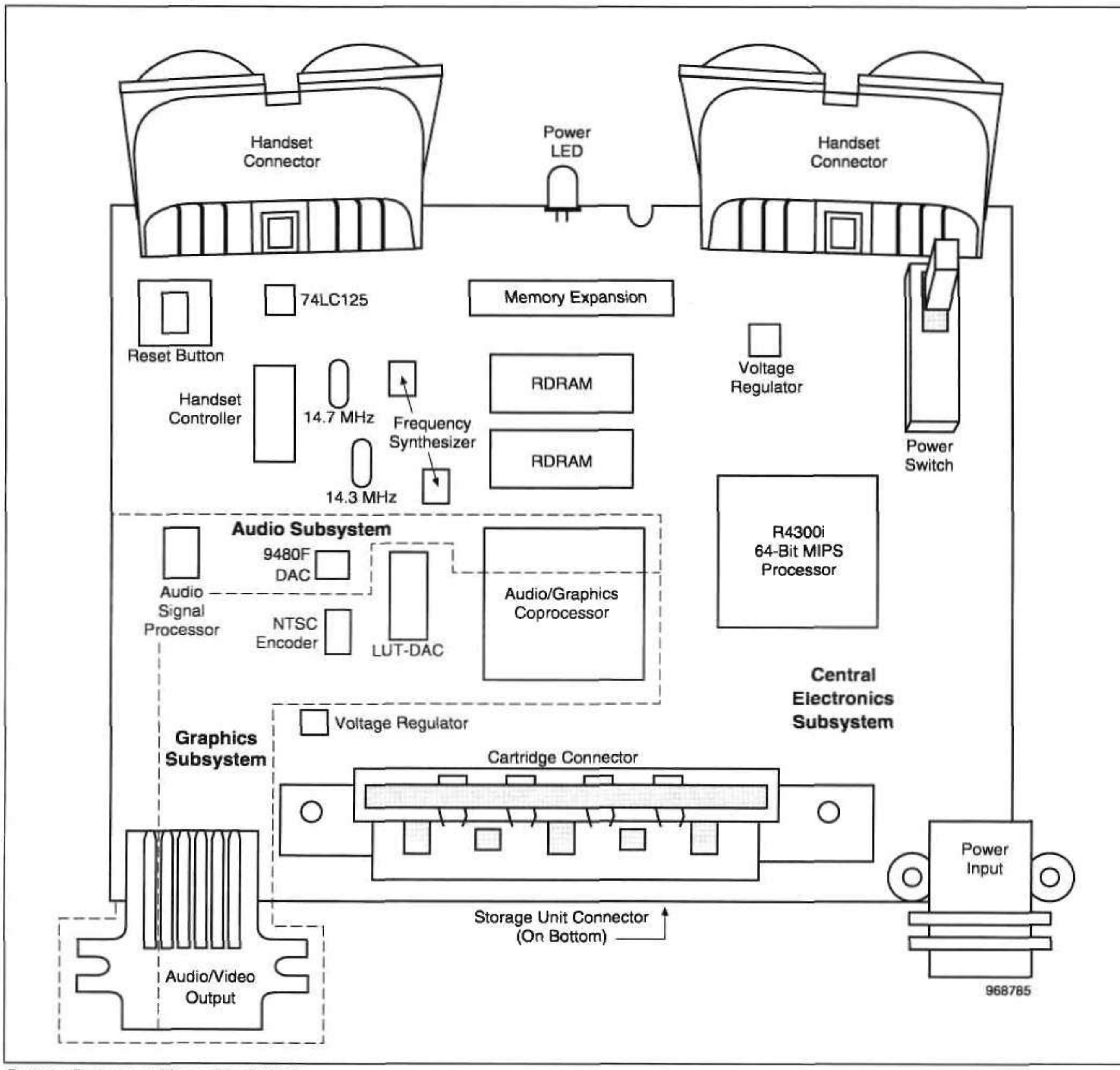
Source: Dataquest (December 1996)

The performance delivered by this system keeps it one step ahead of another major competitor, the multimedia PC. PCs will have to await the next generation of processors before they can start to compete with the gaming experience delivered by the Nintendo 64. Even then, these systems will cost over $2,000, compared to the $199 Nintendo system. Some of the basic technical specifications for the Nintendo 64 are listed below:

- CPU: 64-bit RISC MIPS R4300i; clock speed 93.75 MHz
- Memory: Rambus DRAM 36Mb; maximum transmission speed of 4,500 Mbps
- Coprocessor: SP (sound and graphics processor) and DP (pixel drawing processor) incorporated; clock speed of 62.5 MHz
- Resolution: 256 x 224 to 640 x 480 dots; flicker-free interlaced mode support
- Color: 32-bit RGBA pixel color frame buffer support; 21-bit color video output
- Graphics processing functions:
  - Z buffer
  - Antialiasing

- Realistic texture mapping:
  - Trilinear mip-map interpolation
  - Environmental mapping
  - Perspective correction
- Memory expansion slot and storage unit connector for 64DD cartridge drive

Figure 1
Nintendo 64 System Card



Source: Dataquest (December 1996)

The next planned enhancement to the Nintendo 64 system will be a magnetic storage accessory called the 64DD. A prototype of the 64DD was displayed at the Shoshinkai Japanese trade show in November. The drive will increase the storage capacity of N64 cartridges by a factor of eight and also deliver data to the processor at two to three times the speed of CD-equipped game machines. The drive will also allow players to customize their characters, environments, and game play mechanics.

The Rest of the Nintendo Portfolio

Although the Nintendo 64 is capturing all the headlines, it is important to remember that Nintendo is also pursuing other video game markets based on other platforms.

- Super NES: Nintendo has remained committed to the development of markets based on this platform, and this 16-bit system continues to deliver profits. Nintendo is continuing to invest in the development of titles for the Super NES.
- Virtual Boy: This 32-bit platform was introduced to the market during 1995. It provides a visually immersive, three-dimensional gaming environment using a self-contained display that resembles a large pair of goggles. Even though Nintendo reduced the price from the original $180, system shipments have been below Nintendo's expectations. New titles were introduced for the Virtual Boy in 1996 in an effort to stimulate the market.
- Game Boy: Since its introduction in 1989, over 48 million units have been sold worldwide. Currently, there are over 450 titles available for the Game Boy. Nintendo introduced a new product called the Game Boy Pocket during 1996 that offers very attractive enhancements:
  - The Game Boy Pocket is 30 percent smaller and about half the weight of the original Game Boy.
  - A new LCD display offers sharper images and improved contrast, which allow game play in the glare of sunlight, and improved viewing angles .

The Competition

The departure of Atari and 3DO has narrowed the video game console industry to three principal players: Sega, Sony, and Nintendo. In addition to this trio, the multimedia PC has become a very popular gaming platform competing with the video game console segment. Based on the cost analysis of the Sega Saturn, Sony PlayStation, and Nintendo 64 shown in Table 4, Nintendo holds a significant advantage in system production costs, with an estimated cost of $162 for 1997. The production costs for the Sony PlayStation are $50 higher, and the Sega Saturn costs almost $90 more than the Nintendo 64 to produce. This difference in production costs allowed Nintendo to easily match the $199 retail prices of the PlayStation and Saturn and eliminate cost as a factor in a customer's purchase decision. It appears

that Nintendo plans to compete in the market based on system performance rather than continue the price war that Sony and Sega started at the E3 show. Based on the cost advantage Nintendo holds in this area, it is hard to imagine Sega or Sony engaging in another price war in the near future.

Table 4
Total Production Cost Summary for 32/64-Bit Video Game Consoles (Dollars)

	1995	1996	1997
Sega Saturn			
Total Semiconductor Cost	261.61	199.92	121.00
Passive Components	13.66	13.29	12.92
Systems, Modules, and Batteries	76.46	39.32	38.14
Printed Circuit Boards	23.00	22.54	22.09
Mechanical Components	16.46	16.48	16.51
Labor and Freight	36.81	38.04	39.32
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Source: Dataquest (December 1996)

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Perspective

Consumer Multimedia Semiconductors and Applications Worldwide

Vendor Analysis

SGS-Thomson: The Right Products, the Right Place, the Right Time

Abstract: *This report covers SGS-Thomson's business in semiconductors used in consumer electronics equipment. SGS-Thomson offers a broad line of semiconductors for audio equipment, video equipment, and appliances. The company has established a leadership position in the lucrative market for MPEG-2 decoders used in digital set-top boxes and DVD players. With its early participation in the development of the European DVB standard, SGS-Thomson could be a key supplier as the worldwide consumer video market transitions to digital technology.*
By Jonathan Cassell

Opportunity Knocks

The proliferation of digital technology into the consumer electronics marketplace offers tremendous opportunity to those semiconductor companies prepared to seize it. Franco-Italian SGS-Thomson Microelectronics NV, Saint Genis, France, has been one of the biggest beneficiaries of the digitization of consumer video, attaining leadership in the market for MPEG-2 video decoders used in satellite set-top boxes over the past two years. A longtime player in the analog consumer electronics market, SGS-Thomson has been at the right place at the right time to cash in on digital video. SGS-Thomson at an early stage identified MPEG decoding as a lucrative technology and aligned itself with a key customer, Thomson Consumer Electronics, which has propelled SGS-Thomson into its leading position.

Dataquest

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Now, as the consumer digital video phenomenon spreads, SGS-Thomson faces increasing competition from other players that want a piece of the expanding opportunity. Keeping a leadership position will be a major challenge for SGS-Thomson as competitors attempt to leapfrog it with lower-cost, more highly integrated approaches to silicon in set-top boxes and in other consumer digital video platforms. However, SGS-Thomson is moving forward to offer its own highly integrated solution, leveraging its comprehensive yet well-targeted line of consumer electronics devices. Meanwhile, SGS-Thomson is taking a leading role in the development of silicon for digital video standards that are likely to become pervasive worldwide in the future. Thus, circumstance and strategy continue to favor SGS-Thomson's chances of being at the right place at the right time to seize new digital video opportunities as they knock.

A Major Player

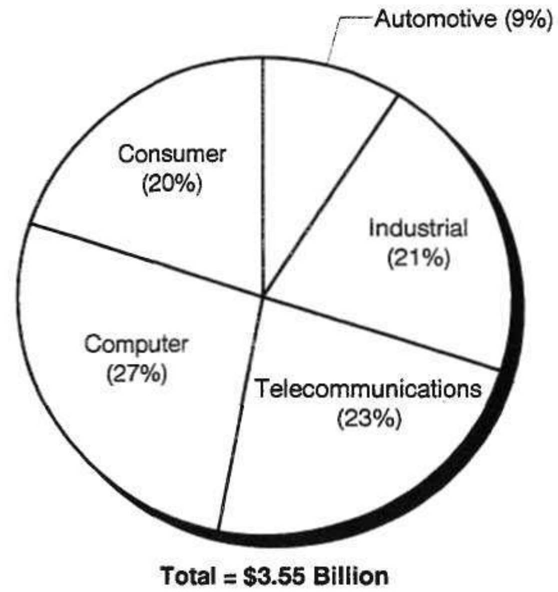
SGS-Thomson is one of the world's largest semiconductor companies, ranking No. 15 with $3.55 billion in revenue in 1995. With more than 3,000 main types of products sold to 1,500 customers, SGS-Thomson is a broad-line supplier. The product line includes extensive offerings in areas including standard ICs, discretes, memories, programmable devices, and application-specific products using bipolar, CMOS, BiCMOS, mixed-signal, and digital technologies. SGS-Thomson's sales are well distributed among major semiconductor applications, including computer, industrial, telecommunications, and consumer, as shown in Figure 1. Consumer, which consists of semiconductors for VCRs, stereos, TV and satellite receivers, appliances, and home automation, accounted for 20 percent of the company's revenue in 1995, or about $710 million.

SGS-Thomson's consumer sales have been growing rapidly in recent years, rising 28 percent in 1995 compared to 1994. The company's growth has outstripped increases in the consumer semiconductor market as a whole.

SGS-Thomson is a worldwide supplier, with large percentages of its revenue coming from every major region, excluding Japan, as shown in Figure 2. Although the Americas represent only 24 percent of worldwide revenue, much of SGS-Thomson's sales in the Asia/Pacific region are into divisions of U.S.-based companies. When revenue from those Far Eastern-based subsidiaries is combined with sales to those companies' parent companies in the United States, the Americas account for one-third of SGS-Thomson's overall revenue, making it the second-largest sales region for the company, after Europe.

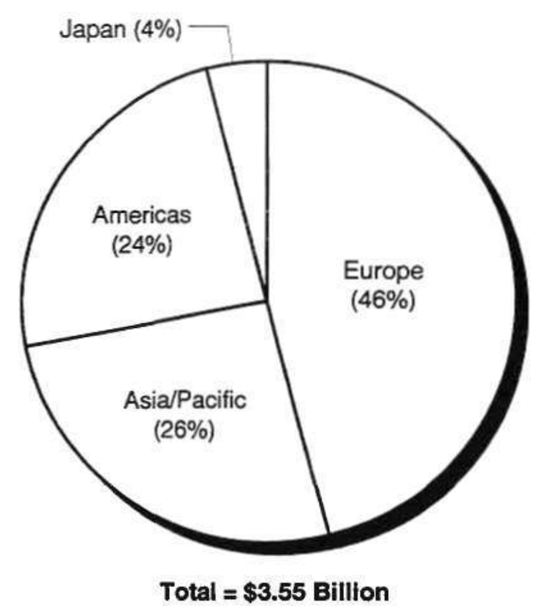
SGS-Thomson is a worldwide manufacturing powerhouse, with 11 fabs and six back-end assembly facilities located in Europe, the United States, Asia/Pacific, and Africa. Among its fabs are two operating 8-inch wafer facilities that are located in Phoenix, Arizona, and in Crolles, France, and three that are under construction or just beginning production in Rousset, France, in Catania, Italy, and in Singapore. The company has a 0.5-micron process and is beginning production at 0.35-micron.

Figure 1
Market Share of SGS-Thomson's 1995 Revenue by Application



Source: SGS-Thomson, Dataquest (October 1996)

Figure 2
Regional Share of SGS-Thomson's 1995 Revenue



Source: SGS-Thomson, Dataquest (October 1996)

Competitive Position

SGS-Thomson has an extensive line of dedicated digital and mixed-signal products for consumer audio, video, appliances, and other devices. Despite that, SGS-Thomson in 1995 was not a top-ranked vendor in many basic categories of chips used in consumer applications, such as microcontrollers, microperipherals, digital signal processors (DSPs), or analog video and audio ICs.

The market position SGS-Thomson lacks in nuts and bolts consumer products it more than makes up for with its dominant role in digital video decompression, also called decoding. In the major types of digital video decompression chips—MPEG-2 and MPEG-1—SGS-Thomson in 1995 held the No. 1 and No. 2 positions, respectively, and was the No. 1 vendor of MPEG digital decoding chips overall, as shown in Table 1. Overall, SGS-Thomson in 1995 sold 4.2 million MPEG decoders, 1.4 million of which were MPEG-1 and 2.8 million of which were MPEG-2, both audio and video.

Table 1
SGS-Thomson's Competitive Position in Digital Video Decompression Chips in 1995

Market Ranking	MPEG-1 Decode	MPEG-2 Decode	Total MPEG Decode
No. 1		X	X
No. 2	X		

Source: Dataquest (October 1996)

SGS-Thomson was able to achieve its leading position and high sales largely because of its early entry into this market and because it garnered a key design-win for its MPEG-2 decoders with Thomson Consumer Electronics. Thomson Consumer Electronics used the MPEG decoders in its wildly popular digital set-top box, known as the Digital Satellite Service (DSS) system. The majority of the Thomson Consumer Electronics DSS boxes also included other SGS-Thomson silicon, including a transport demultiplexer ASIC that works with the MPEG-2 decoder and the 16-bit ST90R51FB1 microprocessor that performs system control. Overwhelming demand for the MPEG-2 decoder and for associated chips used in the DSS boxes was responsible for much of SGS-Thomson's sales growth in the United States in 1994 and 1995. The majority of SGS-Thomson's MPEG-1 decoders were used in Video CD and karaoke players used in Japan and the Asia/Pacific region.

The Competition

With its broad line of consumer products, SGS-Thomson competes with a host of other semiconductor manufacturing powerhouses, including Toshiba, Sanyo, Sony, Philips, Motorola, Texas Instruments, and NEC. In MPEG video decompression, the company faces a smaller group of competitors, including C-Cube Microsystems Inc., LSI Logic Corporation, and Texas Instruments Inc.

Market Outlook: A Tale of Two Markets

SGS-Thomson participates both in the traditional analog market and in the emerging digital market for audio, video, and appliances. Although both are part of the consumer electronics business, the analog and digital portions of the market are as different as night and day when it comes to projected growth rates. Overall, the demand for semiconductors in consumer electronic equipment is expected to grow at a compound annual growth rate (CAGR) of 14.9 percent from 1996 to 2000. Major product categories in the consumer market consist of semiconductors that are mostly used in mature types of analog equipment, such as audio, video, and appliances. Those categories should experience compound revenue growth rates ranging from 11 percent to negative 1.3 percent from 1996 to 2000.

In contrast, semiconductor use in new digital consumer electronics products, such as cable and satellite set-top boxes and DVD, is expected to grow at rates ranging from 15.3 percent to 114.4 percent in the same period, as shown in Figures 3, 4, and 5. SGS-Thomson's strong product line and experience will allow it to exploit the high growth opportunities offered by these new digital platforms.

Products

SGS-Thomson is a long-term participant in the consumer electronics market and has built up an extensive portfolio of chips for that area. That portfolio provides most of the basic building blocks required to build consumer televisions, set-top boxes, stereos, radios and associated devices. That product line has been enhanced in recent years with new digital video decoders, which have become some of the company's most popular products for the consumer electronics market.

Video Products

SGS-Thomson's line of devices for video products includes power transistors, remote control transmitters, display drivers, teletext decoders, satellite sound and video processors, PAL/NTSC encoders and decoders, analog-to-digital converters, PAL/SECAM and PAL/NTSC TV processors, and video and audio intermediate frequency (IF) amplifiers.

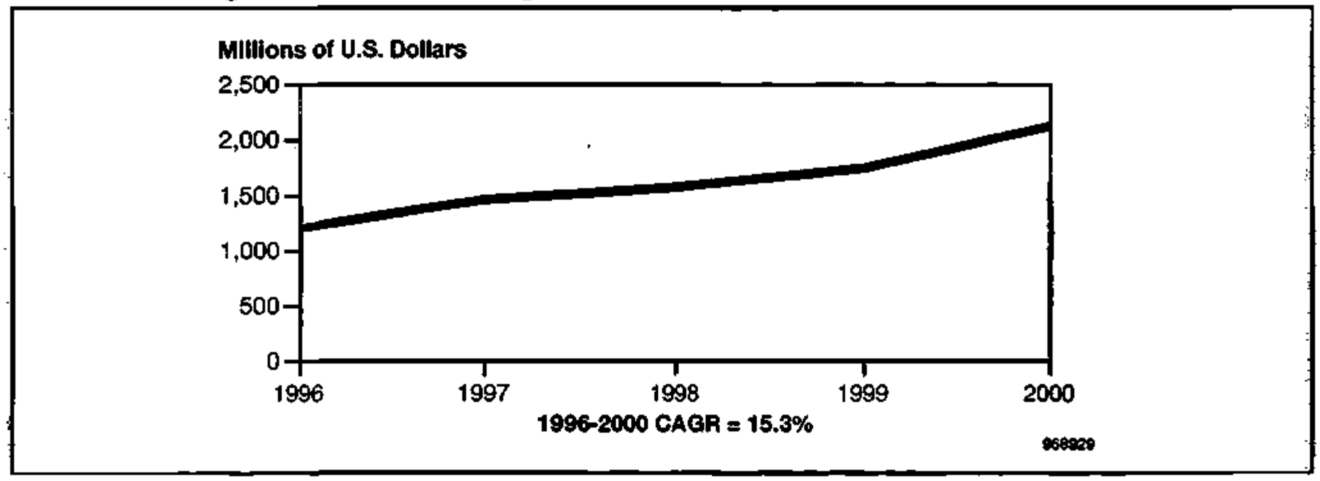
Audio Products

SGS-Thomson offers audio devices including hi-fi and stereo amplifiers, AM/FM radios, stereo decoders, audio signal processors, surround sound matrix digital audio processors, cassette playback systems, stereo audio processors, graphic equalizers, frequency synthesizers, and audio processors with Sound Retrieval System (SRS) surround sound and voice cancellation.

MPEG-2 Decoders

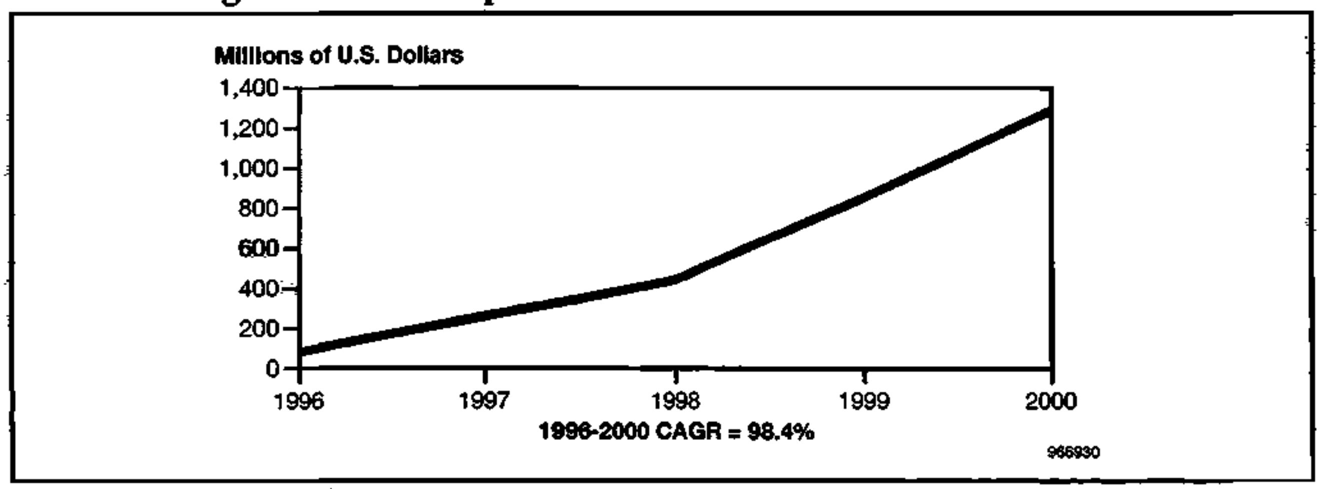
SGS-Thomson has been a pioneer in MPEG-2 decoders. Most of its sales before 1996 were of decoders that performed either audio or video decompression, requiring two separate chips to carry out decompression in a digital video system. Although SGS-Thomson still offers standalone MPEG-2 audio and video decoders, its primary sales now are of devices that integrate audio and video functions onto a single die.

Figure 3
Worldwide Digital Satellite Set-Top Box Semiconductor Forecast



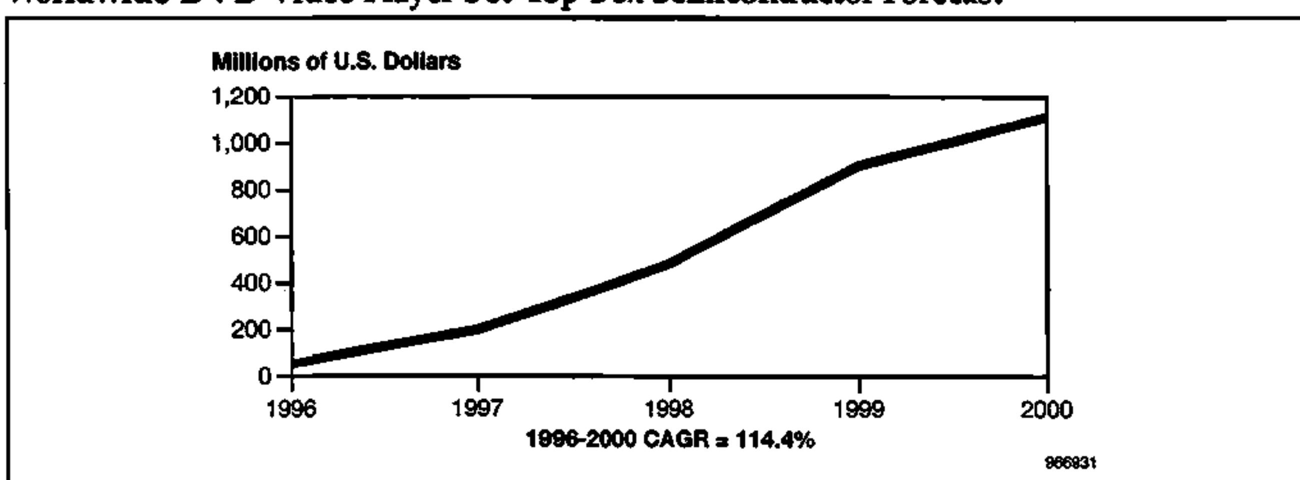
Source: Dataquest (October 1996)

Figure 4
Worldwide Digital Cable Set-Top Box Semiconductor Forecast



Source: Dataquest (October 1996)

Figure 5
Worldwide DVD Video Player Set-Top Box Semiconductor Forecast



Source: Dataquest (October 1996)

The STi3500, introduced in 1993, is generally recognized as the industry's first single-chip MPEG-2 video decoder in production. Because of its early availability, it found its way into many first-generation digital platforms. Thomson Consumer Electronics-manufactured DSS set-top boxes based on the Sti3500 began shipping in 1994 and continued to use derivatives of the part until early 1996. SGS-Thomson still manufactures the Sti3500, even though it now offers more integrated, more cost-effective parts.

The STi4500/4510 MPEG-2 audio decoder is a companion chip to the STi3500A.

The Sti3520, introduced in April 1995, combines the features of the Sti3500 and Sti4500 into a single-chip MPEG-2 audio and video decoder. The device is targeted at the markets for direct broadcast satellite (DBS) and digital cable TV set-top boxes.

The Sti3520A is an enhancement to the Sti3520 that reduces memory requirements for PAL-format video and that integrates a phase-locked loop (PLL).

The Sti3550 is a combined MPEG-2 audio and video decoder designed for DVD players and drives. The device supports output in NTSC and PAL data bit rates and has a serial interface for linking to the AC-3 audio used with DVD applications.

The Sti4600 is an audio decoder that can decompress AC-3 format sound typically used with MPEG-2 video in DVD applications. Applications for the Sti4600 include consumer and PC DVD players, as well as high-definition TV (HDTV) receivers and high-end audio equipment.

MPEG-1 Decoders

The Sti3430 is an MPEG-1 video and audio decoder targeted at Video CD and karaoke applications.

The Future

Like every other major player in the digital set-top box silicon market, SGS-Thomson is pursuing an integration path that eventually will reduce the number of chips required for such platforms to just a few devices, down from as many as 12 today. With a price war raging in the set-top box market, a premium has been placed on integration in order to achieve cost reduction. Thomson is developing a highly integrated digital set-top box device—the STi5500, code-named Omega—that combines on a single die MPEG-2 audio and video decoding, transport demultiplexing, video encoding, system control, and peripheral interfaces. Reflecting the strength of SGS-Thomson's product portfolio, the company already has all the cores and functions required to build Omega.

Omega will integrate an ST20 microprocessor, a 32-bit RISC microprocessor core capable not only of system control, but also of running the operating systems, applications, and drivers used in a set-top box. Beyond that, the ST20 will be capable of running interactive applications such as programming guides or even Internet access. SGS-Thomson may offer a version of the ST20 that is optimized to run Java code.

Expected to begin shipment to customers in the fourth quarter of 1997, Omega will allow the creation of digital satellite set-top boxes based on just three logic chips, a tuner, and a single 16Mb SDRAM, as illustrated in Figure 6. In comparison, SGS-Thomson's current digital set-top box solution requires five logic chips, a tuner, and two memories totaling 20Mb.

Reflecting Thomson's strong position in the satellite set-top box market, the company already has a chip that supports the type of error correction and demodulation used in satellite set-top boxes. However, the company at present lacks similar front-end chips for cable and multipoint, multichannel distribution system-type digital set-top boxes. Such chips are in the works, however.

When Omega ships, SGS-Thomson will have a solution that will be close to, but somewhat behind, the integration level of that offered by competitors such as LSI Logic.

In a separate effort, SGS-Thomson is part of a consortium that is developing a chipset for televisions that work with the segment of the European Digital Video Broadcasting (DVB) standard that deals with terrestrial digital video broadcasting. The project, called DVBRID, will produce a four-chip solution for digital television that will be completed in late 1997. The chipset will be used in a trial of the system in the United Kingdom later that year. The DVBIRD chipset is likely to establish the required semiconductor technology for terrestrial digital video systems throughout Europe.

SGS-Thomson is responsible for the forward error correction (FEC) portion of the DVBRID chipset, using technology originally developed for its digital satellite set-top box chips. Leveraging the work it has done on DVBIRD, SGS-Thomson plans to introduce in early 1998 a more integrated DVB chipset using its 0.35-micron process technology. The more highly integrated version of DVBIRD will consist of only two or three devices.

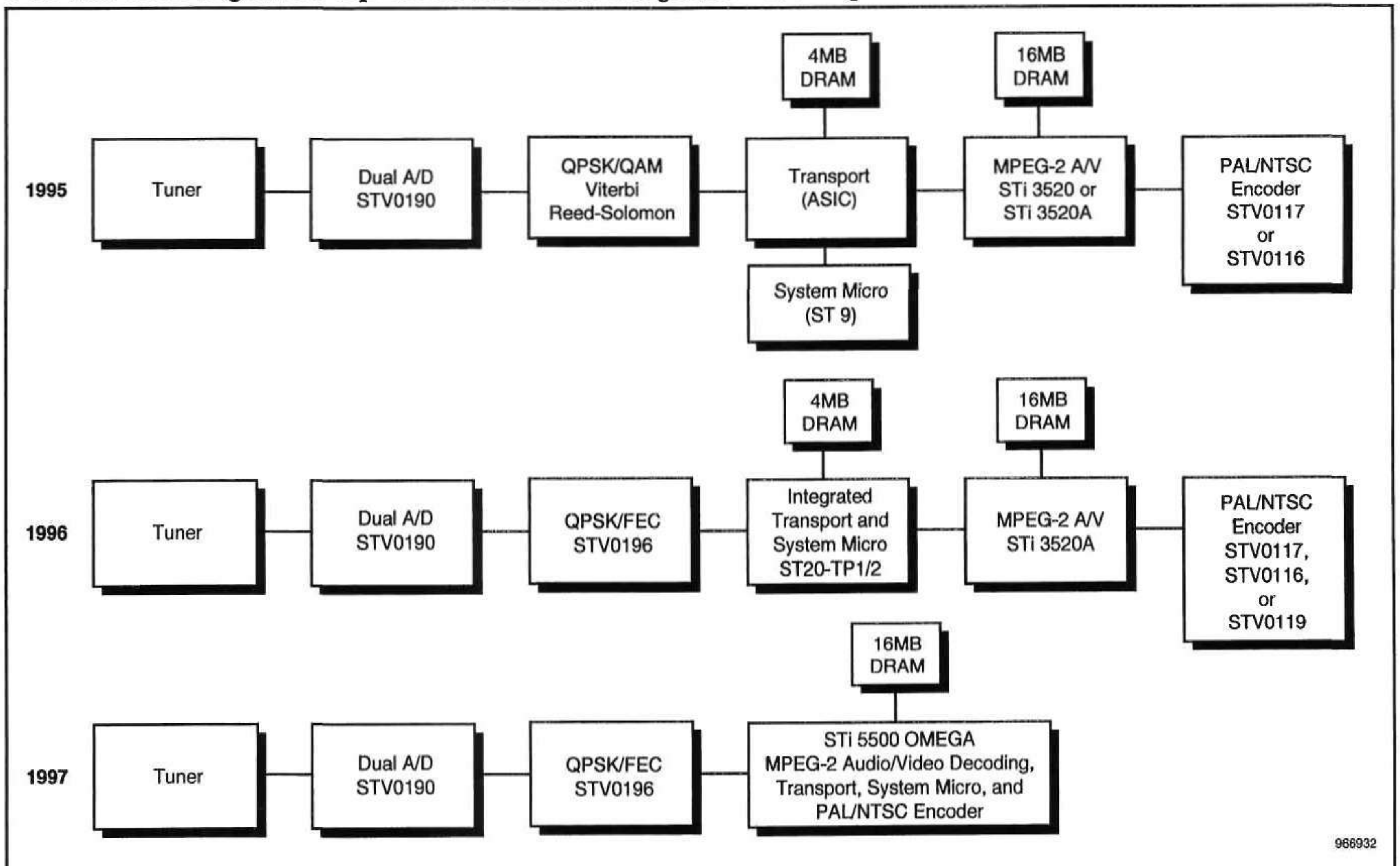
Thomson's work on the DVBIRD project and its own development work in digital video chipsets will allow it to be one of the leading vendors of chipsets for both digital set-top boxes and for digital televisions in Europe, as well as other regions of the world.

SGS-Thomson is planning to offer chips that address most of the major subsystems in a DVD player, including audio and video decoding and processing, servo electronics, channel encoding and decoding, and SCSI/EIDE interface.

Customers and Partnerships

Despite sharing a name and—indirectly—sharing some ownership by a common parent company, SGS-Thomson and Thomson Consumer Electronics say there is no special arrangement between their two companies beyond a normal customer/vendor relationship. However, the two companies clearly have benefited from working together. Thomson Consumer Electronics in 1995 was the No. 1 maker of digital DBS boxes, with 1.26 million sold that year. The vast majority of those boxes were based on SGS-Thomson MPEG-2 decoders, making SGS-Thomson the world's largest vendor of those devices.

Figure 6
SGS-Thomson's Digital Set-Top Box Semiconductor Integration Road Map



Source: SGS-Thomson, Dataquest (October 1996)

Beyond Thomson Consumer Electronics, SGS-Thomson also has garnered other design-wins for its MPEG-2 decoders and transport chips, most notably with Sony.

Dataquest Analysis

On most fronts, SGS-Thomson is well-positioned to continue to exploit opportunities offered by the digitization of consumer electronics. Just as SGS-Thomson's experience in consumer electronics semiconductors helped it identify MPEG as a key technology at an early stage, the company's leading position in digital video chips will allow it to enter new product areas quickly and attain leadership.

SGS-Thomson's experience in digital set-top boxes, combined with its work on the DVBRID project, will allow it to establish a leading role in the emerging digital television market in Europe. The introduction of Thomson's highly integrated version of the DVBIRD chipset will coincide with the commencement of terrestrial digital video broadcasting in Europe.

However, the influence of DVB is spreading beyond Europe. The DVB standard is moving ahead rapidly, with versions having been developed for all common delivery systems, including satellite, cable, and terrestrial. DVB is emerging as the standard of choice for digital video systems such as DBS in all regions of the world, excluding the United States.

Meanwhile, other next-generation and digital television standards worldwide are floundering. U.S. HDTV is mired in the political process and is being held hostage by special interests. Calls are increasing to scuttle the idea of setting a digital television standard at all and to let the market decide. Japanese MUSE analog HDTV is still bumping along, with sets costing a whopping $3,500 and only a few hours of broadcast available each week.

With other standards failing, DVB could become the worldwide standard for next-generation television, mirroring the success of the Global System for Mobile Communications (GSM) in digital cellular applications.

On the DVD front, SGS-Thomson is leveraging its knowledge of digital video systems to come to market quickly with a chipset. Given that the company has more experience than any other in the high-volume manufacturing of MPEG-2 decoders, SGS-Thomson's products will be extremely cost-competitive in the DVD market.

One cloud does loom on the horizon for SGS-Thomson, though. While Omega may put the company in the pack in the integration race that is raging now, it is not as integrated as other solutions offered or soon to be offered by companies such as LSI Logic, VLSI Technology, and Texas Instruments. Companies in that race are leapfrogging each other at an accelerating pace, increasing the penalty for straggling with each design cycle in the market.

Despite that, SGS-Thomson's early leadership in MPEG-2 decoding and transport will help it to maintain a strong position in the digital set-top box market. Designers in Thomson Consumer Electronics and in other companies have a great deal of familiarity with the SGS-Thomson parts, making them easier to design in than parts from some other competitors.

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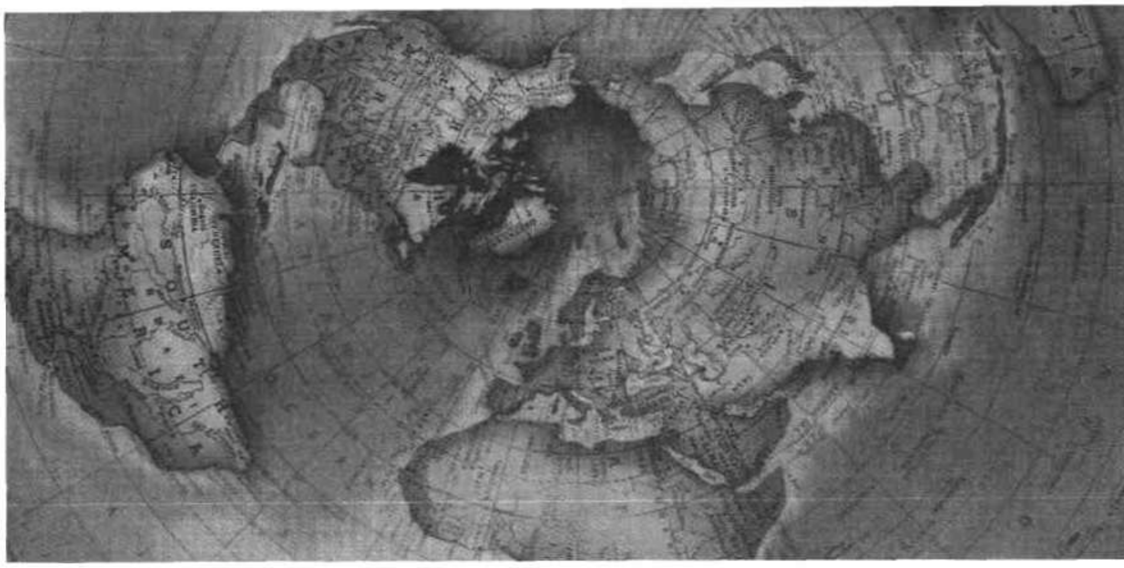
Perspective



Consumer Multimedia Semiconductors and Applications Worldwide

Market Analysis

Media Processors Help Bridge the Gap between Computers and Consumer Electronics

Abstract: *The markets for computers and consumer electronics equipment are charging forward on convergent paths. The consumer electronics market is "going digital" at the same time that multimedia computers are becoming more consumer oriented. One specific example of a semiconductor product that bridges the gap between computers and consumer electronics is a media processor. This document is a variation of a Perspective published by the Semiconductor Directions in PCs and PC Multimedia Worldwide program at Dataquest. It has been revised for delivery to clients of the Consumer Multimedia Semiconductors and Applications Worldwide program because of its relevance to consumer electronics semiconductor markets.*

New products called media processors and media engines could bring more multimedia performance to PCs for a lower price than conventional chipsets. These devices are unproven in the marketplace because they are new, but they offer some compelling benefits. Product positioning is squarely between application-specific standard products (ASSPs) and general microprocessors, leveraging the speed and programmability benefits of each of those products. Media processors must compete with ASSPs as well as with multimedia enhancement to general microprocessors, such as Intel's MMX, to be successful. The market for these products expands beyond PCs into consumer and communications equipment, but this document focuses on the PC market opportunity. This document defines what a media processor is, identifies key issues for these products, and provides a five-year forecast for the use of these devices in PCs.

By Geoff Ballew

New Chips Provide More Bang for the Buck in Multimedia PCs

Multimedia. This one word has a tremendous impact on PC architecture because the simultaneous processing of graphics, audio, and video data places large demands on the major components in a PC. The trend toward

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more multimedia features and higher multimedia performance is pushing PCs harder than ever before. Today's PCs are much faster and better equipped for multimedia processing than they were just a few years ago, but they are clearly not powerful enough to handle new multimedia features such as 3-D audio, MPEG-2 decompression, and videoconferencing.

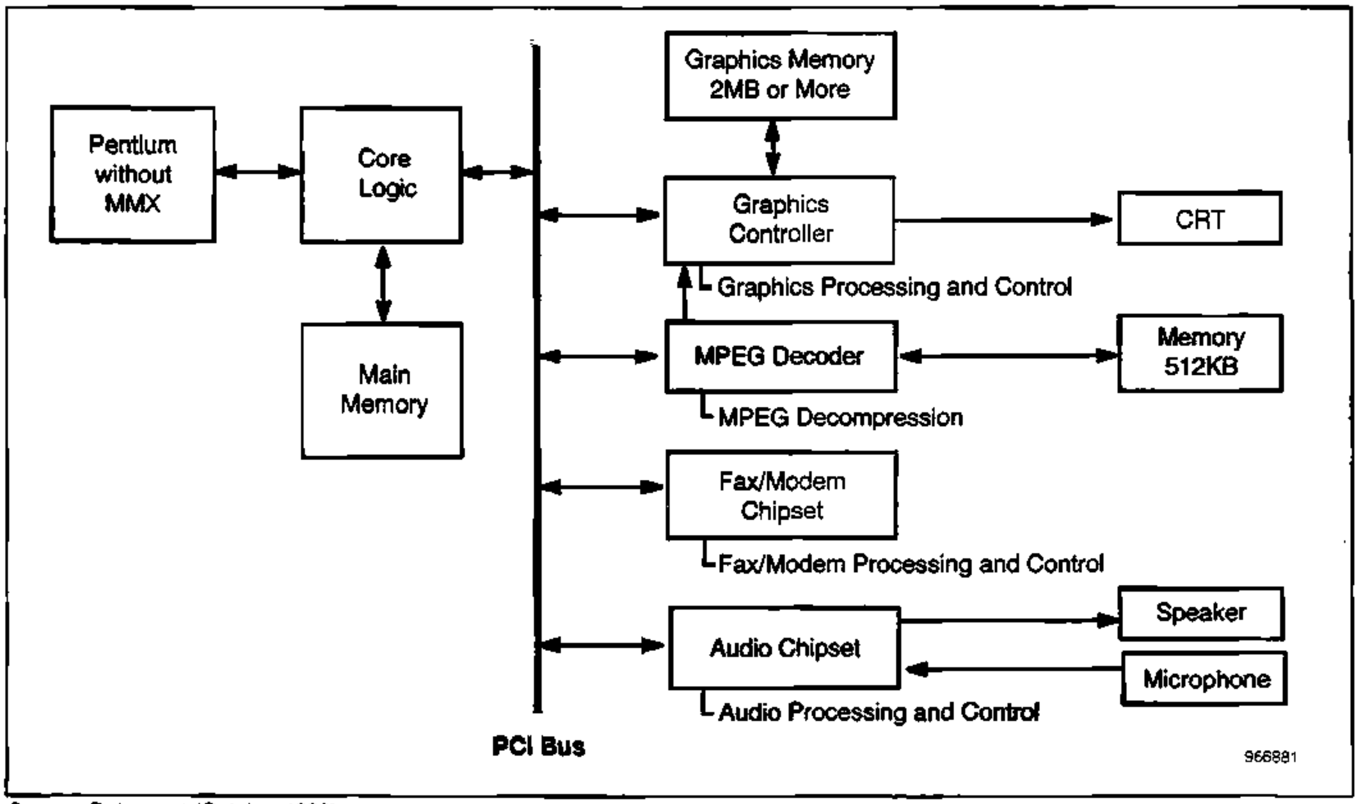
As PC OEMs strive to provide higher multimedia performance at low prices, they need to find efficient ways (on a price versus performance basis) to add additional multimedia muscle to a PC. So far there is no single answer; we have a variety of new solutions and old solutions that will compete. These include improving the application-specific standard products (ASSPs) or fixed-logic chipsets, making the CPU faster with special instructions (such as Intel's MMX) and higher clock speeds, and using an embedded processor that is optimized for multimedia data types. This last category includes chips such as programmable DSPs and a new class of embedded processor called a media processor or media engine. Media processors are the newest solution for boosting PC multimedia performance. They offer compelling benefits, but have some challenges to overcome if they are going to succeed in the PC semiconductor market. For the purposes of this document, media processors are not distinguished from media engines.

Each of these solutions has an impact on PC design, so a basic system diagram showing an example of each one is provided here. A bulleted list of the digital signal-processing tasks handled by each chip or chipset is provided, with the bullet located below the chip or chipset that performs that task. Figure 1 shows a typical multimedia PC with the multimedia features implemented with standard chipsets or ASSPs. Note that each subsystem (graphics, audio, and fax/modem) is implemented with a complete chipset. Figure 2 shows the same features using a CPU enhanced with Intel's MMX instruction set. This solution leverages the computing power of the CPU for signal processing and control functions instead of putting dedicated controllers in the peripheral chipsets. Figure 3 shows an implementation using a media processor called Mpact from Chromatic Research, a media processor company. This solution is similar to the one shown in Figure 2 but uses a dedicated processor rather than the CPU for signal processing and control. Each of these three solutions has price and performance advantages and disadvantages. Also, it is important to note that these solutions are not mutually exclusive. As Intel incorporates MMX into its entire x86 MPU product line, MMX will coexist with ASSPs and media processors in the same systems because the performance should be additive. This means that a system having MMX and a media processor will be more powerful than a system with a media processor but without MMX.

Media Processors: What Are They?

Media processors are a new class of semiconductor device. They have fixed-logic elements just like ASSPs or standard chipsets, but they also have a programmable signal processing core like a programmable digital signal processor (pDSP). These products are designed for processing digital signals just like a pDSP but have additional features that make them more suitable for PC and consumer electronics applications. These features include standard bus interfaces such as Peripheral Component Interconnect (PCI) and I^2C, integrated ASSP functions such as a VGA controller, greater processing power, and a high degree of concurrency for handling multiple real-time processes. A general definition of a media processor is a device that meets the following criteria:

Figure 1
System Diagram of a Multimedia PC with 3-D Graphics, MPEG, Telephony, and Audio Features Implemented with ASSPs

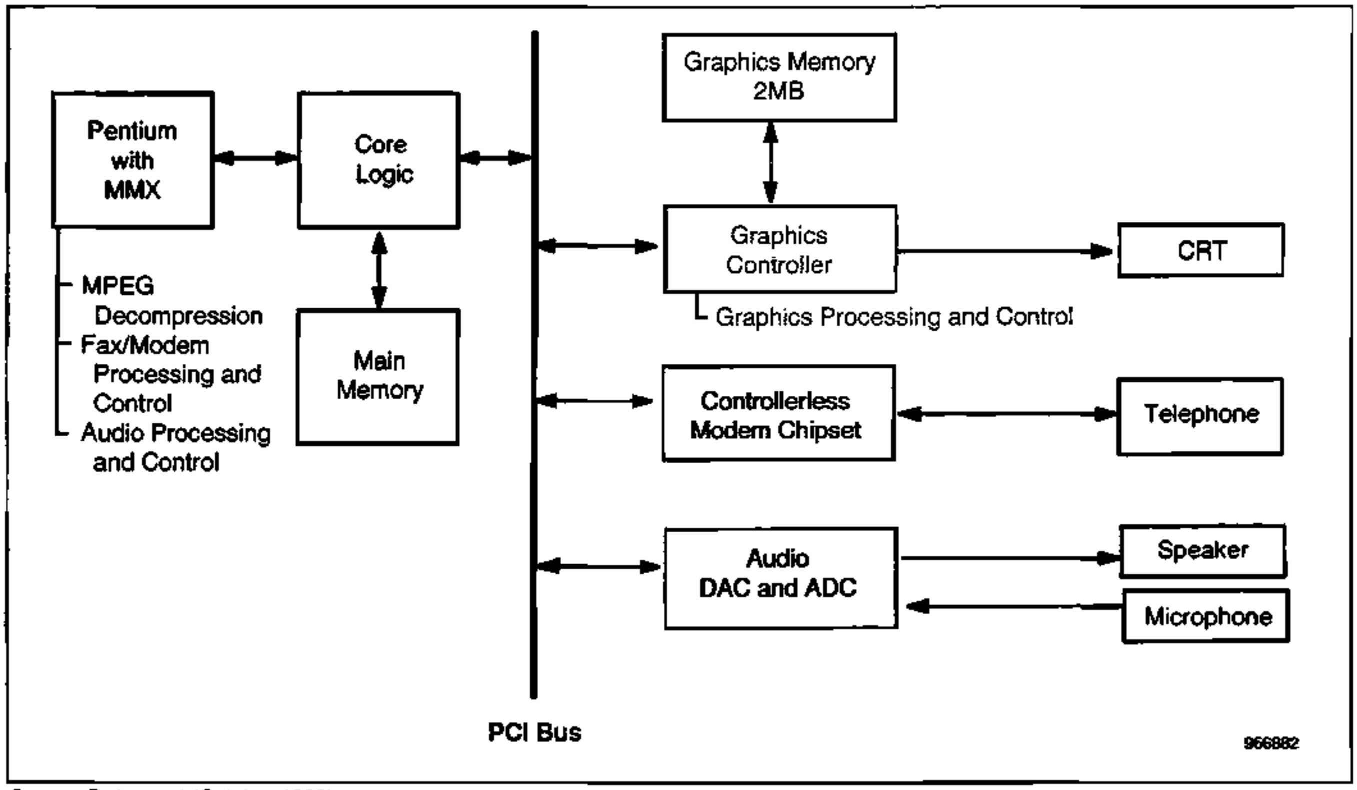


Source: Dataquest (October 1996)

- Media processors are programmable. This separates them from highly integrated, multiple-function logic chipsets, such as integrated audio and fax/modem chipsets.
- Media processors must have a high degree of concurrency. The ability to handle three or more real-time processes simultaneously is essential.
- Media processors have a dedicated purpose. The addition of application-specific bus interfaces, such as PCI or I^2C, targets these devices to communications and multimedia applications in PCs and consumer electronics rather than other applications for digital signal processing. This also distinguishes media processors from general-purpose microprocessors with multimedia functions, such as Intel's MMX.

These requirements are very general, but so is the media processor product category. These devices straddle the abyss between fixed logic implementations such as ASSPs (which are fast but not flexible) and general-purpose microprocessors (which are flexible but not fast). Figure 4 shows this graphically.

Figure 2
System Diagram of a Multimedia PC with 3-D Graphics, MPEG, Telephony, and Audio Features Implemented with MMX

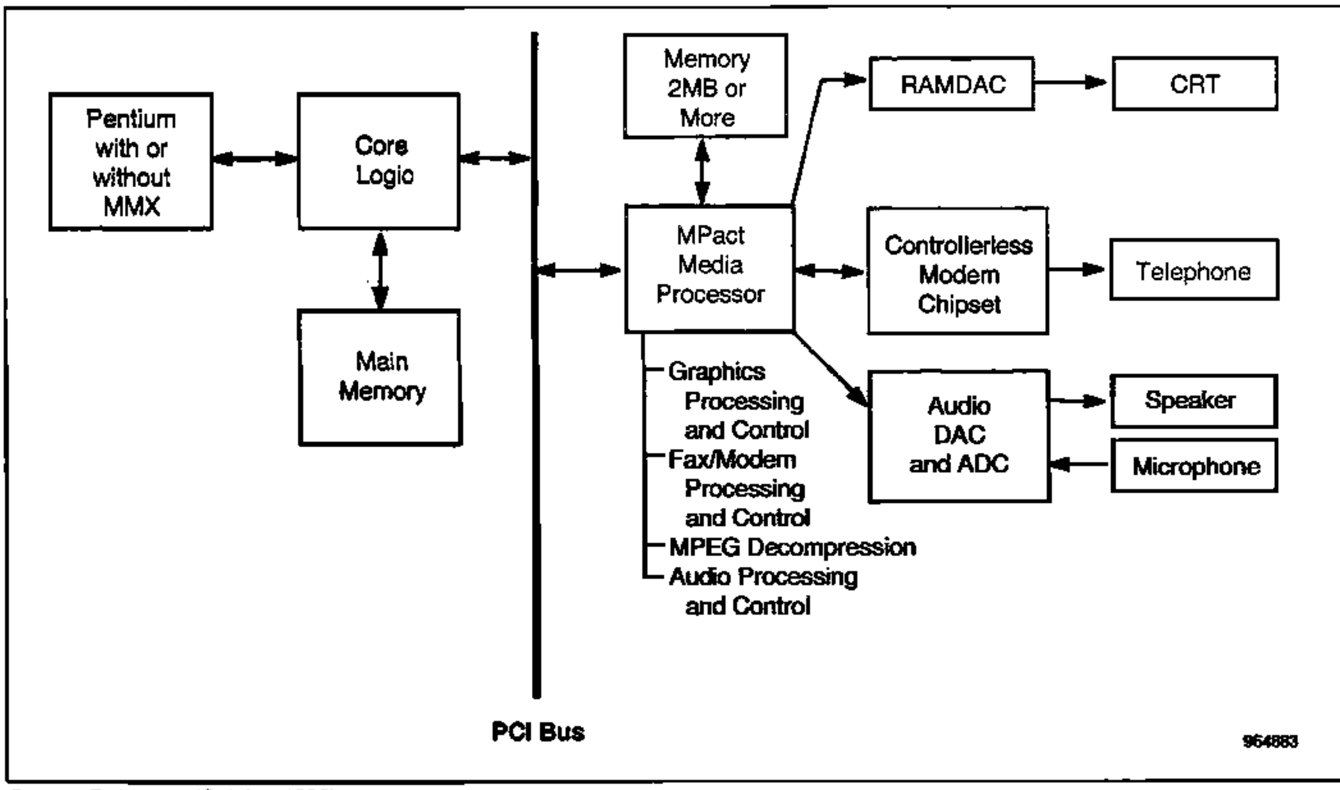


Source: Dataquest (October 1996)

Software Defines the Functionality

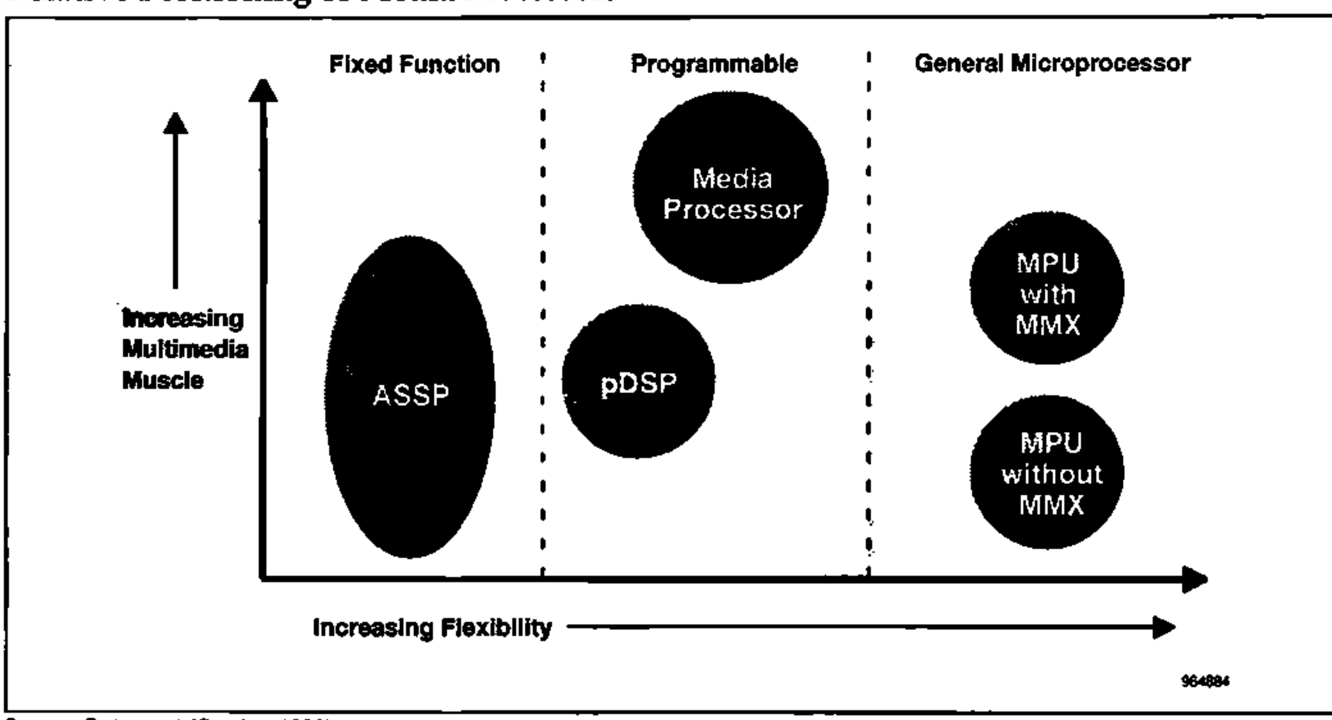
Media processors require software to define their functionality. The hardware provides computational power for processing digital signals, but software is required for compatibility with various data types, standards, and protocols such as V.34 for modems, Sound Blaster compatibility for audio processing, and even digital video decoding standards such as MPEG-1. This is in sharp contrast to ASSPs because those products have the required standards and protocols implemented in the chips rather than requiring software to provide compatibility. Of course both media processors and ASSPs require software drivers to interface with the PC operating system, such as Windows 95. Figure 5 highlights the division between hardware and software for media processors compared with ASSPs.

Figure 3
System Diagram of a Multimedia PC with 3-D Graphics, MPEG, Telephony, and Audio Features Implemented with a Media Processor



Source: Dataquest (October 1996)

Figure 4
Relative Positioning of Media Processors



Source: Dataquest (October 1996)

Figure 5
Media Processors Rely on Software for Compatibility

	ASSPs	Media Processors
Interface to Operating System Such as Windows 95	Software	Software
Compatibility with Standards and Data Types	Hardware	Software
Processing Power	Hardware	Hardware

964885

Source: Dataquest (October 1996)

The Advantages of Media Processors

The major advantages of using media processors over alternative solutions are discussed after this bulleted list:

- Media processors centralize signal processing to reduce redundant functions (and therefore redundant cost) across multiple subsystems, such as audio processing, fax/modem, networking, graphics, and video processing.
- Media processors enable functional upgrades through software rather than hardware changes. This benefits PC OEMs by reducing the risk of inventory and design obsolescence, and it benefits PC users because features and performance can be enhanced without the challenges of opening the PC and changing hardware.
- Scalability allows functions to use as much processing power as possible on a real-time basis.
- Lower total system costs are possible. The potential for cost savings increases dramatically when high-end functions such as MPEG-2 decompression, Dolby AC-3 decoding, and videoconferencing are included.
- Media processors are more powerful than multimedia enhancements to microprocessors.

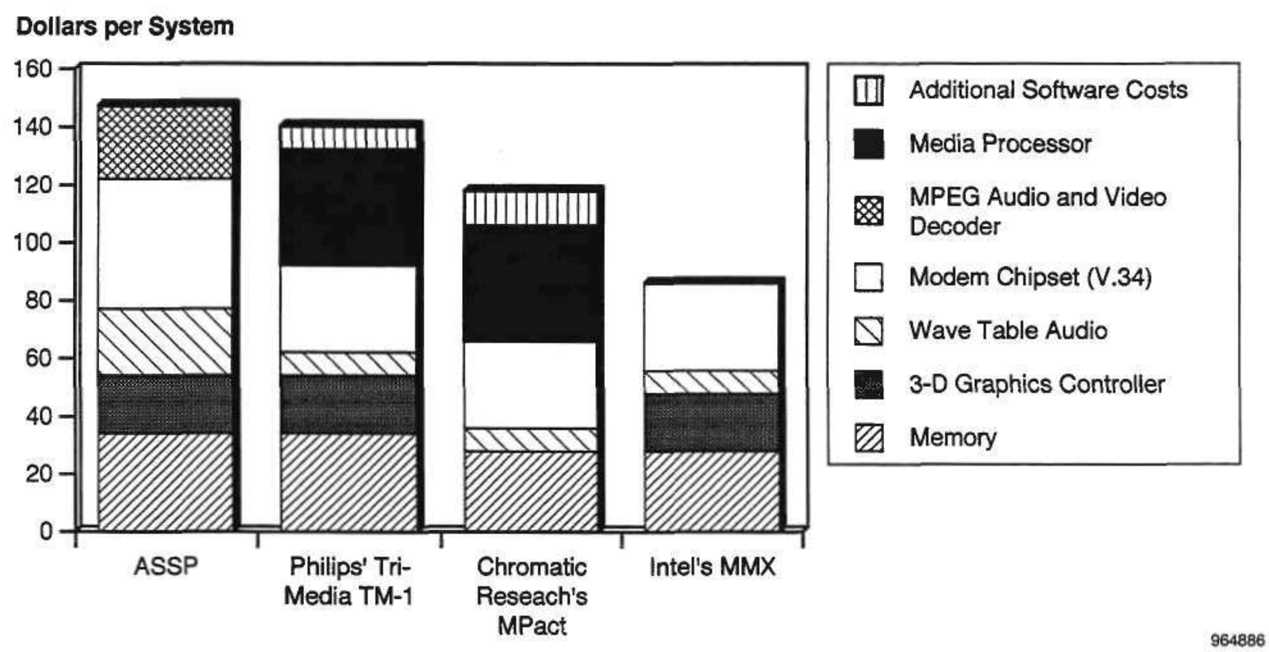
Media processors have the potential to provide many benefits for PC OEMs and PC users by making hardware designs more flexible without incurring a large cost penalty. The traditional way to add features to PCs has been to add a new chipset for each new subsystem—for example, adding a modem chipset for modem functions or an audio chipset for sound processing. The problem with this method is simply that adding another major function requires another standalone chipset. All the functions for a given subsystem are integrated into a compact chipset, but there is little integration across subsystems to minimize the total number of chips (and more specifically the total number of gates) for the whole PC. Media processors are designed to leverage processing power across multiple functions by separating the control elements of peripheral chipsets from the interface elements of peripheral chipsets. Processing power is centralized and can be allocated to various functions (such as MPEG decode, audio processing, or communications processing) on a real-time basis. Media processors do require support chips, such as analog-to-digital conversion (ADC) and digital-to-analog conversion (DAC), to interface with external peripherals. However, the cost of these interface chips is significantly lower than the cost of complete chipsets.

A second benefit of using media processors instead of fixed-logic chipsets is software upgradability. A PC user today who wants to upgrade a modem must take the old modem out and put a new modem in. If a PC has a media processor, its multimedia functions can be upgraded just by installing new software, rather than by opening the box and changing the hardware. In the same way, a PC OEM that designs around a media processor rather than ASSPs will be able to reconfigure inventory and work in process more easily by changing software rather than hardware. This helps protect the OEM against the risks of product obsolescence and having a large inventory of undesirable products in the midst of a technology shift.

A third benefit of media processors is scalability. All of a media processor's processing power is divided among the functions in use on a real-time basis. When only one or two functions are used simultaneously, those functions receive more processing power and therefore show higher performance than they would have in an average ASSP. When the user requires multiple functions in demanding applications such as Internet gaming (a simultaneous use of modem, audio, graphics, and probably motion video decoding) each function receives only its share of the total processing power. For this reason, media processors must be powerful enough to process multiple data streams concurrently.

A fourth benefit of using a media processor is the opportunity for a lower total bill of materials cost to implement a feature-rich, multimedia PC. A PC with a media processor requires only a controllerless chipset, rather than a standard chipset, for a given subsystem such as a fax/modem. A controllerless chipset is a subset of a standard chipset; it does not include the microcontroller and DSP functions, which makes it less expensive than a standard chipset. The media processor provides the microcontroller and DSP functions in place of having those functions in the peripheral chipset. If enough subsystems are added with these lower-cost controllerless chipsets, then the cost savings from buying less-expensive chipsets will exceed the cost of buying the media processor. A rule of thumb is that four or more subsystems must be added to make a media processor cost-effective. If an OEM will use the media processor for only one or two functions, then ASSPs will provide a lower total cost. Figure 6 shows some Dataquest estimates of the semiconductor costs for implementing a multimedia subsystem with the following four functions: accelerated 3-D graphics, MPEG-1 decompression, wave table audio, and V.34 modem functions. Media processors offer more dramatic cost savings if high-end functions like MPEG-2 decoding, Dolby AC-3 decoding, and videoconferencing are added to a PC design.

Figure 6
Cost Comparison between Media Processors and Other Solutions for Adding 3-D Graphics, MPEG, Telephony, and Audio Functions to a Multimedia PC



Source: Dataquest (October 1996)

The fifth advantage is simply that higher performance can be achieved by using a media processor than by relying solely on MMX or other MPU multimedia enhancements for signal-processing power. If a media processor is added to a system with MMX, the available multimedia processing power will be approximately additive. Although the two resources (MMX and a media processor) will not work cooperatively on a single task, the list of tasks can be divided between them to maximize performance.

The Disadvantages of Media Processors

The potential disadvantages of using media processors versus alternative solutions are discussed after this bulleted list:

- Functional redundancy with MMX puts vendors in partial competition with Intel for low-end PC designs.
- There is risk in adopting new design strategies.
- Higher total system costs are possible.

Functional redundancy with MMX and other multimedia enhancements to microprocessors is a potential barrier to getting design-wins in low-end PCs. Media processor vendors are not the only advocates of centralizing multimedia processing. Intel evangelizes the centralized model because it creates greater demand for new microprocessors. The MMX instruction set is one step Intel is taking to make its microprocessors able to process multimedia data more efficiently. Other MPU vendors are implementing similar multimedia enhancements to their own designs. Two examples are Sun Microsystems' Visual Instruction Set (VIS) and Cyrix's own implementation of the MMX instruction set. Media processors and multimedia enhancements to general-purpose MPUs are variations on the same theme. Media processor vendors must position their products carefully against MMX because MMX will be shipping for "free" as it becomes a standard feature in all Intel's Pentium and Pentium Pro microprocessors and as the non-MMX versions are discontinued.

As PC OEMs strive to differentiate their products, there is risk associated with adopting a new design strategy such as using a media processor instead of ASSPs. OEMs that use ASSPs can choose each chipset from a different vendor, so their audio chipset vendor can be independent from their fax/modem chipset vendor. This will change slowly, because higher levels of integration are necessary for minimizing costs, but media processors make this transition much more immediate. Of course, there is also potential gain by adopting a new strategy because it does differentiate one OEM from another.

The issue of total system cost was mentioned as a possible advantage as well as a possible disadvantage. Media processors are new products, so the actual cost of implementation is not established. The total cost of implementation must be competitive compared with ASSP implementations because PCs are sold on the basis of price, performance, and features. Media processor vendors must make the chip and software available at a volume price that makes it competitive even if an OEM does not include high-end functions such as videoconferencing, MPEG-2 decompression, or Dolby AC-3 decoding.

Company Highlights

Two companies, Chromatic Research and Philips Semiconductors, are leading the race to bring media processors to the PC market. Below is a brief description of each company's media processor strategy.

Chromatic Research

Chromatic is bringing a new business model—the "chipless semiconductor company"— to the market. The company's media processor is named Mpact, but will not be manufactured or sold by Chromatic. Strategic partners will make and sell the chip, while Chromatic will sell the software to use the chip. The company has announced two partners so far, LG Semicon and Toshiba, and may add one additional partner.

As a chipless semiconductor company, Chromatic will design new versions of the Mpact chip, as well as write and sell software for the chip. In fact, Chromatic will be the sole source of software "modules" for the Mpact chip. These modules are required for any implementation, but OEMs can purchase only the functions they need. This strategy keeps Chromatic focused on product technology and marketing rather than manufacturing and allows it to leverage the manufacturing expertise and process technology of its partners.

Chromatic announced version 1.0 of Mediaware, the software for the Mpact media processor, on September 23, so both parts of its media processor "solution" are now available. Toshiba and LG Semicon are ready to fabricate volumes of Mpact chips, and Chromatic is ready to ship the software. The next step for these companies is securing design-wins into leading OEMs. Chromatic expects to announce several key design-wins soon, but this information is not yet public.

Philips Semiconductors

This consumer electronics giant has been a market leader in digital video chips but until recently did not actively participate in the PC semiconductor market. Philips is now pursuing the PC market more aggressively with PC graphics products as well as its TriMedia TM-1 media processor. The Tri-Media name refers to a family of media processors that Philips plans to bring to market. TM-1 is the first actual product in the Tri-Media family. In the fall of 1995, the company plunged into the PC graphics market by acquiring the multimedia products group from Western Digital. That acquisition gave Philips immediate access to PC graphics technology, as well as giving it the Paradise brand name for board-level graphics products.

Philips is using its expertise in signal processing (most notably video encoders, decoders, ADCs, and DACs) to gain a larger role in the PC semiconductor market. TM-1 is focused on signal processing for the PC but does not include a VGA controller. This makes it highly complementary to the graphics products acquired from Western Digital. Future products in the TriMedia family will be tailored for consumer applications other than PCs. Those products are likely to include VGA or TV output as well as greater capability to act as the system microprocessor rather than just as a coprocessor like the TM-1.

Others

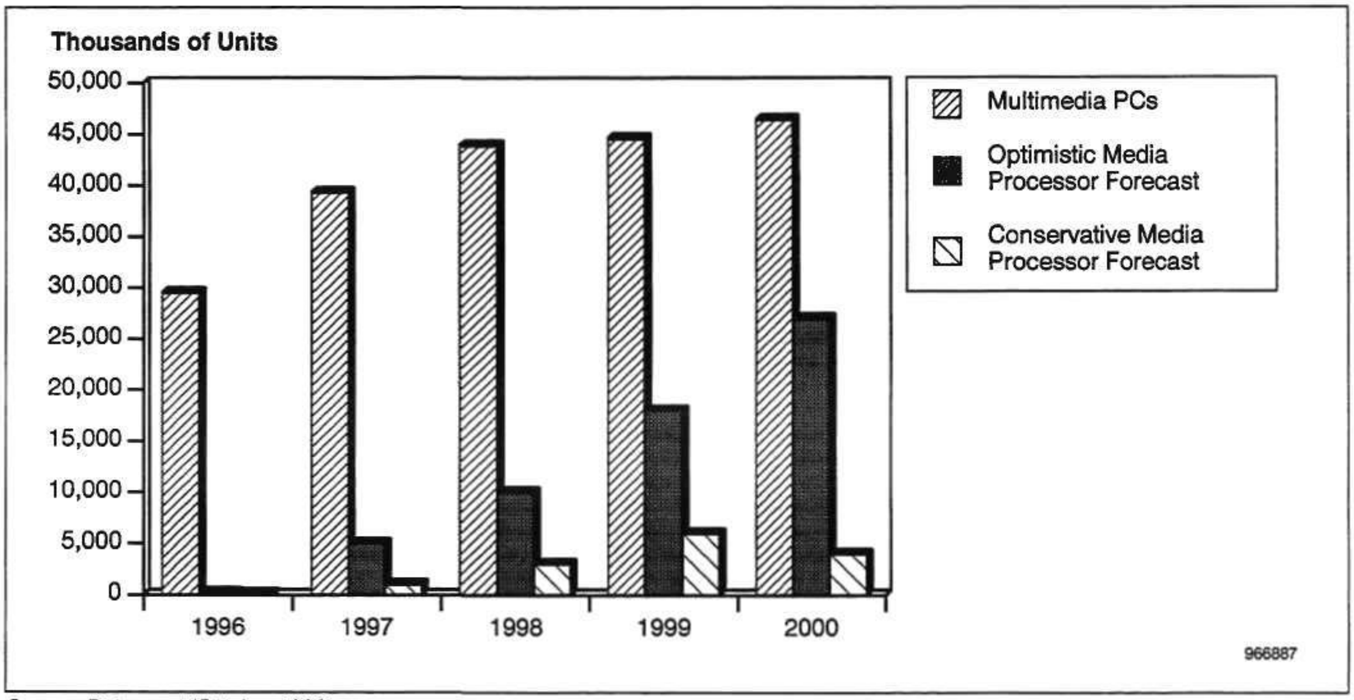
Several other companies have announced development efforts for media processors, including Samsung, Mitsubishi, and others. Also, a number of companies are developing products that are similar to media processors but fall into other product categories. These include programmable DSPs like IBM's MWave chip and products from Analog Devices, as well as multifunction chipsets like NVidia's NV1 and NV3 products. These products will compete with media processors for PC design-wins, but they offer varying levels of performance and programmability.

Five-Year Forecast

Multimedia PCs

Multimedia PC shipments will continue to grow through the year 2000, with slower growth in 1999 and 2000. Figure 7 and Tables 1 and 2 show Dataquest's forecast for multimedia PCs and media processors used in PCs through the year 2000. The limiting factor for this forecast is the attach rate of CD-ROM drives. Dataquest's definition of a multimedia PC requires an audio subsystem as well as a CD-ROM drive. Two market factors that could provide stronger growth for 1999 and 2000 are continued strong demand for home PCs and continued emphasis on CD-ROM discs as media for software distribution. Software distribution is a significant reason for adding a CD-ROM drive to any PC that is not networked, so this forecast should be viewed as conservative for 1998 to 2000.

Figure 7
Five-Year Forecast for Multimedia PCs and Media Processors Used in PCs



Source: Dataquest (October 1996)

Media Processors

Media processors are a new product that will bring new levels of flexibility to the PC market. These devices are becoming available at a critical time in the PC market, as expectations for multimedia processing are increasing faster than microprocessor performance. Multimedia functions can always be implemented in ASSPs, but the cost of adding multiple chipsets can be prohibitive and this approach does not take advantage of redundancies across chipsets. Media processors have the opportunity to balance this equation by providing lots of processing power tailored for multimedia data types (audio, video, communications, and graphics) at a competitive price versus performance level. However, the adoption of media processors into a product does require a shift in product design and configuration. For media processors, 1996 will be an interesting year, with some exciting announcements of design-wins, but it will not be a strong indicator of long-term acceptance. Philips is not scheduled to reach volume production until first quarter 1997, and other vendors will take even longer. Greater competition between media processor vendors will develop as they bring new products to market through 1997 and 1998.

Table 1
Five-Year Unit Forecast for Media Processors Used in PCs (Thousands of Units)

	1996	1997	1998	1999	2000	CAGR (%) 1996-2000
Multimedia PCs	29,503	39,302	43,905	44,595	46,455	12.0
Optimistic Forecast	200	5,000	10,000	18,000	27,000	240.9
Conservative Forecast	100	1,000	3,000	6,000	4,000	151.5

Source: Dataquest (October 1996)

Table 2
Five-Year Revenue Forecast for Media Processors Used in PCs (Thousands of Dollars)

	1996	1997	1998	1999	2000	CAGR (%) 1996-2000
Optimistic Forecast	8,000	190,000	360,000	630,000	945,000	229.7
Conservative Forecast	4,000	38,000	108,000	210,000	140,000	143.2
Dataquest Estimated ASP ($)	40	38	36	35	35	-3.3

Source: Dataquest (October 1996)

Media processors are a new product and have not started shipping as of the date of this forecast. At this early stage in the market, Dataquest has forecast media processor shipments based on the best of its knowledge and information and has provided two scenarios (optimistic and conservative). Actual shipments are expected to fall somewhere between these two scenarios. This forecast will be updated as more information becomes available and as these products begin to ship into the PC marketplace. Critical factors that will affect media processor shipments are:

- Willingness of ASSP vendors to compete in a price war
- Willingness of OEMs to embrace programmable solutions versus ASSPs
- Introduction of media processors from additional vendors to increase competition
- Real demand for high-performance multimedia features such as MPEG-2 decompression, AC-3 decoding, and videoconferencing

Dataquest Perspective

Multimedia muscle, or the ability to process digital information for audio, video, and communications applications, is increasingly important for computing applications as well as consumer electronics applications. Media processors are new products that could help fill the need for multimedia muscle in these two applications markets, but PCs will be the initial driver for media processor shipments. Additional opportunity exists within consumer electronics as consumer devices become increasingly based on digital technologies and the gap between PCs and consumer electronics gets narrower.

Media processors could bring advantages such as scalability and programmability to the consumer electronics market. Most consumer electronics products are not upgradable; they are usually replaced if new formats, standards, or other requirements develop. The technology treadmill moves quickly, and flexible, programmable designs are important. The ability to adopt new technologies quickly could be a key differentiator among consumer electronics OEMs as their products increasingly compete with computers as sources of entertainment.

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Perspective

Consumer Multimedia Semiconductors and Applications Worldwide

Market Analysis

Set-Top Box Semiconductor Opportunity

Abstract: *This document analyzes the competitive landscape and opportunities for makers of semiconductors for digital set-top box boxes. A forecast of growth of set-top box production and their semiconductors is presented. This report also provides an analysis of changes in set-top box architectures and ways in which semiconductor manufacturers can tailor their products and strategies to address those trends.*
By Jonathan Cassell

Set-Top Box Definitions

"Set-top box" is a generic term that means different things to different industries. The seven product categories presented in Table 1 all have been referred to as set-top boxes (STBs), based merely on their location in relation to the TV set.

This report will focus on the first category, pay TV receivers, specifically, digital pay TV receivers. In this document, digital pay TV receivers are referred to as digital set-top boxes. Digital STBs are pay TV receivers capable of accepting digital audio and digital video input. This is in contrast to analog STBs—the most common type of pay TV receiver in use today—which can accept analog audio and video signals. Digital STBs that use all kinds of delivery technologies will be covered in this report, including cable and satellite types. Table 2 presents a list of definitions of digital STB terms.

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Table 1
Descriptions of Various Products Referred to as Set-Top Boxes

Product	Description
Pay TV Receivers	Includes both analog and digital receivers. Includes cable, Direct Broadcast Satellite (DBS), and Multipoint Multichannel Distribution System (MMDS) pay TV receivers.
Dedicated Game Consoles	Examples are Sony PlayStation and Sega Saturn
Read-Only Multimedia Computers	Examples are 3DO and Philips CD-I. Formerly known at Dataquest as TV CD-ROM players. This category is being replaced by dedicated game consoles.
Back-Channel Transmitters	Allow user to play along with networked sports and game shows—TV Answer, for example.
Audio and Data Decoders	Used for nonvideo signals transmitted out of band in the vertical blanking interval, in-band video, or in-band audio. Include digital cable radio and closed captioning.
Navigational Systems	A special type of data decoder for electronic programming guides. Dedicated hardware systems exist, but most are being integrated into pay TV receivers. Examples are StarSight, Prevue Network, and Interactive TV Guide.
Data Storage Devices	Examples are VCR-Plus and Sega Channel Game Adapter

Source: Dataquest (August 1996)

The Digital Transformation

The STB market is undergoing a mass migration from analog to digital technology. This migration is fundamentally changing the shape of the STB market. Digital technology allows STBs to receive many more channels with much higher quality audio and video than is possible with analog systems. It also increases the interactive capabilities of STBs, giving customers a greater choice of what to watch and when. Even more significantly, digital technology is bringing a new business model to the STB market, a model that adds real competition to the equation for the first time.

With the proliferation of new digital television systems, such as DirecTV, PrimeStar, and EchoStar, consumers now have a choice of which service to subscribe to, which provides an alternative to the monopolistic delivery model of analog cable. The emergence of digital television standards, such as digital video broadcasting (DVB), has allowed STB vendors for the first time to compete on price and technology, in contrast to the analog market, where customers were forced to use proprietary boxes rented to them by their cable service provider. Some digital STBs now are sold in retail outlets, allowing customers to compare products from numerous manufacturers and make choices based on price, features, and brand name.

Dataquest Perspective

If anything, the EchoStar price cut illustrates the benefits that highly integrated silicon can bring. EchoStar was considered an underdog in the DBS market. The company was several months late in beginning its services, and it entered a market dominated by the rapidly growing DirecTV/USSB DSS system. However, cutting its price to just $199 should do a great deal to boost its fortunes in the market.

EchoStar said it was able to achieve the price reduction in its second-generation system by using highly integrated silicon in its systems. The EchoStar system uses a proprietary ASIC that integrates functions that formerly took 12 chips to perform, including MPEG-2 transport decoding, DVB descrambling, and general-purpose input/output.

Although the integration will allow EchoStar to cut costs, it will not reduce them enough to allow it to make any money off the sales of the boxes or even to break even. At $199, EchoStar is losing money on each unit it sells. EchoStar acknowledges that its strategy is to make a profit by selling services, rather than the boxes themselves. The fact that EchoStar is willing to take this step shows how tough the competition in the DBS market is—and how great the rewards are for running a successful service. EchoStar's move also underscores the importance that STB makers are placing on finding low-cost silicon solutions that will allow them to minimize losses from equipment sales.

Many semiconductor companies participating in the digital STB market now possess strengths in specific technology areas. As long as integration strategies are limited to certain portions of the STB, such as demodulation or MPEG decompression, those companies will do well. However, in the long term, digital STB makers will be seeking chipsets that integrate most functions into just one, two, or three chips. This will require semiconductor vendors to have all STB functions in their portfolio. Semiconductor makers wanting to be players in this market in the long term should ensure that they have all the pieces of the STB puzzle through internal development, partnerships, licensing, and acquisition. The STB market likely will follow the pattern of the PC market, where OEMs use high-volume ASSPs to reduce costs. Thus, in the long term, STB silicon solutions should be standard chipsets.

In the war between DSS and DVB, DVB appears to be the long-term winner. By 2000, DVB should constitute the majority of digital video systems. Although DSS now has more support, the openness of the DVB standard eventually will cause it to be adopted by more MSOs and STB vendors worldwide. It is expected to become dominant in the same fashion that Europe's General Standard for Mobile Communications (GSM) has for cellular phones. Intrinsically, DSS is somewhat cheaper to implement compared with DVB, given that it is specifically designed for only one market and has no requirements to support multiple languages and Chinese characters, such as DVB does. However, the widespread support that DVB will garner will allow it to achieve lower costs in the long run. DVB's influence may well extend beyond STBs. While efforts to develop a digital high-definition TV standard in the United States have been mired in factional fighting, DVB—with its comprehensive support for digital broadcast—could become the worldwide standard for next-generation television.

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Table 2
Digital Set-Top Box Terminology

Term	Definition
Set-Top Box	In this document, STB refers specifically to pay TV receivers.
Digital Set-Top Box	An STB that receives digital audio and video signals
Analog Set-Top Box	An STB that receives analog audio, and video signals
Analog Television	A television system that broadcasts audio and video in an analog format Analog is the most common form of broadcast today and is used by the majority of cable and radio frequency systems.
Digital Television	Television systems that deliver digital audio and video to STBs using any one of a variety of delivery technologies
Digital Cable	A digital television system that broadcasts digital audio and video signals to STBs over cable lines
Direct Broadcast Satellite	DBS is generic term for a technology that broadcasts video and data from satellites directly to STBs attached to receiver dishes. Also known as Direct to Home (DTH)
Digital Video Broadcasting	DVB is a European-based group of international companies formed to set standards for digital video broadcasting. DVB standards cover satellite, cable, and other delivery technologies.
Digital Satellite Service	DSS is a DBS system designed by Hughes Electronics Corp. for use with its satellite system. Works with DSS-type DBS set-top boxes.
Asymmetrical Digital Subscriber Loop	ADSL is a digital television delivery technology that makes telephone twisted-pair lines capable of supporting MPEG-2 transmissions.
Multipoint Multichannel Distribution System	MMDS is a digital television delivery technology that broadcasts multiple channels of video and data services from a central transmitter, also known as wireless cable.
Hybrid Fiber Coax	HFC is a technology that can be used for digital and analog television delivery. Switched digital video allows interactive digital TV to be broadcast as well as two-way communications over cable lines. HFC uses fiber links from the central site to neighborhood hubs and then uses coaxial cable to transmit to homes.
Switched Digital Video	SDV is similar to HFC except that it requires a digital STB to receive the signals in the home.
MPEG-2	A standard from the Motion Picture Experts Group for video compression The most commonly used compression technology for digital video systems
Multiple Service Operator	MSOs are providers of television services, such as cable TV or DBS companies.

Source: Dataquest (August 1996)

In 1996, the dynamics of this new, highly competitive market are beginning to assert themselves. DBS MSOs are cutting subscriber rates to steal customers away from analog cable and from other digital satellite services. STB makers, too, are slashing the price of their equipment. In the future, competition will become more intense as new MSOs enter the market using any one of the variety of delivery methods possible with digital STBs.

For chipmakers, the hot competition means hot opportunity as STB makers and MSOs look to the semiconductor content of their equipment to cut costs. STB makers are finding that better silicon translates directly into competitive advantage. With the emphasis on cost reduction, semiconductor vendors that can offer their customers low-cost, highly integrated standard products for digital STBs will be successful in the long run.

The Digital Set-Top Box Market

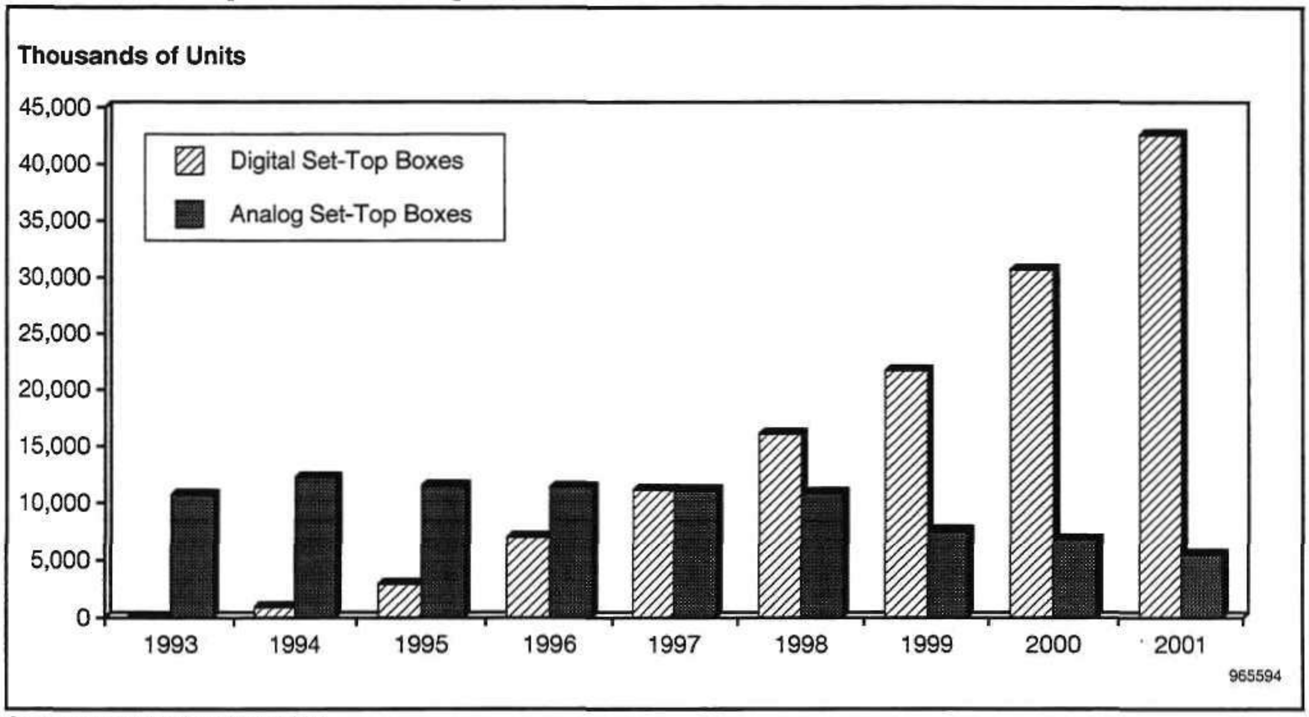
The move from analog to digital technology in the set-top market unlocks the potential for fast growth. Sales growth for analog STBs has ceased in recent years because of the tight control that analog cable MSOs have over the distribution of their equipment. Analog cable MSOs rent their STBs. When customers no longer need the analog cable box, they return it to the MSO, which then rents it to someone else, increasing the life span of that equipment and depressing sales of new STBs. Analog STBs tend to be proprietary to the MSO, eliminating the possibility of consumers choosing which box they want to use.

As consumers are attracted to the larger number of channels and higher quality of video and audio brought by digital video systems, they will begin to buy more digital STBs than analog ones. As shown in Figure 1, the bulk of production in 1997 will cross over from analog to digital STBs in order to meet customer demand. Production of digital STBs will grow rapidly over the next few years, increasing to more than 42 million units in 2001, up from 2.9 million in 1995.

Because digital STBs have higher average selling prices (ASPs) than analog STBs, factory revenue from sales of digital STBs surpassed that of analog STBs in 1995, as shown in Figure 2. Factory revenue from sales of digital STBs is expected to grow to nearly $9 billion in 2001, up from $1.4 billion in 1995.

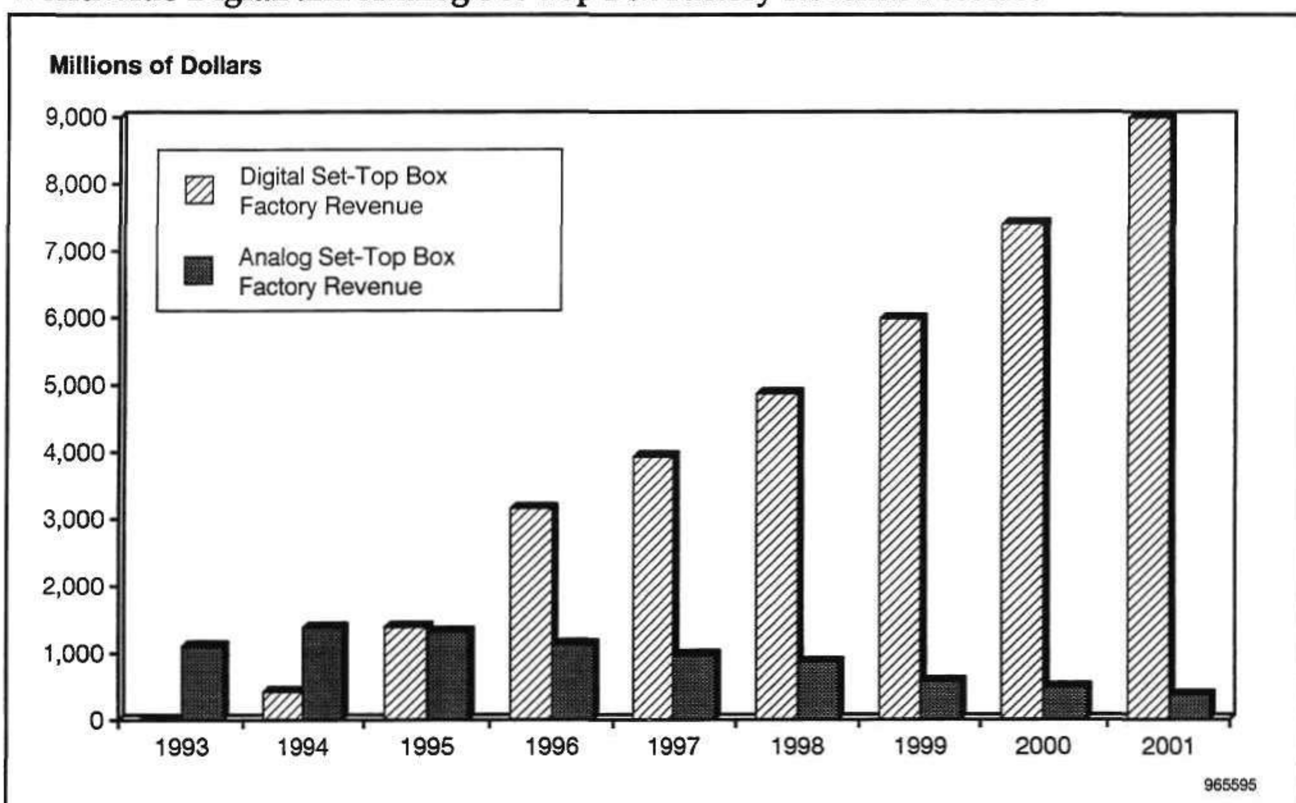
Digital STB unit production and factory revenue will experience strong increases through the year 2001. Growth will be boosted in intervals each time a new region ramps production of systems. Initial growth will come from production of digital DBS STBs, particularly in the Americas, which at present is the leading region for satellite set-top box manufacturing. However, rapid growth of digital DBS STB production in Europe will propel that region past the Americas in 1998. Europe will continue to drive the digital STB market until the year 2000. However, late in the century, Asia/Pacific will emerge as a digital DBS STB manufacturing powerhouse and will outstrip European production by the year 2001.

Figure 1
Worldwide Digital and Analog Set-Top Box Production Forecast



Source: Dataquest (August 1996)

Figure 2
Worldwide Digital and Analog Set-Top Box Factory Revenue Forecast



Source: Dataquest (August 1996)

Asia/Pacific manufacturing will grow as ASPs for digital DBS STBs fall. As shown in Table 3, factory ASPs for digital satellite set-top boxes will decrease to $203 in 2001, down from $474 in 1995. Much of the decline in ASPs can be attributed to manufacturers using lower-cost, more highly integrated chipsets.

Meanwhile, production of digital cable STBs will move into high volume starting in 1997. The Americas will be the center of digital cable STB production as the analog cable systems migrate to digital technology. Factory ASPs for digital cable set-top boxes will fall to $225 in 2001, down from $682 in 1995.

Types of Digital Video Delivery Systems

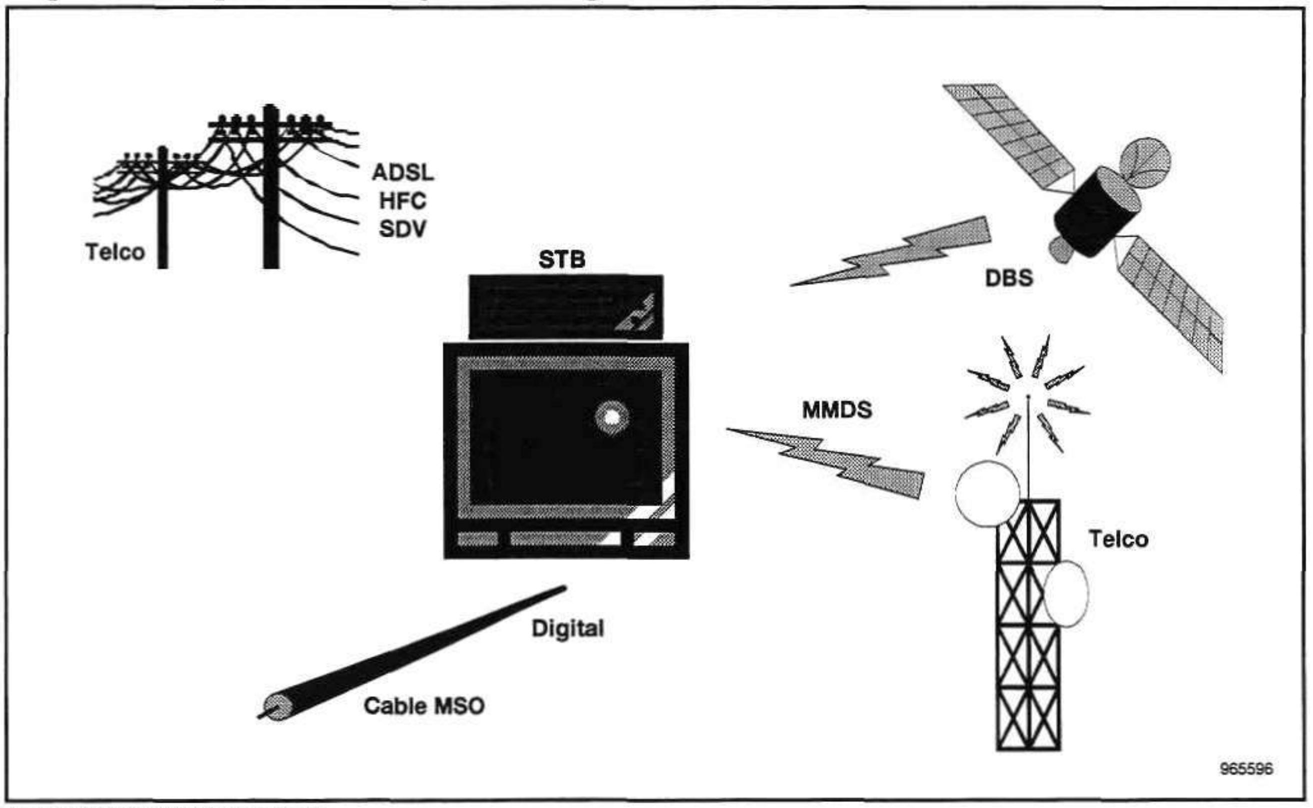
In addition to encouraging competition between MSOs and equipment manufacturers, the move to digital in the STB market is increasing the number of options for delivery of services. Numerous options exist for transmission of video and audio to digital STBs, as opposed to analog STBs, where the only widely used delivery methods are cable and satellite. As shown in Figure 3, the type of transmission system used often is determined by the service provider's line of business. Telecommunications companies are backing delivery methods that use the telephone infrastructure, such as ADSL, HFC, and SDV. They also are pioneering development of MMDS systems. Cable MSOs are concentrating most of their efforts on delivering digital video over existing cable lines. DBS services are used by a mix of companies including cable companies, telecommunications operators and media companies.

Table 3
Worldwide Cable and DBS Set-Top Box Production

	1993	1994	1995	1996	1997	1998	1999	2000	2001	CAGR (%) 1996-2001
Digital Cable Set-Top Boxes (K Units)	8	20	63	437	1,500	3,199	6,447	10,405	15,711	151
Factory ASP ($)	900	702	682	492	383	326	294	257	225	-17
Factory Revenue ($M)	7	14	43	215	574	1,043	1,895	2,671	3,535	108
Semiconductor Content ($)	474	272	208	190	174	138	132	124	116	-9
Semiconductor TAM ($M)	4	5	13	83	260	441	852	1,287	1,822	127
Percentage Americas	100	72	64	77	64	48	46	39	32	-11
Americas Production ($M)	7	10	28	165	367	503	868	1,039	1,140	86
Digital DBS Set-Top Boxes (K Units)	0.50	874	2,841	6,579	9,655	12,903	15,295	20,255	26,872	45
Factory ASP ($)	900	465	474	447	348	296	267	233	203	-13
Factory Revenue ($M)	0.45	406	1347	2,943	3,358	3,824	4,086	4,727	5,455	26
Semiconductor Content ($)	400	262	198	176	151	122	114	105	97	-11
Semiconductor TAM ($M)	0.20	229	562	1,158	1,458	1,572	1,744	2,127	2,607	29
Percentage Americas	0	96	67	42	32	28	25	22	18	-20
Americas Production ($M)	0	389	902	1,228	1,066	1,054	1,038	1,035	991	2

Source: Dataquest (August 1996)

Figure 3
Digital Set-Top Box Delivery Technologies

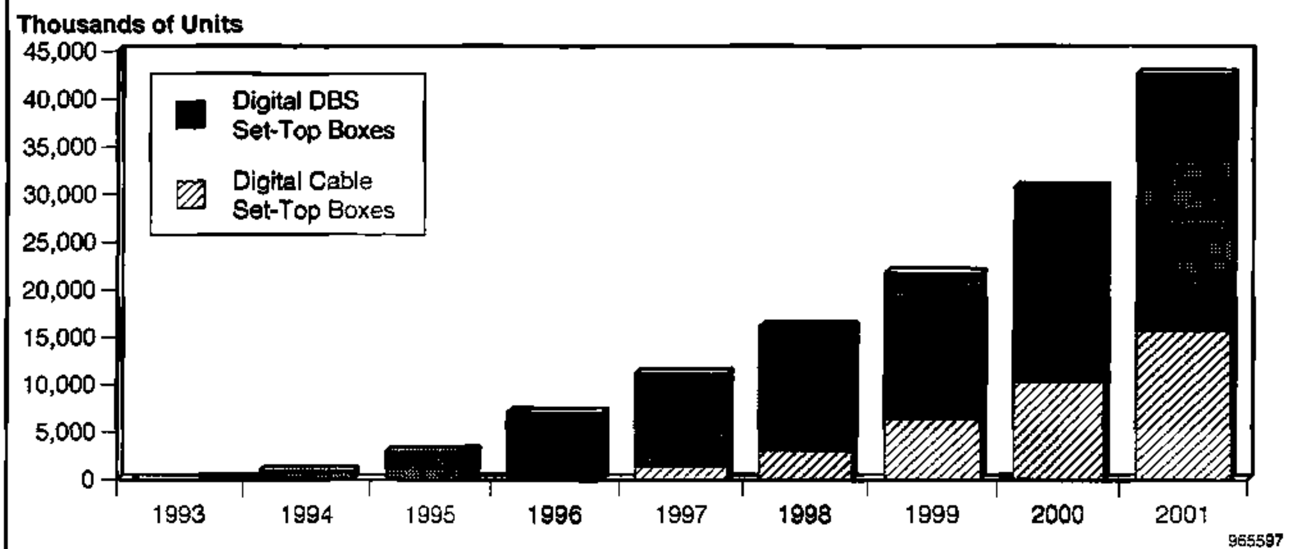


Source: Dataquest (August 1996)

At present, the vast majority of digital STBs produced use DBS delivery systems; nearly 98 percent of the STBs shipped in 1995 are of the DBS variety. DBS will remain the No. 1 digital television delivery system at least through 2001, despite strong growth of digital cable, as shown in Figure 4. The deployment of digital cable has been delayed by infrastructure issues. However, production of digital cable STBs is increasing at a rapid rate. SDV and HFC are in the trial phase and are not likely to undergo any large-scale deployments until 1997. Early deployment of ADSL and MMDS is not expected to begin until 1998.

From a semiconductor point of view, STBs designed to work with the various delivery technologies can be largely alike. For example, a digital cable STB can use most of the same components as a digital DBS STB. The only major difference between those two types of systems is in the demodulation functions, which currently account for about 23 percent of the semiconductor content of a digital STB. Some delivery systems require no changes in STB design. For example, a digital cable STB and an HFC STB both interface to coaxial cable and could use an identical demodulation and network interface subsystem. Thus, in Figure 4, delivery systems such as HFC and SDV are accounted for in the digital cable listing.

Figure 4
Worldwide Cable and DBS Digital Set-Top Box Production Forecast



Source: Dataquest (August 1996)

1996: Satellite Wars

In 1996, the battle in the digital STB market is between competing DBS services and standards. Ventures such as DirecTV, PrimeStar, and EchoStar are fighting to gain market share by cutting the prices of services and equipment.

Rapid growth of sales of DBS services and equipment in 1995 resulted in the highly competitive environment of 1996. As shown in Table 4, the leading DBS STB vendor in 1995 was Thomson Consumer Electronics, which sells under brand names that include RCA and General Electric. Thomson produces boxes that can accept broadcasts from the DirecTV and U.S. Satellite Broadcasting (USSB) MSOs. Other STB makers enjoyed strong sales in 1995 as well, including General Instrument, which produces boxes for the PrimeStar system, and Sony, which also manufactures DirecTV and USSB-compliant DSS systems. The main market for DBS systems was in the United States, with 92 percent sold in that region.

In 1996, new players EchoStar Communications Inc. and AlphaStar have entered the digital DBS MSO market. A host of other vendors are preparing to throw their hats into the digital STB ring before the end of 1996, including Canal Plus in France and PerfecTV in Japan. Table 5 lists some of the major MSOs and the status of their businesses in 1996.

With the ranks of competitors swelling, the battle for the digital STB market has begun in earnest. EchoStar in July fired a broadside on the competition when it slashed the price of its second-generation DISH network STB to $199, down from $599. While the deal lasts only through the end of 1996 and comes bundled with a $300, one-year service deal, EchoStar had decisively undercut the competition's pricing. In response, DirecTV and USSB

Table 4
DBS Set-Top Box Vendor Sales, ASPs, and Regions in 1995

Set-Top Box Vendor	Units	Americas (%)	Europe (%)
Thomson Consumer Electronics	1,260,000	100	-
General Instrument	1,000,000	100	-
Sony	100,000	100	-
Others	210,000	-	100
Total	2,570,000		

Source: Dataquest (August 1996)

instituted their own low-cost STB deal, reducing the price of their set-top boxes to $199, down from about $499. To achieve that price point, the two MSOs used a combination of rebates to customers and subsidies to manufacturers of DSS systems. EchoStar's move has spurred a price war among DBS MSOs.

The importance of the aggressive price reductions of DBS systems has not been lost on cable MSOs. With the popularity of DBS rising, cable companies have responded with advertising campaigns critical of the quality of satellite services. They have also accelerated their own digital video plans, with Tele-Communications Inc. announcing that it is making a purchase of several million General Instrument digital STBs in August.

DSS versus DVB

Although the satellite war can be seen as a battle among MSOs and box manufacturers, it also is a fight between standards. At present, the most popular format for DBS is the Digital Satellite Service , which was designed by Hughes for use with its satellite system. DSS is supported by the DirecTV and the USSB services, which have about 1.7 million subscribers, the largest number of customers in the DBS business. In addition to having the most subscribers, DSS has the largest number of STB manufacturers building or committed to building systems for it. RCA and Sony are building DSS STBs, and Samsung, Sanyo, Daewoo, Sony, Toshiba, Uniden, and Panasonic are planning to introduce compatible systems. The standard itself specifies use of MPEG-2 video decompression and AC-3 audio.

New services like EchoStar and AlphaStar use the Digital Video Broadcasting standard, which was specified by a Europe-based consortium of companies. Like DSS, DVB uses the MPEG-2 video compression standard. As for audio, DVB uses MPEG-2's own audio format. Although DVB now has fewer subscribers and fewer box manufacturers in its camp, it is an open standard, with most semiconductor manufacturers supporting or planning to support it. With widespread support anticipated, DVB backers believe that economy of scale eventually will allow it achieve lower costs than DSS.

As a specification, DVB is comprehensive, covering all major types of delivery systems. In late 1995, the DVB steering board approved the specification for the terrestrial flavor of DVB, known as DVB-T, and for DVB-MS, a digital multipoint video distribution system (MVDS). DVB-T allows digital television signals to be transmitted to receivers that use roof-mounted aerials

Table 5
Status of Some Major MSO's Digital Video Systems in August 1996

System Name	Company	Delivery Mode	Standard	Set-Top Box Suppliers	Region Served	Status	Subscriber Base
DirecTV/USSB	Hughes and General Motors/ Hubbard Broadcasting	DBS	DSS	Thomson, Sony, Hughes, Toshiba, Uniden, Hughes, Sanyo, Samsung, Daewoo, and Matsushita	United States	Began broadcasts in 1994	1.7 million subscribers combined nationwide in late June
EchoStar	EchoStar Communications Inc.	DBS	DVB	Groupe Sagem and SCI Systems Inc.	United States	Began broadcasts in April	100,000 at end of July
AlphaStar	Tee-Com	DBS	DVB	Tee-Com	United States	Began broadcasts in July	NA
PrimeStar	TCI and Cable Co. Consortium	DBS	DigiCipher	General Instrument	United States	Began broadcasts in 1993	1.39 million by end of July
PerfecTV	Four major Japanese trading houses	DBS	DVB	Toshiba Corp., Hitachi Ltd., NEC, Sony, Matsushita, Sharp, Fujitsu	Japan	Will begin broadcasts in September	NA
Galaxy	DirecTV (Hughes Electronics)	DBS	DSS	Thomson, Sony, Hughes	Latin America	Began broadcasts in mid-June	NA
Canal Plus	Canal Plus	DBS	DVB	Philips and TV/ Com	France	Set to begin service in fall	NA
Tele-TV	Bell Atlantic, NYNEX, Pacific Telesis	MMDS		Thomson Consumer Electronics	United States	Set to begin service in fall	NA

NA = Not applicable
Source: Dataquest (August 1996)

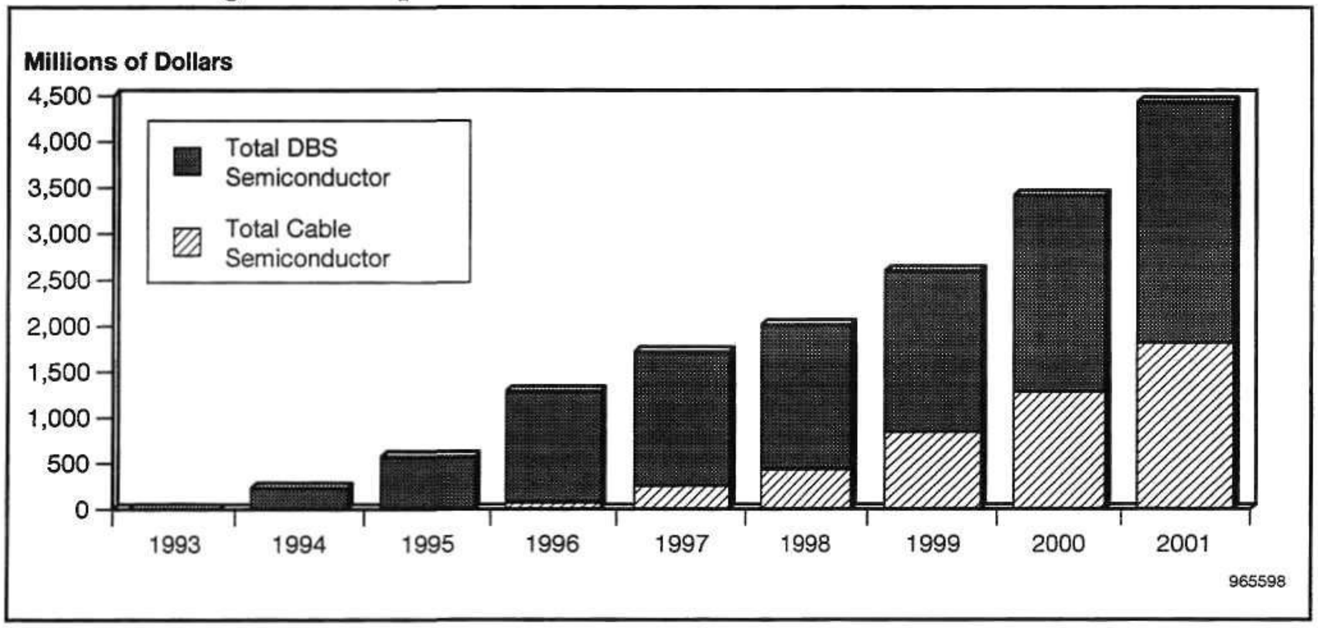
or even simple indoor antennas. DVB-MS is similar to MMDS wireless cable, using microwaves to transmit signals to rooftop antennas that are in the line of sight.

Built on top of the DVB is the Digital Audio-Visual Council 1.0 (DAVIC 1.0) specification, which standardizes interactive elements of digital video systems, such as video on demand, and home shopping. DAVIC soon is expected to give final approval to Version 1.1 of its specification, which adds support for Internet access. The group is also working to define standards for digital cable modems. By offering a standard approach to digital video interactivity, DAVIC intends to make these functions available as widely as possible.

The Digital Set-Top Box Semiconductor Opportunity

The digital STB market represents an extremely attractive opportunity for chip manufacturers prepared to serve it. Semiconductor sales into the digital STB market are expected to rise to $4.4 billion in 2001, up from $575 million in 1995, as shown in Figure 5. Over the next few years, DBS set-top boxes will command the lion's share of semiconductor sales into the digital STB market. However, sales of digital cable STBs will grow rapidly and will account for 41 percent of semiconductor consumption in the digital STB market by the year 2001.

Figure 5
Worldwide Digital Set-Top Box Semiconductor Revenue Forecast



Source: Dataquest (August 1996)

Top suppliers into the STB market include Motorola, which sells CPUs and microcontrollers into those systems as well as some DigiCipher video decompression chips and demodulation devices. SGS-Thomson also achieved a high rank in 1995 because of sales of MPEG-2 decompression chips, a market the company leads. Symbios Logic in 1995 was a major supplier to the digital STB market based the strength of sales of demodulator ASICs and some decompression devices.

Today's digital STBs use a mix of off-the-shelf parts and ASICs. Devices such as RCA's first-generation DSS system, which was manufactured by Thomson, used readily available parts such as SGS-Thomson's MPEG-2 video and audio decoder and its 16-bit microcontroller. It also incorporated three ASICs manufactured by Symbios Logic that perform demodulation and error correction. While such a design allowed RCA to enter the market quickly and capture a large amount of market share, it was not the most cost-efficient approach to building a system, with the large number of semiconductors, passives, and standard logic pushing the cost to build an entire system to $283.82.

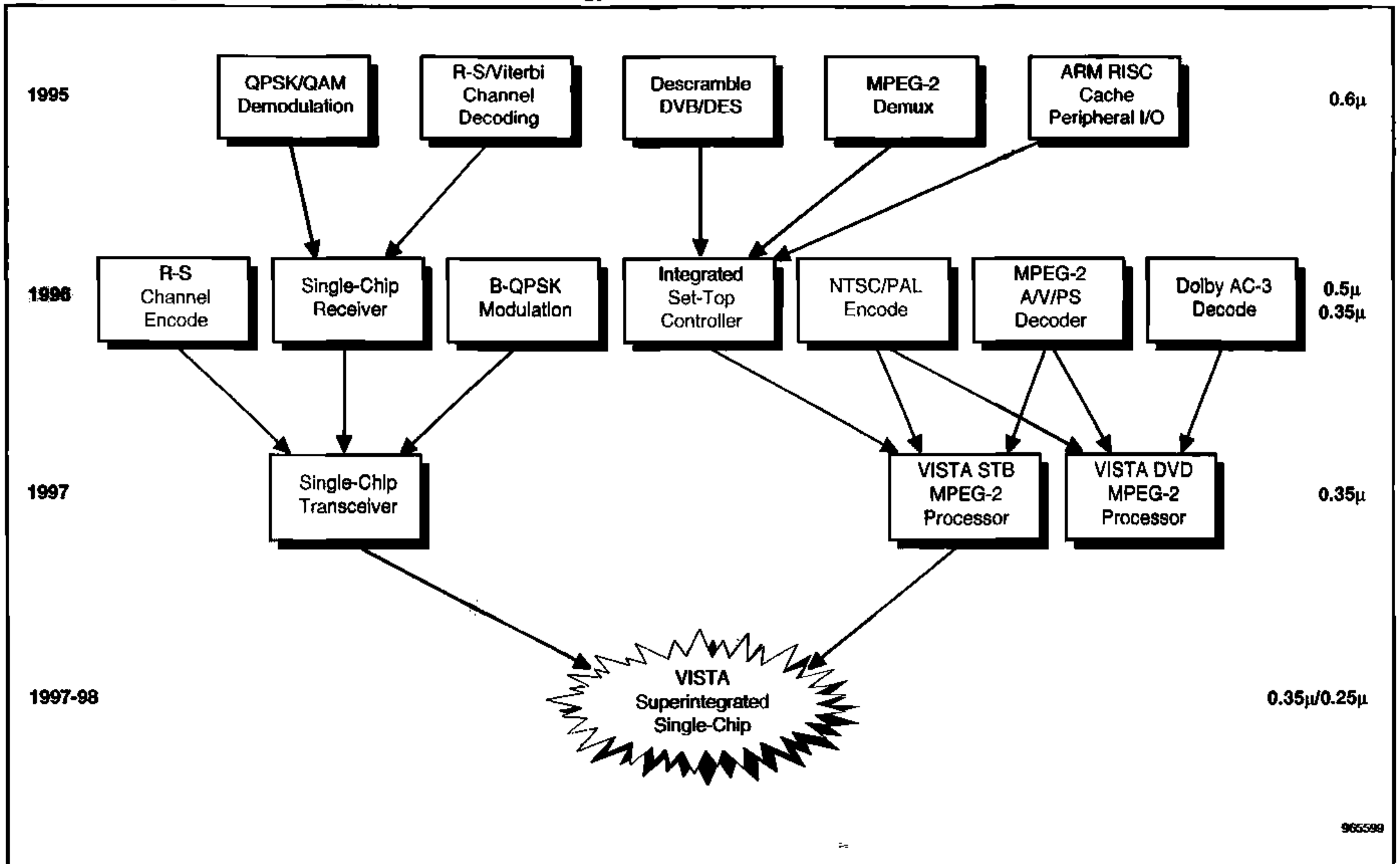
In the short term, STB vendors are turning to ASICs to reduce costs and to differentiate themselves from the competition.

However, many vendors now believe that the future of the STB market lies in highly integrated, application-specific standard products (ASSPs). LSI Logic has been the early leader in this area with its Integra design, which boils down most of the logic required into just three chips, which together are priced at only $70 to $75 in high volume. VLSI Technology recently announced its Vista STB architecture, which—like Integra—is a comprehensive digital STB chipset. Other companies including Motorola and C-Cube Microsystems are planning to offer similar standard chipsets.

Road maps from LSI Logic and VLSI Technology call for a an aggressive integration of functions into fewer and fewer chips. Figure 6 shows VLSI Technology's road map for integration of digital STB functional blocks. When VLSI Technology moves production of its STB silicon into a 0.35-micron process, it believes it can integrate most functions into just one chip. Dataquest believes STB semiconductor integration will be somewhat less comprehensive. By the year 2000, the STB still will use several chips, including a separate demodulator device, as shown in Figure 7. Having a separate demodulator device allows different front ends to be used, depending on the transmission format employed by the STB, whether it is cable, satellite or a newer technology, such as ADSL.

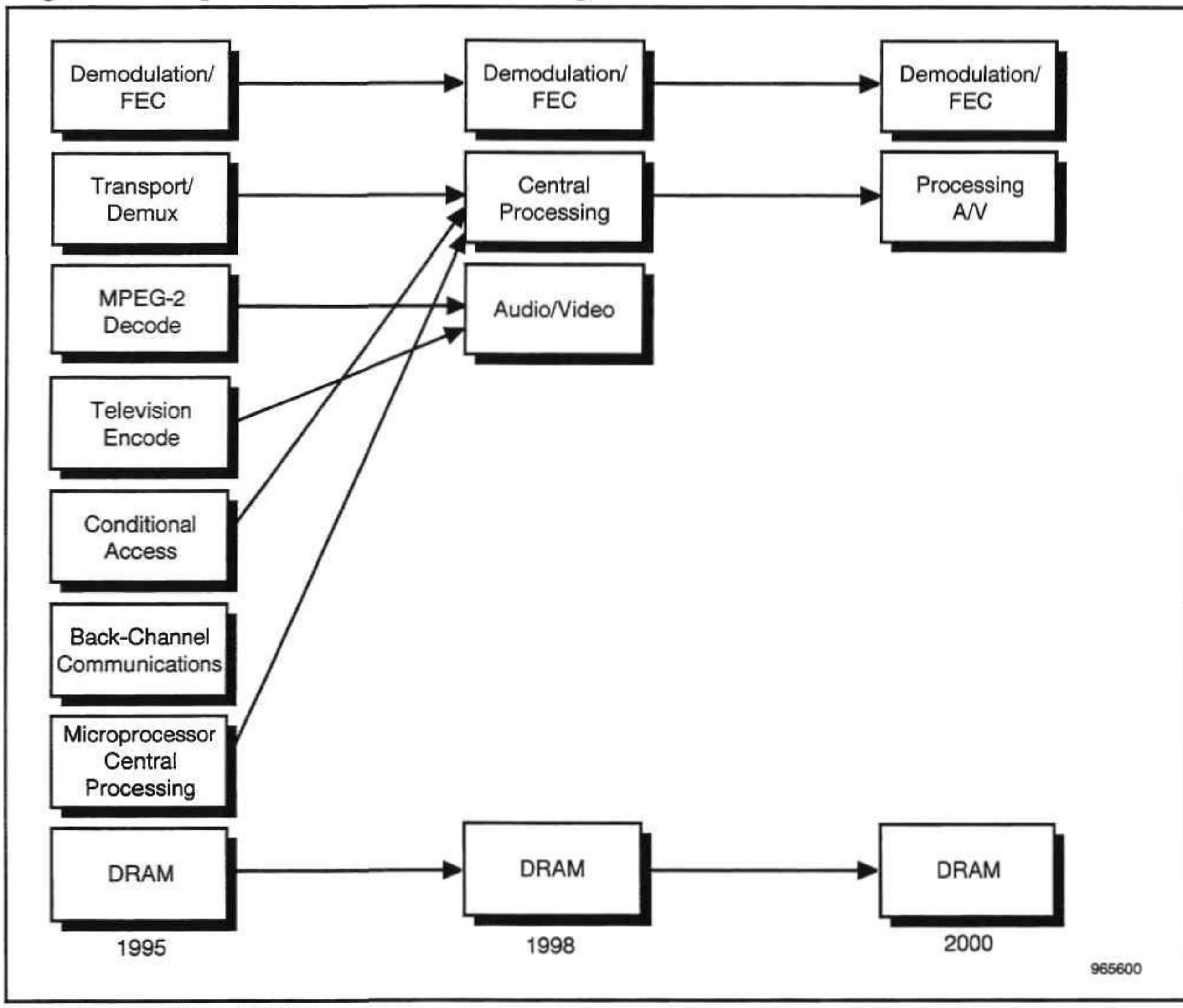
As STB silicon becomes more integrated, its costs will decline precipitously. As shown in Figure 8 and Table 6, the silicon content of a digital DBS STB in 1996 was $175.93. That cost will drop to $121.80 by 1998 and to $105.36 by 2000. Figure 8 shows the semiconductor content of a set-top box divided into major subsystems. The cost listed for each subsystem accounts for logic ICs, memory, passives, discretes, and crystal oscillators. In Figure 8, the value of the semiconductor content of a digital DBS STB is divided by major subsystem rather than by component because, as time passes, the functions of each subsystem will be integrated into a single chip. Of the major subsystems, MPEG-2 decompression will remain the most costly, in part because of the complexity of the logic used and in part because of the large amount of memory used compared with other subsystems of the STB.

Figure 6
Digital Set-Top Box Road Map for VLSI Technology



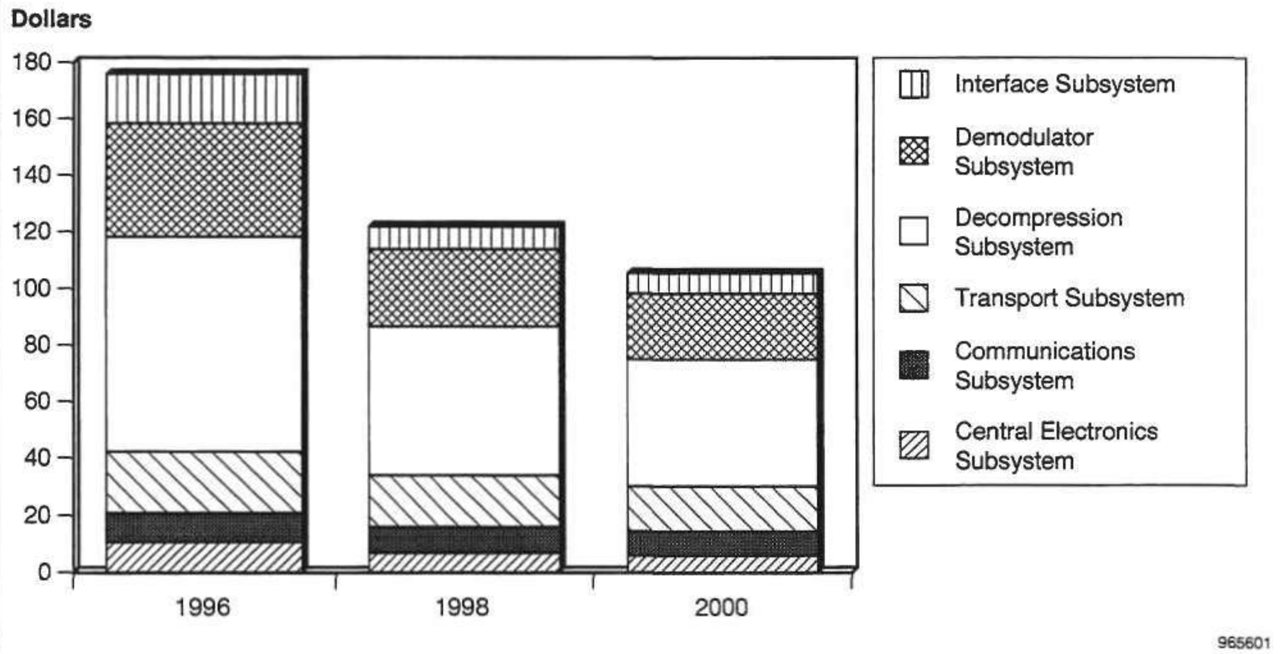
Source: VLSI Technology

Figure 7
Digital Set-Top Box Functional Block Integration Path



Source: Dataquest (August 1996)

Figure 8
Semiconductor Content of Digital DBS Set-Top Boxes



Source: Dataquest (August 1996)

Table 6
Semiconductor Content of Digital DBS Set-Top Boxes (Dollars)

Semiconductor Content	1996	1998	2000
Central Electronics Subsystem	10.95	6.99	6.10
Communications Subsystem	10.12	9.26	8.56
Transport Subsystem	21.47	18.05	15.80
Decompression Subsystem	75.88	52.65	44.77
Demodulator Subsystem	40.02	27.17	23.22
Interface Subsystem	17.49	7.68	6.91
Total	175.93	121.80	105.36

Source: Dataquest (August 1996)

In order to provide a complete STB chipset, companies must have all the pieces of the STB platform in their portfolio. In pursuit of this goal, semiconductor companies now are moving to add more and more functions to their STB portfolios through internal development, partnerships, and acquisitions. Table 7 give a list of the STB functions offered by various players in the STB semiconductor market.

Table 7
Summary of Manufacturers' Digital Set-Top Box Chipsets

	Dual A/D Converter	Demodulator	Forward Error Correction	Transport Demux	MPEG Audio	MPEG Video	System CPU
Analog Devices	X	X	X				
AT&T				X			
Broadcom		X	X				
C-Cube				X		X	X
Comstream		X					
Crystal					X		
Fujitsu	X	X	X	X	X	X	
GEC Plessey Semiconductors	X						
Hitachi				X	X	X	X
Hyundai		X	X	X	X	X	X
LSI Logic		X	X	X	X	X	X
Philips	X	X	X	X	X	X	X
Siemens	X	X			X	X	
SGS-Thomson	X	X	X	X	X	X	X
Sony	X	X	X	X	X	X	
VLSI Technology		X	X	X	X	X	

Source: Dataquest (August 1996)

Perspective

Consumer Multimedia Semiconductors and Applications Worldwide

Competitive Analysis

For Video Game Players, It's Time to "Go Big or Go Home"

Abstract: ***This report provides a competitive analysis of the recent price cuts and product announcements by Sony, Sega, Nintendo, and Bandai. The implications for chip manufacturers are explored, and significant winners in the semiconductor industry are highlighted.***

By Dale Ford

The Gloves Come Off with Price Cut Announcements by Sony and Sega, while Nintendo Launches N64 at E3

The dramatic price announcements and product introductions in the video game industry during 1996 have set the stage for a competition in which only the fittest will survive.

How Low Can They Go?

Nintendo came into the 1996 E3 Show in Los Angeles with carefully orchestrated plans to capture the limelight with the long-awaited public unveiling of its Nintendo 64 platform. However, Sony and Sega managed to capture the headlines with dramatic announcements of steep retail price cuts for the Sony PlayStation and Sega Saturn. Coming into the show, Sony's PlayStation was priced at $299, and Sega's Saturn was $249 after a $50 price cut that was announced on April 1. E3 began on Thursday morning, May 16, with a Chief Executive Roundtable that included participants from Sony Computer Entertainment America, Nintendo of America, Sega of America, Acclaim Entertainment, Electronic Arts, Microsoft Interactive Media, Disney Interactive, and The 3DO Company. Taking the first question directed to him, Sony Executive Vice President Jim Whims delivered the sound-bite punch: "At Sony, our philosophy regarding price changes is really very

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Filing: Perspective
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simple. Go big or go home." He then delivered the news that, effective immediately, the Sony PlayStation price would be cut by $100 to $199, which was met by extended cheers and applause in the audience. It appears that the announcement caught Sega and Nintendo a bit flat-footed in the meeting, but Sega's Tom Kalinske responded on Friday morning with another $50 price cut announcement that brought the Saturn down to $199. These price cuts generated such excitement because retailers and software companies believe these cuts are necessary to add strength to the rebounding video game market in the United States.

Make no mistake, the video game industry titans have moved the competition to a level that would cause even the most seasoned veterans of Mortal Kombat, Virtua Fighter, or Killer Instinct to catch their breath. These price cuts are painful, high-stakes moves that will have major impacts on the bottom line. A cost analysis of the Saturn and PlayStation reveal the investments being made by Sony and Sega to promote their platforms and who has the relative advantage. Dataquest performed a detailed cost analysis of each platform, shown in Tables 1 and 2. This analysis indicates that the cost to manufacture each Sega Saturn is $330, while the Sony PlayStation has a manufacturing cost of $260. These costs reflect only the cost of goods and labor in manufacturing and exclude fixed overhead and channel costs.

Table 1
Sega Saturn System Cost Analysis (Dollars)

Category	1995	1996	Percentage Change
Total System Production Cost	428.0	329.6	-23.0
Total Semiconductor Cost	261.6	199.9	-23.6
ICs	261.4	199.7	-23.6
Memory	166.6	116.0	-30.4
DRAM/VRAM/SDRAM/RDRAM	161.6	111.7	-30.9
Nonvolatile	5.0	4.4	-12.5
MPU, Graphics/Video	57.9	51.8	-10.5
Audio	9.5	8.4	-11.2
CD-ROM Control	15.0	12.6	-16.3
System Support	9.8	8.6	-12.5
Standard Logic, Linear	2.6	2.3	-9.0
Active Discrete Components	0.2	0.2	-2.0
Passive Components	13.7	13.3	-2.8
Systems, Modules, Batteries	76.5	39.3	-48.6
Printed Circuit Boards	23.0	22.5	-2.0
Mechanical Components	16.5	16.5	0.2
Labor and Freight	36.8	38.0	3.3

Source: Dataquest (July 1996)

Table 2
Sony PlayStation System Cost Analysis (Dollars)

Category	1995	1996	Percentage Change
Total System Production Cost	289.4	258.7	-10.6
Total Semiconductor Cost	196.9	166.6	-15.4
ICs	195.6	165.4	-15.5
Memory	105.2	81.6	-22.5
DRAM/VRAM/SDRAM/RDRAM	99.6	76.4	-23.3
Nonvolatile	5.6	5.2	-7.4
MPU, Graphics/Video	34.0	30.1	-11.5
Audio	16.8	16.1	-4.1
CD-ROM Control	35.5	33.7	-5.0
System Support	2.5	2.3	-8.0
Standard Logic, Linear	1.7	1.7	-2.0
Active Discrete Components	1.3	1.2	-2.4
Passive Components	18.1	17.7	-2.3
Systems, Modules, Batteries	27.0	26.5	-1.9
Printed Circuit Boards	12.5	12.3	-2.0
Mechanical Components	11.7	11.8	0.6
Labor and Freight	23.1	23.8	3.0

Source: Dataquest (July 1996)

The cost to manufacture the Saturn has dropped by $100 since it was first introduced at a retail price of $399. Half of the Saturn's cost decrease comes from recent drops in DRAM memory prices, while another 30 percent is caused by reduced CD-ROM drive prices. At the same time, the PlayStation's manufacturing costs have dropped by $30 since its original introduction at $299 retail. Again, most of this cost reduction is because of a decline in memory prices. However, even these cost reductions do not completely compensate for the price cuts that have been announced. If Sega were to ship 1.5 million Saturns at $199 (it has stated that its goal for 1996 is to ship 1.5 million Saturns in the United States), it would cost the company almost $200 million. To put this investment in perspective, this is twice as much as the $90 million in marketing costs that Sega has planned for all of its U.S. marketing and sales activities for all Sega products during the rest of 1996.

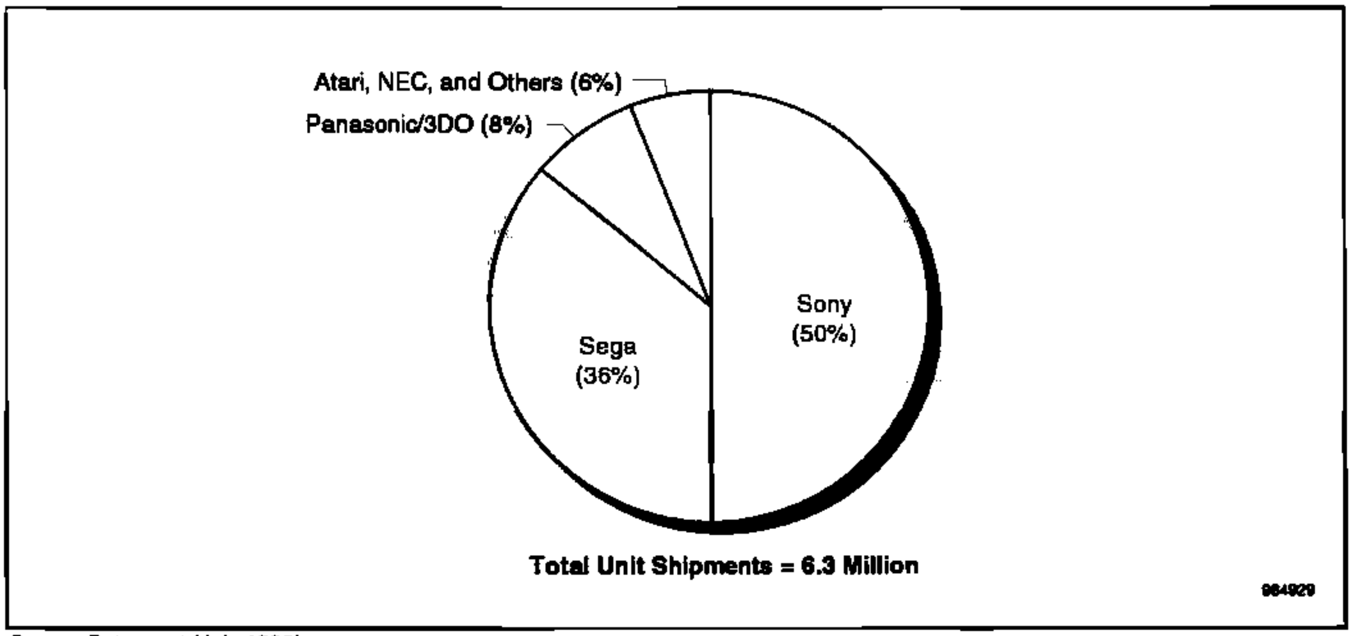
In the context of the classic four Ps of marketing (product, price, place, and promotion), price has become the lethal weapon of choice for these industry giants. The cost figures in Tables 1 and 2 reveal that the Sony PlayStation enjoys a clear cost advantage over the Sega Saturn across the board. The more elegant and highly integrated PlayStation design yields cost advantages in everything from memory and MPU/graphics costs to the printed circuit boards (PCBs), mechanical components, and labor. The one area in which Tables 1 and 2 seem to show Sega with a major advantage is in the CD-ROM control chips. However, this is because of the fact that the Sony PlayStation uses a stripped-down CD-ROM mechanism and places the control chips on the system board, where their cost is that shown in Table 2. The Sega Saturn uses a complete CD-ROM drive, and the cost for this drive and the chips it contains are included in the systems and modules category in Table 1. A straight comparison of the complete cost for the CD-ROM and chips in each system shows the two systems nearly equal in cost in this area. On the bottom line, if Sony were to ship 1.5 million PlayStations, it would cost it $90 million, less than half the cost that would be incurred by the Sega Saturn. In a simple price war, Sony would appear to hold a significant advantage over Sega.

But what about Nintendo and its $249 64-bit machine? Will it feel pressure to drop its price to come closer to Sega and Sony by the time of the September introduction of the Nintendo 64 in the United States? Dataquest has acquired a Nintendo 64 and will be publishing a detailed cost analysis of this system from the Teardown Analysis program. From a preliminary analysis, it would appear that the high level of semiconductor integration Nintendo has achieved with its system and the absence of added costs for a CD-ROM drive would put it in a strong position to compete in this price war. Judging from the early market demand for the Nintendo 64 at the $249 price point, Nintendo should be able to maintain its current pricing for the rest of 1996. In fact, Nintendo has commented that it expects to generate a small profit from the sales of its hardware in 1996.

The final and most important question is, "What has motivated these companies to make such aggressive pricing moves?" The answer to that question may come from remarks made by the CEO of Electronic Arts at the Executive Roundtable. In his comments, he indicated that the presence of the multimedia PC as a gaming platform is shaping the investment decisions of the content developers. It was his opinion that, given the requirement that most game developers feel to support the multimedia PC, there is not room for all three of the dedicated console platforms to survive. The competition among Sega, Sony, and Nintendo goes beyond capturing incremental market share. Indeed, it may be a fight for survival. Figure 1 illustrates the uphill battle that Sega faces after capturing only 36 percent of the worldwide 32/64-bit video game controller market during 1995, compared with Sony's 50 percent.

The high-stakes warfare being played out in the video game industry has already claimed its first casualties with the departure of the top executives involved in the price cut announcements at E3. Tom Kalinske resigned from Sega of America in July after six years as president and CEO in the wake of reported losses of $170 million in Sega's U.S. operations for the fiscal year ended in March 1996. Jim Whims was sent packing by Sony Computer Entertainment of America in the face of denials that his forced resignation was related to the recent price cuts. In both companies, executives were installed who effectively shifted tighter control back to the parent companies in Japan. It is obvious that these companies want the "generals" at headquarters calling the shots as they move forward into perilous terrain.

Figure 1
Worldwide 32/64-Bit Video Game Controller Market Share, 1995



Source: Dataquest (July 1996)

Nintendo 64 Explodes onto the Market

Nintendo began selling its long-awaited Nintendo 64 (formerly called the Ultra 64) in Japan at the end of June. With the Nintendo 64, Nintendo not only matches its competitors, it surpasses them. Playing some early game titles on the Nintendo 64 reveals that the platform offers stunningly realistic 3-D graphics and smooth, highly responsive control. The anticipated performance of this system has stimulated high levels of enthusiasm in the video gaming community. While Nintendo sat out the first round of competition among RISC-based platforms in 1995, the excitement generated by the Nintendo 64 has created an unprecedented level of pent-up market demand.

Nintendo announced that, less than four weeks after the system's debut in Japan, it had shipped more than 800,000 units into the market. Nintendo expects to sell a total of 3.6 million systems in the Japanese market in the first nine months of availability and more than 1 million units in North America. The company noted that it will begin selling the Nintendo 64 in the United States on September 30, and it has committed to deliver 500,000 units to the U.S. between launch and Christmas 1996. However, cumulative orders from U.S. retailers have already reached 1 million units.

The Nintendo 64, which originally was expected to ship in November 1995, is based on a pair of chips designed by Silicon Graphics Inc. subsidiary MIPS

Computer Systems and on Rambus memory technology. The key system components are:

- The 64-bit MIPS R4300i RISC microprocessor; clock speed 93.75 MHz
- The Reality sound and graphics coprocessor; clock speed 62.5 MHz
- Two 18Mb Rambus DRAM (RDRAM) chips with a maximum transfer speed of 4,500 Mbps

Nintendo wants the Nintendo 64 to have a five- to six-year lifetime. To make sure the platform has the legs to last, Nintendo has several upgrades planned for the platform. In the area of storage, Nintendo will offer a SyQuest-type, removable cartridge hard drive that will give users a range of new features, including the ability to download game software. Nintendo said that the drive, which will plug into the bottom of the console, will begin shipping in Japan by the end of 1996 and in the United States sometime in 1997. The drive, called 64DD, will use high-density magnetic discs that front-load into the unit and hold 64MB of data. For reference, the Super NES version of Donkey Kong Country requires only 4MB of storage. The drive specifications are listed at 150ms average seek time (AST) and 1-MB/sec data transfer rate (DTR). Nintendo said it is already working on a DVD peripheral for the Nintendo 64.

In the area of memory, the Nintendo 64 has a door on its top that allows additional RDRAM to be added to the system. The memory expansion module that goes in the door allows users to give the Nintendo 64 a performance and memory boost. However, this memory expansion module for the Nintendo 64 is not yet available.

The design of the Nintendo 64 certainly is forward-looking. Figure 2 shows the system controller and joystick. The interior of the Nintendo 64 first unveiled in 1995 reveals an extremely simple design, with a total of just four major chips on a single, dual-layer board. The R4300i and the Reality coprocessor share the Rambus DRAM, using it for everything, including system memory, frame buffer, and 3-D texture buffer. This is a major contrast to designs like the Saturn, which has a total of seven processors and ASICs on the system board and which has four different memory subsystems.

MIPS MPU Suppliers and Rambus Cash In Their Winning Chips

In May 1996, MIPS Technologies claimed that 10 million MIPS processors had shipped since the architecture was introduced in 1985. Eighty percent of those processors had shipped in the preceding 18 months, and 5.5 million had shipped during 1995 alone. With more than 3.1 million of those processors shipping in the Sony PlayStation in 1995, the video game industry could claim credit for the success of the MIPS architecture. Or, viewed from another perspective, Sony could credit its success to the advanced system architecture enabled by the MIPS processor. In any event, the video game industry will continue to be a major driver of MIPS processor sales. With the MIPS chips that will ship in the Nintendo 64 and Sony PlayStation combined, the video game industry could easily account for over two-thirds of the 10 million MIPS processors that MIPS Technologies has predicted will ship in 1996.

Figure 2
The Nintendo 64

Source: Nintendo (July 1996)

On the other hand, sales of the SH-2 processor could be in danger unless Sega is able to rejuvenate the sales of its Saturn platform. The efforts to promote the PowerPC architecture and the M2 technology developed by 3DO in the video game industry appear to be putting pressure on Sega executives and designers. Although there is no reason to expect Sony or Nintendo to abandon the MIPS architecture, it would not be surprising to see Sega take the risk of turning to the PowerPC to breathe new life into its flagship platform.

Rambus announced that over $100 million in revenue had been generated by products incorporating its interface technology, memory, and processors, during the first half of 1996. Again, the video game industry can take credit for helping this leading-edge technology get off the ground. A Creative Labs graphics card and the Nintendo 64 were the only products shipping into the market at the time of the Rambus announcement. In addition to leading in generating revenue for Rambus during 1996, the success of the Rambus technology in the Nintendo 64 platform will help open new doors for these chips to be designed in other next-generation consumer electronics products.

The Bandai Pippen @World Arrives in the United States

Bandai Digital Entertainment captured a share of the spotlight at the E3 show with the unveiling of its Pippen @World product. This hybrid product, based on the PowerPC Macintosh architecture, provides access to the Internet and the ability to run various multimedia and gaming CD-ROM-based titles. Although this box enables access to the Internet, it would not be accurate to call it a Network PC. From the system specifications outlined below it can be seen that it does not conform to the architecture commonly described as a Network PC. The key hardware specifications for the Pippen @World system are:

- PowerPC 603 operating at 66 MHz
- 5MB DRAM expandable to 13MB with an 8MB module
- 4MB of ROM for operating system main kernel storage
- 128K of flash memory for nonvolatile storage
- 1MB of DRAM for video storage
- Front-loading 4x CD-ROM drive
- Two standard Apple Computer serial interfaces for printer and modem support
- PCI-compatible expansion connector

The Pippen @World will begin shipping in the United States in September 1996 at a price of $599. This price does not include the cost of a modem. Consumers who purchase this product will be offered the opportunity to sign up for Internet access services with PSI Services. For a price of $24.95 a month, service subscribers will be supplied with a modem (14.4 baud or higher) and unlimited access to the Internet. After subscribing for one year, the subscriber will own the modem. In discussions at E3, company representatives were already talking about upgrading to a DVD drive in the next product release.

In its primary role of accessing and displaying images from the Internet, the Pippen @World is a compelling product. One of the major challenges for this type of product is creating a clear display of computer text and graphics on a TV monitor. Compared with other products in this category, the Pippen @World does an admirable job. A number of software products were being demonstrated that used a combination of CD-ROM-delivered multimedia content and Internet interactivity. Dataquest expects this type of product to attract broader interest and will begin to track its progress in the market.

Technology Trends: The Internet Shapes Near-Term Plans, while DVD Looms in the Future

The Internet

The development of the Internet appears destined to shape video gaming platforms of the future. Video game companies have already been encouraged by the success of electronic delivery mechanisms such as the Sega Channel and Nintendo Power Source. In its pursuit of expanding the video game market beyond young adolescent males, the video game industry has discovered that an interactive, social gaming experience appeals to a female audience. A number of products and services were introduced at E3 that are designed to create a virtual community for video game players using the Internet as the backbone. This communications capability and the potential it holds to more than double the video game market generated the greatest enthusiasm in a number of panel discussions at E3.

One of the first products that could enable this type of capability for dedicated video game consoles is the Sega Saturn Net Link. The Net Link is a 28.8-Kbps modem that can be plugged into a slot in the Saturn and that runs a custom-designed Internet browser delivered on a CD-ROM. Sega will also offer a keyboard and mouse to enable a complete Internet access solution. Unfortunately, the Saturn does a poor job of converting computer graphics and text for display on a TV monitor. Larger images and text can be read without too much effort, but the use of a virtual magnifying glass is required to read most standard-size text.

DVD

The introduction of a DVD drive in the video game environment will come in the PC first and will then migrate to the dedicated console as a peripheral. The business model employed by Nintendo, Sony, and Sega will delay the introduction of a video game console with an integrated DVD drive to the end of 1998 at the earliest. Video game companies need to derive software revenue and profit from the installed base they are creating today of 32- and 64-bit platforms before they can introduce a DVD upgrade. This delay will also give DVD drives time to come down in price.

Summary

Although the major players in the video game industry have always been fierce competitors, the marketing strategies employed by these players have become increasingly aggressive as the potential consequence of failure could be elimination from the game. The relative price/performance delivered by the flagship platforms of Sega, Sony, and Nintendo will play a major role in determining the winners and the losers. The players that have developed systems based on highly integrated, powerful processors and advanced memory chips would appear to possess the ultimate weapon in this game.

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Perspective

Consumer Multimedia Semiconductors and Applications Worldwide

Vendor Analysis

C-Cube: The Digital Video Specialist

Abstract: *C-Cube Microsystems Inc. has been one of the most notable success stories in digital video compression and decompression chips. In every major product segment of the digital video market, C-Cube was the No. 1 player or held one of the top positions in 1995. This leadership position has helped C-Cube rapidly increase revenue and earnings. C-Cube plans to offer a low-cost MPEG-2 codec in 1997 that will be the company's most important product in the future. Dataquest believes that C-Cube will continue to be a leader in current and future digital video markets.*
By Jonathan Cassell

A Leader

C-Cube Microsystems Inc. is one of the leading players in the market for digital video compression and decompression (codec) chips. The company's product portfolio extends to every major segment of the digital video market, including encoding and decoding of MPEG-1 and MPEG-2, which are the most widely adopted video compression formats in the consumer, computing, and communications markets.

C-Cube differentiates itself from its major competition by focusing exclusively on compression technology. Since its founding in 1988, C-Cube has invested heavily in all aspects of digital video technology. The company has developed considerable expertise in digital video technology, including an understanding of algorithms and a knowledge of system-level issues. C-Cube's high level of expertise in digital video technology has given it a unique understanding of its target markets and the requirements of its

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customers. It has also allowed C-Cube to exploit new opportunities for digital video in any market in which they appear, whether it is computer, consumer, or communications.

Because of this, C-Cube has been able to exploit new, high-volume market opportunities as they appear, helping its sales to grow at an explosive rate recently. Net revenue grew to $124.6 million in 1995, up nearly 300 percent from the $45 million it reported in 1994 (see Table 1). C-Cube's hot performance has extended into 1996, with the company reporting that revenue was up for the first six months of the year by 264 percent and that net income was up by 274 percent compared with the first half of 1995. In addition to allowing C-Cube to exploit high-volume opportunities, the company's expertise in digital video has allowed it to take a leading position in key, high-margin markets, helping to boost profitability. C-Cube's gross margin was 51.9 percent in 1995.

Table 1

C-Cube Microsystems Financials (Millions of Dollars)

	1991	1992	1993	1994	1995
Net Revenue ($M)	5.5	13.6	23.7	45.0	124.6
Gross Margin (%)	20.6	44.8	59.3	53.4	51.9
Net Income ($M)	-8.40	-5.30	-0.50	5.00	24.90

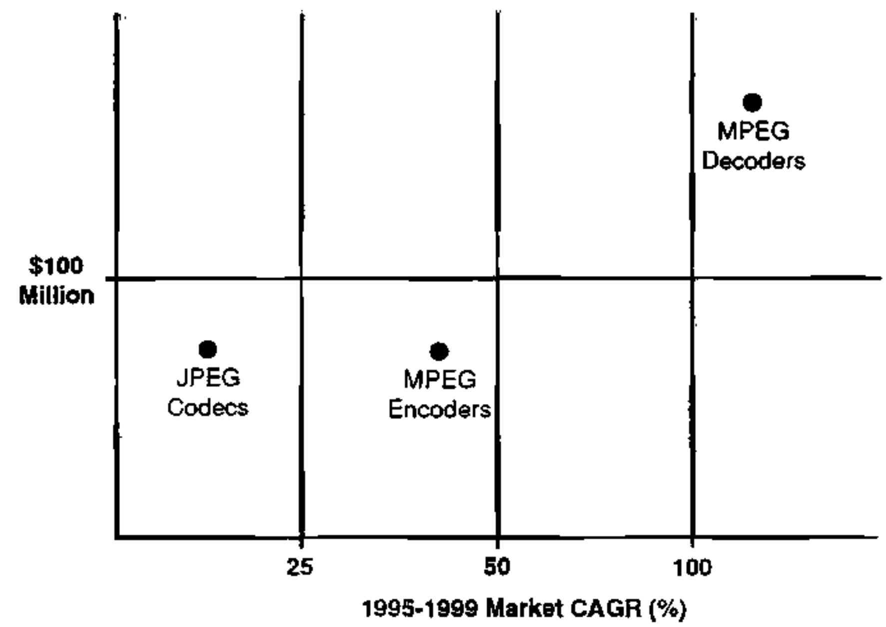
Source: Dataquest (July 1996)

The Portfolio

All C-Cube's major product lines are in areas that are expected to experience extremely strong sales growth. With applications in the consumer, computer, and communications markets, digital video represents one of the hottest growth opportunities for semiconductor technology. Figure 1 presents the market growth potential for C-Cube's major product lines. All the markets C-Cube sells into are expected to experience double-digit sales increases through 1999, with MPEG-2 decoding enjoying a compound annual growth rate (CAGR) well above 100 percent. C-Cube also garners revenue from development contracts. However, that business is declining, both on a dollar basis and when measured as a percentage of revenue.

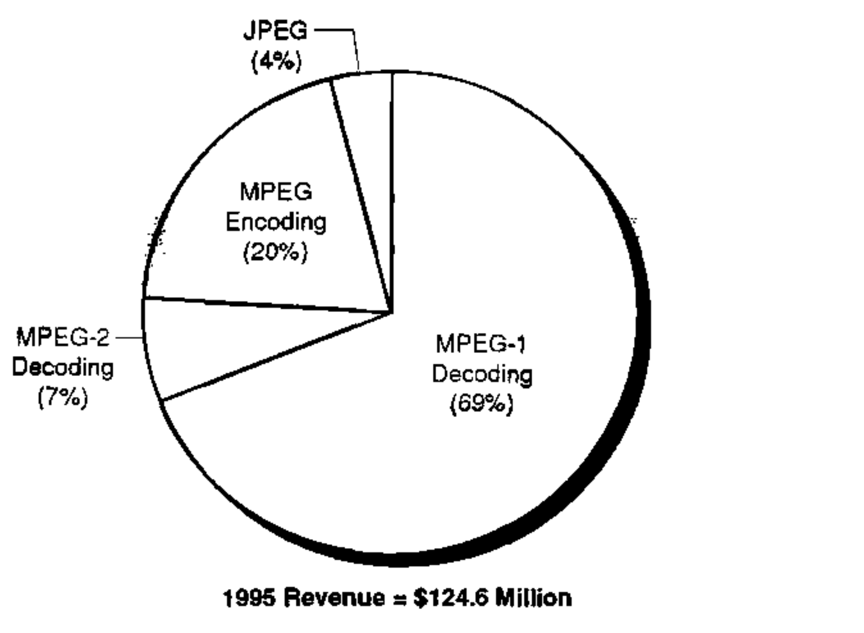
Figure 2 shows C-Cube's 1995 revenue segmented by product type. The majority of C-Cube's revenue is derived from sales of MPEG-1 decoder chips, which are priced between $25 and $30 in large quantities. However, a disproportionate amount of the company's earnings come from sales of high-margin MPEG-2 encoder chipsets, which are sold in small quantities and can cost as much as $6,000.

Figure 1
Market Potential for C-Cube Microsystems



Source: Dataquest (July 1996)

Figure 2
C-Cube Microsystems Revenue Sources (1995)



Source: Dataquest (July 1996)

C-Cube in May 1996 bought DiviCom, a vendor of semiconductors, software, and systems for digital video networks that reported revenue of $34.1 million in 1995. DiviCom's product line includes video and audio encoders and decoders, decoder components, and systems based on the MPEG-2 and digital video broadcasting (DVB) international standards. DiviCom's approach to digital video systems can accommodate all types of delivery systems, including satellite, cable, fiber, and twisted-pair wiring.

MPEG-1 Decoders

C-Cube sells a of line of MPEG-1 decoders primarily used in VideoCD players and karaoke machines, products that are extremely popular in Japan and Asia/Pacific countries. C-Cube now serves the VideoCD and karaoke markets with two devices: the CL450 and the CL480VCD, which are the company's most popular parts.

C-Cube's CL450 video decoder, which began shipping in 1992, was the first commercially available MPEG-1 decompression chip. The CL450 originally was designed with computer multimedia tasks in mind. The CL480VCD, which began shipping in 1994, was designed specifically to address the market for VideoCD, with system decoding support, audio video synchronization, CD-ROM decoding support, and error concealment.

C-Cube announced in March the CL484VCD, an enhanced version of the CL480VCD, which supports the VideoCD 2.0 standard. VideoCD 2.0 added to VideoCD players the ability to display an on-screen menu, among other features. C-Cube began shipping the CL482, the company's latest VideoCD MPEG-1 decoder, in July. The CL482 includes an NTSC-to-PAL converter and logic designed to improve the image quality of CD-ROMs that are of inferior quality or have been damaged.

C-Cube also offers the CL450SWA and the CL480PC for PC-based MPEG-1 decompression.

MPEG-2 Decoders and Related Devices

C-Cube sells an MPEG-2 decoder that is used mainly in direct broadcast satellite (DBS) set-top box applications. The CL9100, introduced in 1994, is a single-chip MPEG-2 video decoder. The device integrates system-level features such as on-screen display and error concealment. C-Cube also sells the CL9110, a companion chip to the CL9100 that performs transport demultiplexing, a set of functions that includes separation of MPEG-2 data streams into their audio and video components.

JPEG Codecs

C-Cube sells the CL550 and CL560, a pair of processors that perform JPEG compression. The CL550 is designed for still image compression. The CL560 is a higher-performance chip designed to perform JPEG compression for professional, nonlinear digital video editing applications.

MPEG-2 Encoders

For encoding MPEG-2 digital video, C-Cube offers the CLM4740, CLM4720, and CLM4450 chipsets. All these chipsets are based on C-Cube's VideoRISC, a processor designed specifically for digital video compression tasks. For simple video encoding tasks, such as simple MPEG-1 encoding, a single VideoRISC can be used. For more demanding applications--like professional-quality MPEG-2 encoding--multiple VideoRISCs can be ganged together. C-Cube has continually updated the VideoRISC and is using the third generation of the processor for its newest MPEG-2 encoders.

The CLM47xx family, each member of which uses 14 VideoRISC processors, is designed to perform real-time, high-quality video compression for digital broadcast systems. The CLM47xx family includes versions for frame and adaptive field/frame encoding in both PAL and NTSC formats. For lower-cost MPEG-2 video encoding applications, C-Cube offers the CLM4400, a chipset based on four VideoRISC processors that performs compression in a half D1 resolution.

In April, C-Cube introduced its latest MPEG-2 encoder chipsets: the CLM4740, the CLM4720, and the CLM4440. The new chipsets are designed to be more cost-effective by using the third-generation version of the VideoRISC processor, which allows fewer chips to be used in each product. The CLM4740, designed for broadcast encoding, consists of only seven VideoRISC processors, half the number of chips used by previous members of the CLM47xx family. The CLM4740 Video Storage Encoder uses only five VideoRISCs, and the CLM4440 Video Authoring Encoder consists of just two devices.

For MPEG-1 encoding, C-Cube sells the CLM4100, the CLM4500, and the CLM4550. The three devices provide different levels of MPEG-1 encoding quality. The single-chip CLM4100 is used in low-cost authoring applications, the dual-chip CLM4500 for midlevel video encoding, and the four-chip CLM4550 for advanced encoding.

Other Products

C-Cube also offers the CLM4100 encoder and the CLM4200 codecs for videoconferencing applications that comply with the H.261 standard. For each family of products, C-Cube sells related development boards. C-Cube's product offerings extend all the way to complete systems—the company offers an MPEG-2 encoder development station.

The Competition

As illustrated in Table 2, C-Cube holds high positions in all major digital video compression markets. Although C-Cube faces stiff competition from larger companies in many areas, no other company challenges it in all the segments of the digital video market.

Table 2

Competitive Product Position for C-Cube Microsystems in 1995

Market Ranking	MPEG-1 Decode	MPEG-2 Decode	MPEG Encode
No. 1	X		X
No. 2			
No. 3		X	

Source: Dataquest (July 1996)

C-Cube was the world's No. 1 vendor of MPEG-1 decompression chips in 1995. Although companies generally encountered disappointing results in the 1995 market for MPEG-1 decompression chips for PCs, C-Cube sold about 1.8 million of those devices in 1995 to makers of VideoCD systems in the Far East. The company's business in that area has allowed it to enter into close relationships with major consumer electronics companies that supply VideoCD systems, including Sony, Philips, JVC, and Matsushita. C-Cube's primary competitors in the MPEG-1 decoder market are SGS-Thomson, Texas Instruments, and Motorola.

C-Cube's stock was battered in early 1996 when LSI Logic and IBM Microelectronics announced that they planned to offer MPEG-2 encoders. The companies' moves were seen as a direct challenge to the virtual monopoly C-Cube owns in the MPEG-2 encoding market. Both LSI Logic and IBM promised to offer products that used fewer chips and were less expensive than C-Cube's VideoRISC-based products. However, IBM had just begun ramping its MPEG-2 encoder in June, and LSI expects to begin volume shipping its MPEG-2 encoder in the first quarter of 1997. As of now, C-Cube still holds its monopoly in MPEG-2 encoding.

Because it is used both in DVD players and in digital set-top boxes, MPEG-2 decoding is a key technology for the present and future of digital video. It is also the only major digital video market in which C-Cube does not have a leadership position. SGS-Thomson is the leader in that market, almost completely because of sales of MPEG-2 decoding chips for DBS set-top boxes. However, C-Cube also sells into the set-top box market and is beginning to expand its presence there. The company has announced set-top box design-wins with companies including Samsung; DiviCom (now owned by C-Cube), which is supplying the EchoStar DBS system; and Tee-Com, which is a supplier to the AlphaStar DBS system.

The Future

C-Cube now is developing a product that will take it far beyond the capabilities of the VideoRISC family: a single-chip device capable of both MPEG-2 compression and decompression. In contrast, the company's current solution uses as many as 14 chips. By boiling down all functions to a single chip, C-Cube will make MPEG-2 encoding inexpensive enough to be used in high-volume consumer products. Set to be introduced in mid-1997, the codec will be essential for future DVD players that will be able to record video in the MPEG-2 format, as well to as play it back. C-Cube sees its inexpensive MPEG-2 codec as being the company's signature product in the future, equivalent to the way Intel sees the Pentium. Initially, C-Cube is likely to enjoy an Intel-like monopoly in this area, as competitors LSI Logic and IBM by mid-1997 will still be offering their first-generation, multichip encoders.

Besides playing the main role in DVD players, the low-cost MPEG-2 encoder will serve as the centerpiece in another platform that C-Cube sees as being more important than the DVD player itself: the set-top box. Because DVD players and digital set-top boxes—both the DBS and cable types—share so much logic (particularly the MPEG-2 codec) combining them would be natural. The codec in a combined DVD player/set-top box could perform a range of functions, including decompressing MPEG-2 video from both the DVD player and the DBS/cable system and compressing video for recording on a DVD player or for videoconferencing.

C-Cube anticipates that the set-top box will be the main consumer entertainment product in the future, integrating interactive television, DVD, and communications into a single platform. The company's acquisition of DiviCom plays into this strategy, because DiviCom has expertise in designing set-top boxes and set-top box semiconductors. By combining its expertise with DiviCom's, C-Cube plans to integrate digital set-top box functions into fewer and fewer chips. Set-top boxes now have 10 to 12 chips. Within a year and a half, C-Cube wants to reduce the number of chips to six. By mid-1999, C-Cube believes that digital set-top boxes will be composed of only two or three chips.

Dataquest Perspective

C-Cube seems to have found the right strategy to win in the market for digital video. By focusing on technology and by consciously addressing three major markets—consumer, computer, and communications--C-Cube stands to benefit no matter which direction digital video takes. This strategy is especially appropriate for an unpredictable market like digital video, whose many twists and turns have shaken out some competitors.

Many companies now anticipate rapid growth in the DVD market. With a line of MPEG-2 decoders and a planned single-chip MPEG-2 codec, C-Cube stands to profit if the DVD market booms. However, if initial growth in DVD is somewhat restrained—which is the expectation both of C-Cube and of Dataquest—C-Cube will not suffer. C-Cube will continue to experience growth in profitability based on revenue from the VideoCD market it dominates.

C-Cube's acquisition of DiviCom clearly was the right move for the company, giving it access to technology it needs to build its presence in the digital set-top box market. However, it is less clear whether the set-top box in the future will emerge as the main consumer entertainment platform, as C-Cube anticipates. Whatever role the digital set-top box plays, it a market that will grow strongly in the coming years, and C-Cube is likely to be one of its major semiconductor suppliers.

Although there are likely to be a few bumps ahead, digital video applications will continue to enjoy strong growth. In both the short term and the long term, C-Cube is destined to be one of the winners in the digital video race.

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Dataquest
A Gartner Group Company

Perspective

Consumer Multimedia Semiconductors and Applications Worldwide

Dataquest Predicts

Consumer Multimedia Chip Technologies: Ready for Prime Time

Abstract: *This document is a summary of a speech given at the Dataquest Predicts conferences and covers the topic of next-generation consumer electronics and the opportunity these markets present for semiconductor manufacturers.*
By Dale Ford

Next-Generation Consumer Electronics and Semiconductor Opportunities

This document provides the results of the research Dataquest has been doing in its new service, Consumer MultimediaSemiconductor Applications Markets. Consumer electronics is an exciting area that we believe is poised to move forward in a very significant way, particularly as it relates to semiconductor manufacturers.

This document covers the following four particular categories, with predictions:

- Set-top boxes
- Next-generation video games (32- and 64-bit video game controllers)
- DVD controllers
- A variety of technologies related to what future televisions might begin to look like.

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A Wave of Interactive, Digital Technologies Is Rolling into the Home

If we were to roughly position some of the consumer electronics market segments, plotting them on a market-size versus market-growth axis with market growth across the bottom, the relative positioning would look something like that outlined in Figure 1. The more mature products on the market that are currently generating strong revenue flows for their manufacturers are in the upper left-hand corner of the figure. We see, of course, color televisions, personal portable stereos, video game cartridges, and VCRs. These are some of the mature products that are out there and currently shipping in high volumes.

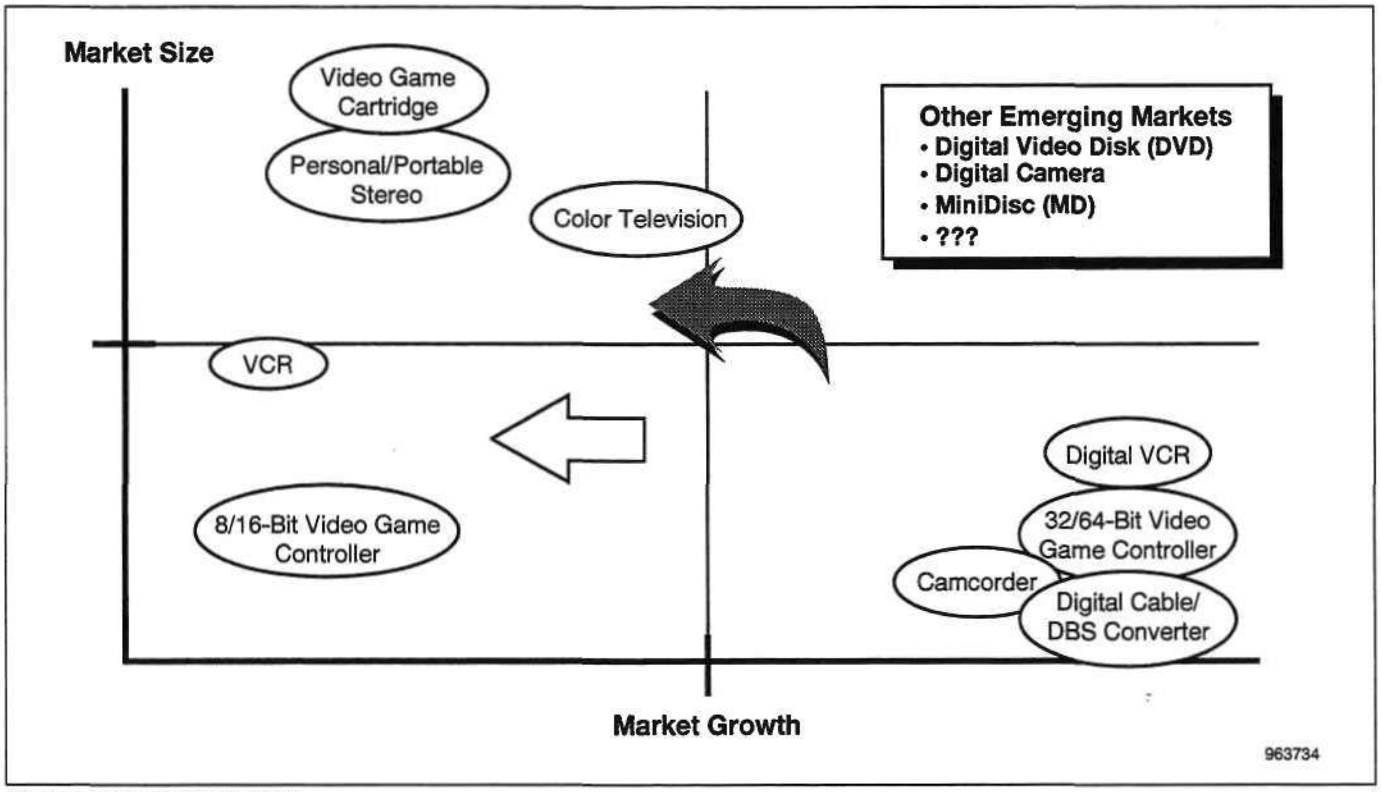
In the lower left-hand corner of Figure 1 we see the decline that's been taking place in the 8- and the 16-bit video game controllers, as shipments of the SegaGenesis and the other products in the 16-bit category have been declining for a couple of years.

The lower right-hand corner of Figure 1 represents the high-growth area, where we see a number of new products that offer promising opportunities for manufacturers and semiconductor makers. Many of these product categories begin with the word digital. Indeed, the era of digital consumer electronics is bursting upon us. We see digital cable and direct broadcast satellite converter boxes, the 32- and 64-bit video game generation, digital VCRs, and digital camcorders. Other digital markets, as mentioned earlier, are the digital cameras and digital video discs. All of these emerging products present exciting opportunities.

The market that is represented by color TVs, VCRs, camcorders, video games, stereos, audio systems, and various types of personal electronics is outlined in Figure 2. Some of the categories that we typically count in the consumer electronics category at Dataquest have actually been taken out of this chart. This chart does not include the appliance and home convenience products. Products such as washers, refrigerators, dishwashers, and so on are all taken out of this figure. Taking this modification into account, we see that the overall market is poised for a little more than 9 percent compound annual growth between 1995 and the year 2000.

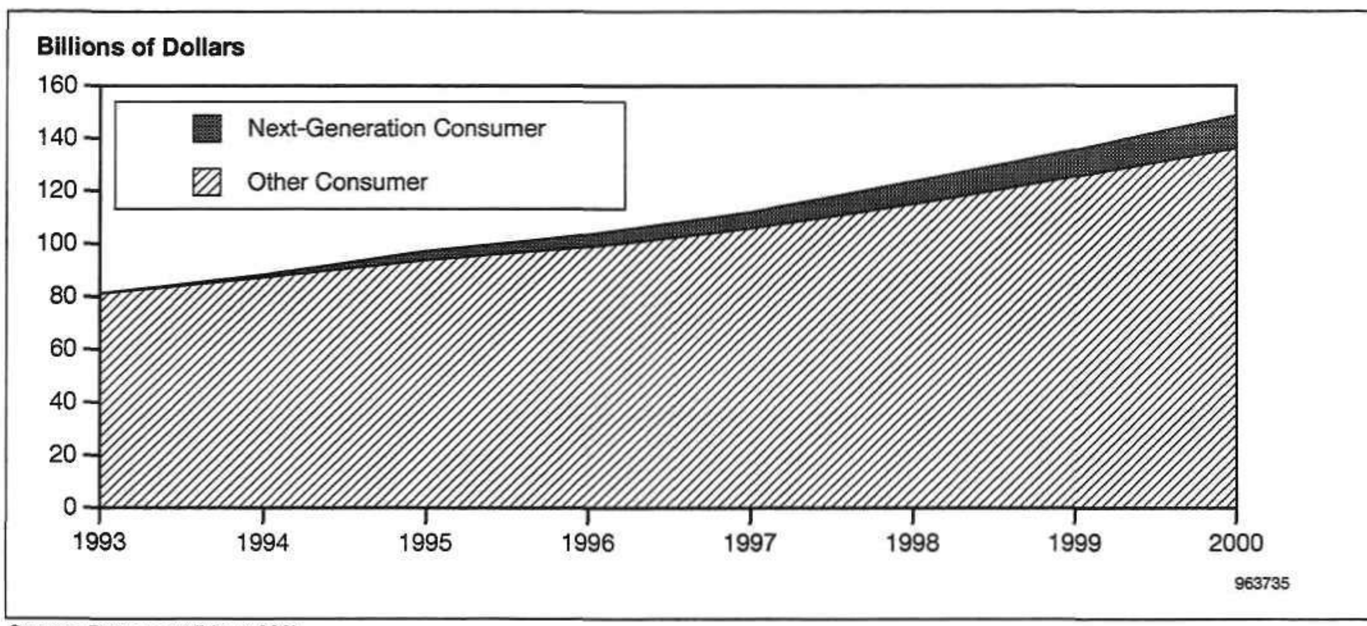
Dataquest is forecasting strong growth for what we call the next generation of consumer electronics. Beginning with a $3.5 billion market in 1995, we are predicting that this market will grow at more than 50 percent CAGR during the next five years, growing up to represent $13 billion in electronics equipment manufacturing by the year 2000. However, even with this rate of growth, next-generation consumer electronics will only push the overall market growth rate up about 1.5 percent and represent less than 10 percent of the consumer electronics market by 2000. While manufacturers of next-generation products are excited about the prospects for their products, an analysis of the impact on overall market growth presents the question, "Why all the excitement over the new digital consumer electronics technologies?" The forecast shown in Figure 3 provides the best answer to this question.

Figure 1
The Consumer Electronics Market



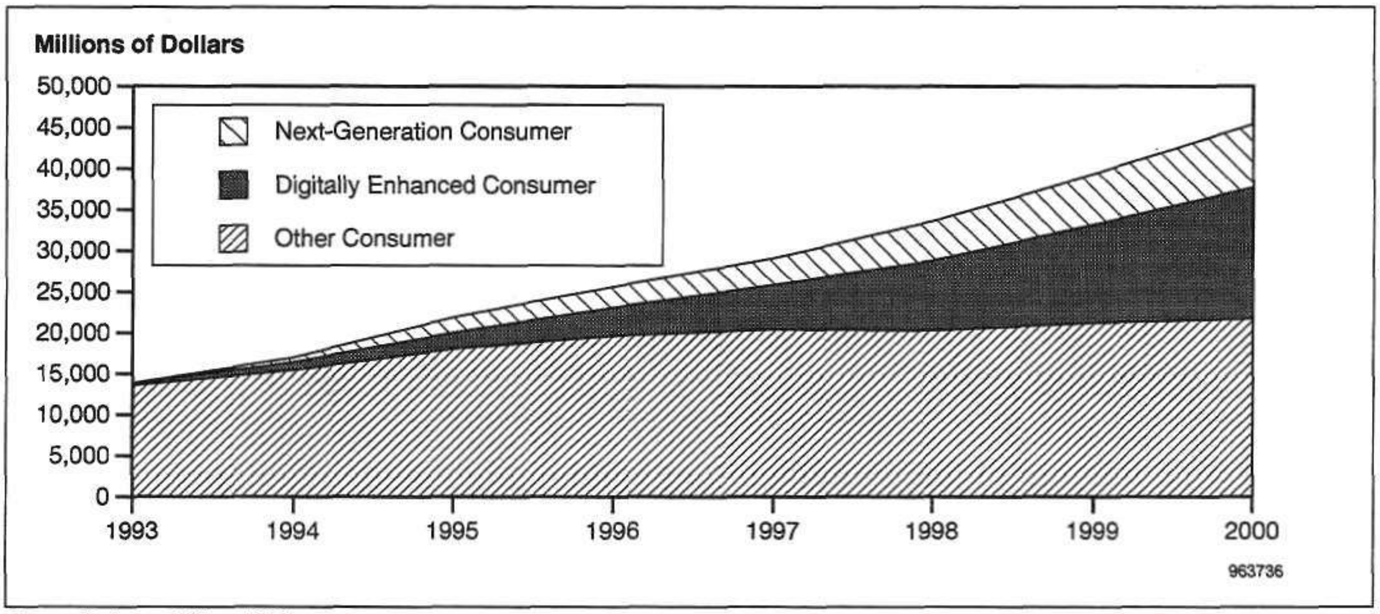
Source: Dataquest (May 1996)

Figure 2
Consumer Electronics Equipment Forecast



Source: Dataquest (May 1996)

Figure 3
Consumer Electronics Semiconductor Market Forecast



Source: Dataquest (May 1996)

Figure 3 is the type of chart that gets the adrenaline of semiconductor manufacturers flowing. The strong growth opportunities that are being created in the consumer electronics segment of the semiconductor industry are being driven by new digital versions of existing consumer electronics and what Dataquest has defined as next-generation products.

For clarity, "next-generation" products are 32/64-bit and beyond video game controllers, DVD controllers (these include only those controllers that are used for video playback and do not include those that would be sold into the PC market), digital set-top boxes, direct broadcast satellite converters, HDTV receivers, and other digital products such as digital cameras and MiniDisc players.

"Digitally enhanced" consumer products are products that we've had in our homes all along, but now we are seeing new versions released with digital enhancements to them. Recently we've seen the introduction of digital camcorders and digital VCRs. We are also seeing new digital content going into our television sets and TV guide set-top boxes on top of our television sets. We are seeing many new products roll out that we've had, but we now have digital versions of those products.

With this added digital content, the semiconductor market growth for consumer electronics is driven to almost 18 percent CAGR over the next five years. Beginning in 1995, the total consumer electronics semiconductor market is a little more than $22 billion. Of that, roughly $2 billion is in next-generation electronics, and another $2 billion in digitally enhanced consumer electronics. By the time we reach the year 2000, if we put these two categories together, they represent more than 50 percent of the consumer electronics semiconductor market, which by then has reached over $45 billion.

If we were to subtract the products in these two categories—if these products would not have come into existence—the market would only grow at a little under 6 percent from now until the year 2000. It's these digital products, the digital enhancements and the next-generation products, that are generating excitement among semiconductor manufacturers and drawing their attention and their investment dollars.

Figure 4 breaks out the next-generation consumer market into a little more detail. Overall, Dataquest is forecasting strong growth in this area with this segment of the chip market expanding from about $2 billion in 1995 and growing at a 55 percent CAGR to $7.7 billion by the year 2000. From this chart you will begin to get an idea of the areas we are bullish on, and one of the areas that we're not as optimistic about. HDTV receivers, shown in the top segment, will only represent about 2 percent of the semiconductor market for next-generation consumer electronics out of a total of $7.7 billion by the year 2000. About 10 percent of the chip market for next generation products will be going into DVD-Video (digital video disc) players. This does not include the chips that will go into the DVD-ROM players targeted at the PC. The combined set-top box and direct broadcast satellite market will account for 41 percent of the market, while 30 percent of the market will be driven by the 32/64 bit and beyond video game controllers. The remaining 17 percent of the market shown in the "other" category includes chips for products such digital cameras and MiniDisc players.

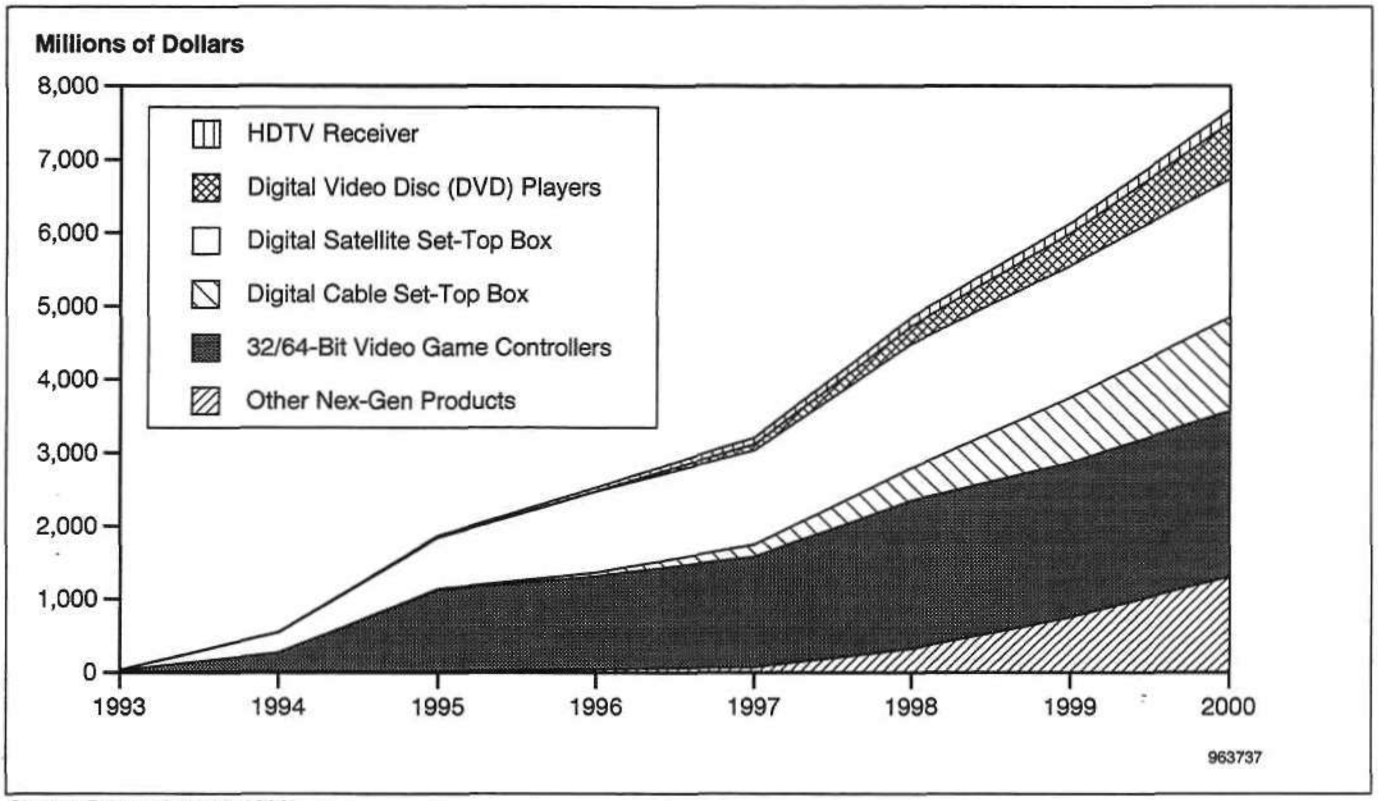
The Home Consumer Battleground

Having addressed the cold hard numbers in the forecast, let's talk a little bit about the battlegrounds that are shaping up in the consumer electronics realm. The most talked about competition is between the television and the PC. However, there are many other battlefronts that are shaping up in the consumer electronics markets. Some of these battles revolve around how content and services are going to be delivered to the PC or the television (see Figure 5).

One of the key areas of competition is between fixed-media and electronic delivery. Examples of fixed-media are CDs, cartridges, and cassettes. Electronic delivery comes in the form of twisted-pair to the home, coax and fiber, broadcast television, cable TV, DBS (direct broadcast satellite), and MMDS (Multipoint Multichannel Distribution System). Both types of delivery will be competing for the home consumer dollar.

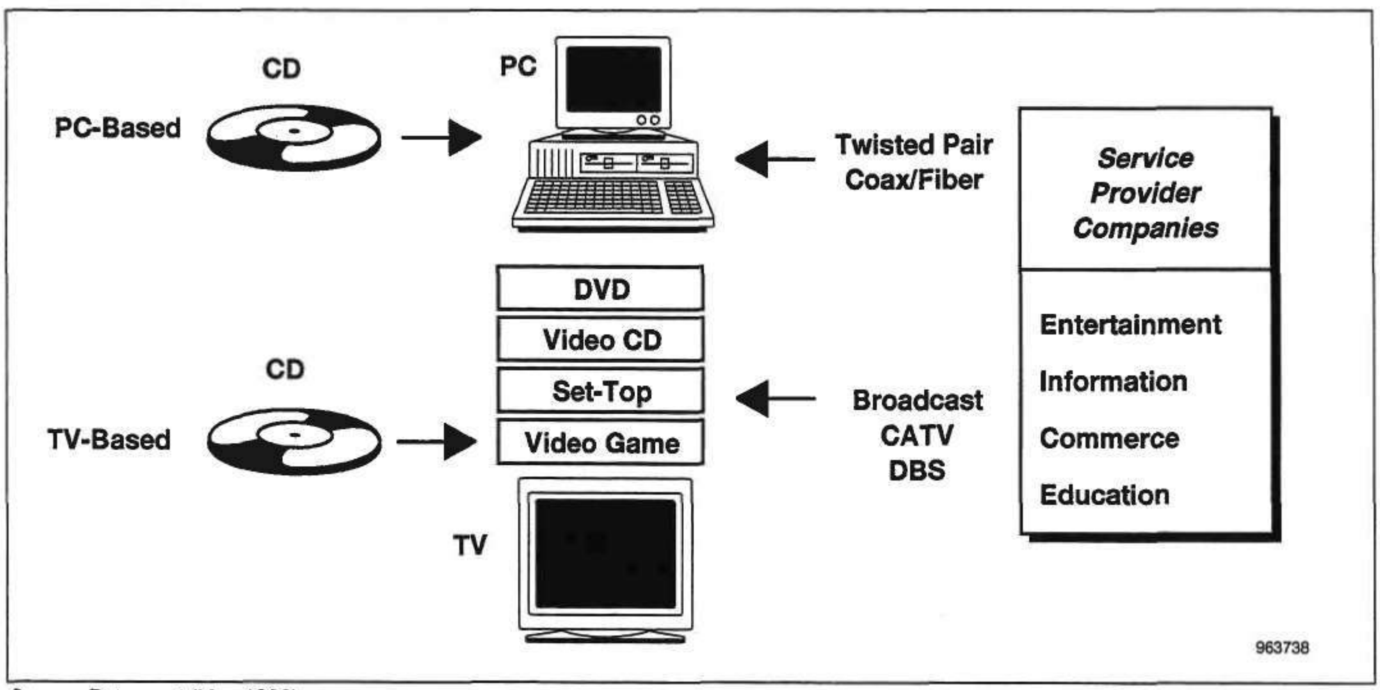
Within the television market, there are multiple consumer electronics products that are competing for space on top of the TV, including DVD-Video players, video CDs (these are still very popular in the Asia/Pacific region), set-top boxes, and video game players.

Figure 4
The Chip Market for Next-Generation Consumer Electronics



Source: Dataquest (May 1996)

Figure 5
The Battle for the Home Consumer Electronics Market Is Only Beginning



Source: Dataquest (May 1996)

While all of these products are competing against each other, they also have the potential to complement one another. For example, look at DVD-Video players and the DBS set-top box. As DVD players are developed that enable a recording capability, it will be possible to develop a hybrid DVD/DBS product where the digital video signal is received through the DBS system and then recorded in the same digital format on the DVD disc. By sharing the core chip set that includes MPEG-2 decoding, the cost of the overall system can be reduced and potentially enable improved economies for penetrating the home market.

In the midst of this pitched battle in the home consumer electronics market, it is interesting to note the devotion and the central role that these products play in people's lives, driving them to spend their money on these devices. Some people have gone beyond the point where this is a convenience, luxury, or an entertainment-type of product in their home. A recent survey conducted by USSB, one of the service providers for direct broadcast satellite, unveiled some interesting statistics. Nineteen percent of those surveyed said that they could not survive without television. Another 78 percent of adults considered watching TV with the kids to be a family activity. The demographics can be quite intriguing. Some people have reached the level of addiction to these products. In the PC world there are recent reports of internet addicts. For example, some students are finding that their studies are beginning to suffer as they jump onto the internet and do not know when to get off. Television can be equally as powerful. A recent study of *Star Trek* devotees found that many exhibited the typical signs of addiction and withdrawal when they are isolated from *Star Trek* programming and products.

Set-Top Boxes

Many of the hopes and expectations that the marketplace had placed on set-top boxes had a bit of a shadow cast on them because of the disappointing results of the trials conducted in various locations across the United States. However, the bright spot that jumped out in 1995 was the exceptional success of direct broadcast satellite (DBS) products. The shipments of DBS systems in their first 18 months qualify this product as a true home run.

At the 1996 Consumer Electronics Show, Thomson Consumer Electronics announced that it had shipped 1.8 million DBS boxes over an 18-month period, with 1.2 million of those shipped during 1995. Thomson Consumer Electronics also announced that its inventories were down to less than one week. It has now announced its second-generation receiver, and the first-generation receivers have dropped down below $500. PrimeStar also claimed its one-millionth subscriber 17 months after the launch of its system. PrimeStar has had the backing of TCI and cable operators, with General Instruments supplying its set-top boxes.

In addition to the services offered by PrimeStar, USSB, and DirecTV, two new services are joining the competition in 1996. EchoStar has rolled out its DISH network and also won the FCC auction for the 148-degree satellite slot. The other system is AlphaStar, a subsidiary of Canada's Tee-Comm Electronics Inc. MCI Telecommunications won the other FCC auction for the

110-degree satellite slot with a bid of $682.5 million and will team up with Rupert Murdoch's News Corp. to offer Direct to the Home (DTH) services.

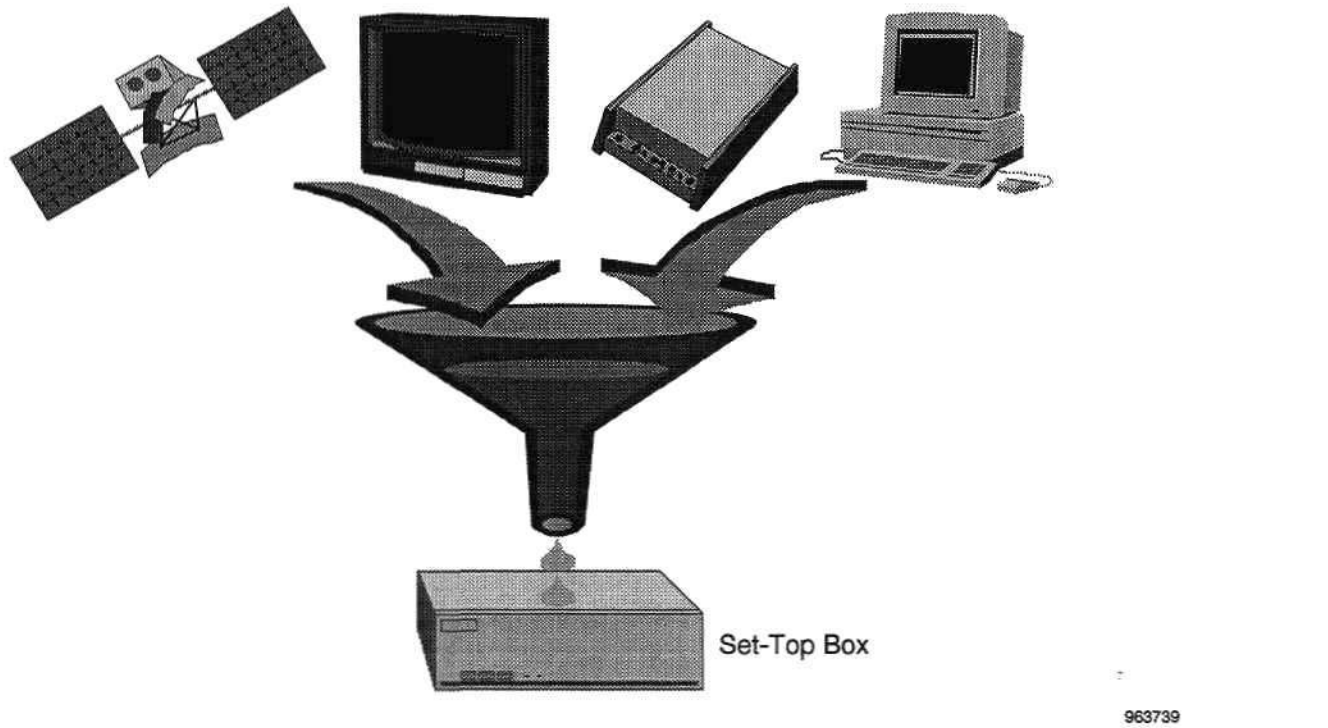
While the shining star for digital consumer electronics was the DBS/DTH set-top, the cable set-top box market continues to be delayed by disappointing trial results. The barriers discovered in the trials have driven service providers and equipment manufacturers to investigate alternative approaches for this market. They are now backing off from the promise of video-on-demand (VOD) to near video-on-demand (NVOD). In the NVOD system, a broadcaster would deliver many more channels and begin transmitting the same movie every 15 minutes so that a subscriber could tune in at one of those 15 minute intervals and watch a program. Service providers are also looking at expanding the network bandwidth from the current 400 MHz to 750 MHz to provide more of room to add these extra channels.

Meanwhile, the search for the most cost-effective and timely communications technologies continues. The competition in this arena ranges from hybrid fiber coax (HFC) technology and fiber-to-the-curb (FTC), to wireless cable services (MMDS) and asymmetric digital subscriber line (ADSL). In fact, we now have so many people with so many schemes for delivering content to the home over a wireless system that these airwaves are really becoming quite valuable. The government will be milking that for all it's worth as it works to get its budget down.

On the home front, there are concerns about the costs of these boxes and what consumers will be willing to spend. There are also questions about what service providers are willing to invest up front in order to get the market rolling. One potential solution to the dilemma over financing was introduced by Hewlett-Packard. At the Western Cable Show, HP announced its leasing plan for its Kayak set-top box, where for $7 to $10, service providers will be able to lease their set-top box from HP. Under this program, HP would step up to shoulder more of the risk and financial burden in order to create a market for its product.

The set-top box draws on technologies from multiple disciplines (see Figure 6). In fact, it's one of the few stories of a successful application of military technology in a consumer application—the DBS set-top box. Perhaps the only other system with a similar successful application of military technology is the Global Positioning System (GPS). Other obvious technologies that play a role in set-top boxes have been borrowed from the television and modem arena. Even PC technologies play a critical role. In addition to robust operating systems, video and graphics processing capabilities developed for the PC have been incorporated into set-top boxes. All of these technologies have to be merged into one product, and this merging has to be done at a very cost-effective, consumer price point. This is truly challenging the industry. Fortunately, industry standards are being developed that will help in the cost of developing these products. With the use of technologies that cut across a number of different disciplines, standards bodies have made progress in creating standards that engineers can design to and move product development forward.

Figure 6
Distilling Diverse Technologies Into the Cost-Conscious Set-Top Box



Source: Dataquest (May 1996)

Encryption has increased in its visibility and its importance to the set-top box market. With hackers and counterfeiters working to crack the codes that protect the value delivered through set-top boxes, the development of more robust encryption schemes has become critical. Fortunately, it appears that those who developed the early set-top box products had enough vision to build in the capability to respond to these attacks. For example, in DBS boxes that there is a convenient smart-card slot that has been designed into the box. Plans have already been put into place to ship out smart cards with new encryption codes and algorithms as another wave of defense against counterfeiters.

Chip Solutions and Opportunities in the Set-Top Box Market

One of the opportunities for semiconductor manufacturers in this area is to drive out the costs for the existing features in set-top boxes. The set-top box world has been dominated by a handful of suppliers. They have managed to maintain a fairly constant price point of $105 for the average set-top box over the past decade. With the advanced set-top boxes that are being developed, chip suppliers also have the chance to deliver new compelling features that will enhance these newer products. Dataquest segments this market into four categories: nonaddressable analog set-top boxes, addressable analog set-top boxes, advanced analog set-top boxes that have an addressable capability and upstream communications capability, and the digital set-top boxes that include the digital video decoder with MPEG-2 and DigiCipher compression technology. As semiconductor manufacturers begin to compete in this area, they will be called upon to bring their economies—the semiconductor economies that have worked so well in providing more bang for the buck in the PC world—into consumer products.

Chip suppliers are also enabling new entrants to penetrate what has been a closed equipment supplier system in the cable world. Recent entrants such as Hewlett-Packard and Sony will create better competition in this market and help drive down prices as they work to end the dominance of earlier players. However, semiconductor manufacturers face this challenge: They need to have the skills and the technologies, whether developed in-house or licensed, so that they can integrate diverse functions into their chipsets. A brief list of the functions they must be able to integrate spans from 32-bit microcontrollers to communications technologies to decoders and memory.

32/64-Bit Video Game Products Move the Market to the Next Level

During the past year we have seen video game hardware move to a new level of performance with the introductions of new 32- and 64-bit platforms. In 1995, a third major player entered the market that had been dominated by Sega and Nintendo. Sony burst onto the scene in a big way with its PlayStation. Sony definitely made a big splash in the North American market and captured significant market share with its 32-bit player.

Sega also launched its next-generation product, the Sega Saturn, and a new portable product, the Genesis Nomad. Sega has not been as pleased with the results of its Sega players in the United States. Sega has pointed the finger of blame at a lack of adequate advertising and promotion for the Saturn and expressed its determination to double its efforts in 1996.

Both Sega and Sony are now anticipating the introduction of Nintendo's new platform, the Nintendo 64. Nintendo did introduce a new product in 1995, the Virtual Boy. This is a unique platform that uses a set of goggles that allow a player to view a 3-D monochrome image. This is not intended to be a portable system. Early success of this system was limited by its high price point, which Nintendo dropped as it works to stimulate the market during 1996.

Again, hitting consumer price points is a key factor in stimulating sales for these new products. Sony introduce its PlayStation at $299, while Sega rolled out the Saturn at $399. Sega shortly dropped the price by $50 to $349 and then dropped it another $50 to $299. Consumers are not willing to pay steep prices for these video game controllers. As a result, it has put severe price pressure on the manufacturers to bring these platforms down into the consumer realm. At the recent E3 show in Los Angeles, both Sony and Sega dropped their retail price for the PlayStation and Saturn to $199.

3DO continues to flounder even as many people comment on the excellent technology it has developed with its Power PC-based platform. 3DO made a number of moves at the end of 1995 and in early 1996 to continue to push its technology. First, Matsushita bought the rights to control the development and production of the next-generation M2 platform from 3DO. Originally, both parties stated that the value of this agreement was in the $100 million range. Subsequent information indicates that the value of this deal was much lower. In 1996, 3DO licensed its technology to Cirrus Logic for use in its graphics controller chipset.

In all of these video game platforms there are new microprocessors bringing increased firepower to game players. The MIPS RISC architectures have had really big wins in this area. LSI Logic is delivering its R3000A processor in the Sony PlayStation ,and Silicon Graphics teamed up with NEC to capture the slot in the Nintendo 64. The Power PC is rumored to have a possible future in Sega's platform. This must be of concern to Hitachi, which has two SH-2 processors and an SH-1 microcontroller in the Sega Saturn. For non-Intel architectures such as MIPS and Power PC, these consumer markets represent a golden opportunity to move into segments where Intel isn't playing and establish a solid presence.

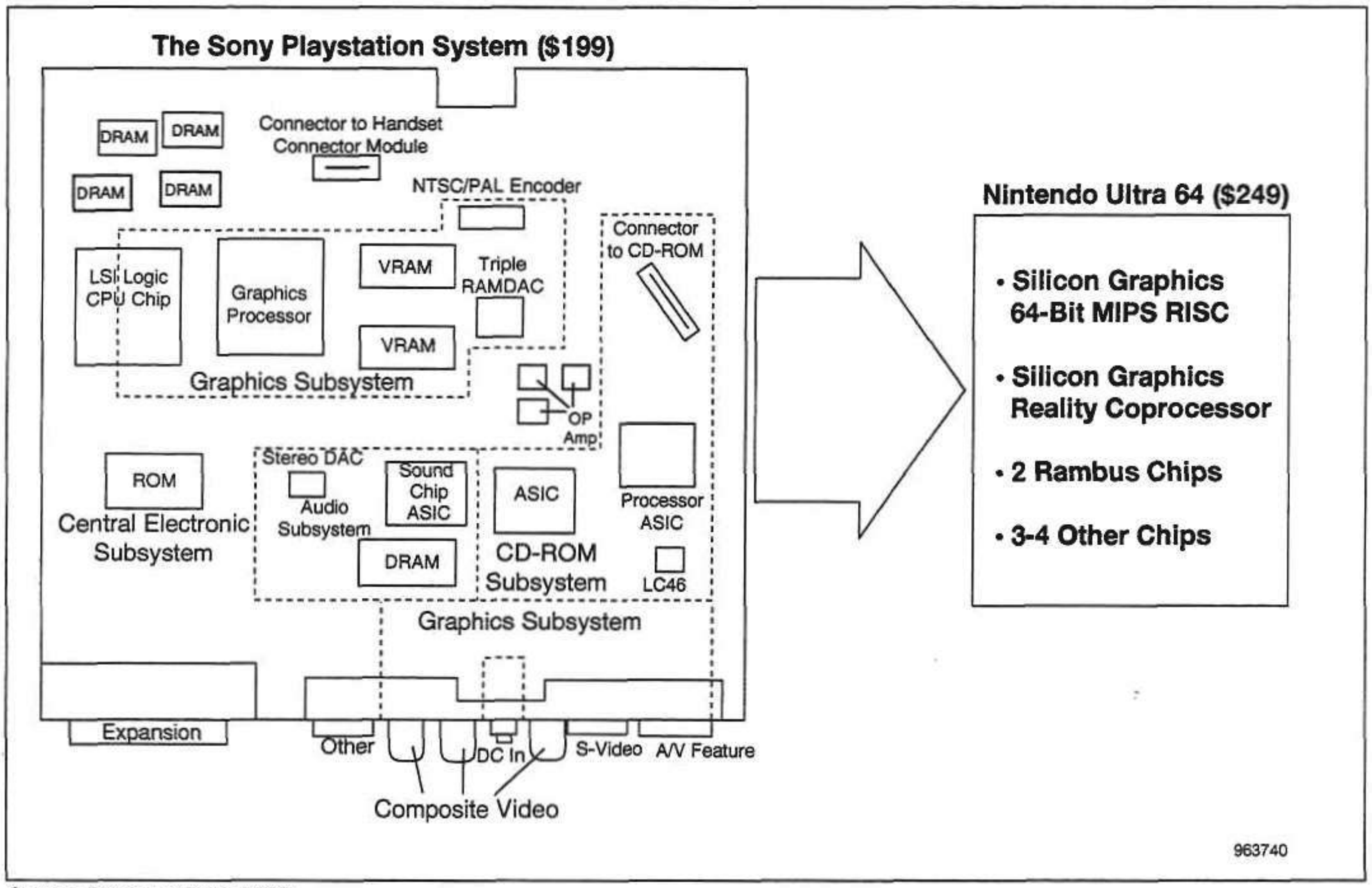
There are also new memory architectures showing up in these platforms. The Nintendo 64 uses a Rambus architecture, and the others are employing various combinations of SDRAM and VRAM. Quite often these advanced memory architectures show up first in consumer electronics products before they move into PCs.

Both Sony and Sega have to be questioning the price they are paying for moving to the CD-ROM format for software distribution. This discussion is best illustrated by Figure 7. Dataquest has had the opportunity to do a detailed analysis of both the Sony PlayStation and the Sega Saturn. We were able to do a close examination of the components in each and assess the major cost drivers in these platforms.

The diagram on the left side of Figure 7 shows the system board in the Sony PlayStation. There are multiple processors on this board including the LSI Logic CPU chip, a graphics processor, a sound chip ASIC, and another couple of processors in the CD-ROM subsystem. All of these chips in the Sony PlayStation are a significant factor in driving the price. Two-thirds of the cost of manufacturing the PlayStation is because of the chips alone.

On the other hand, the Nintendo 64, which Nintendo plans to introduce at $249 (and again, rumors are that it may even try to push the price down to $200), contains two major processor chips: the Silicon Graphics 64-bit MIPS RISC processor and a Silicon Graphics Reality co-processor. The only other chips are two Rambus chips for memory and three to four other smaller chips. There is a slot for upgrading and adding additional memory if desired. The integration that Nintendo has achieved in the Nintendo 64 is definitely playing a factor in its ability to hit that $249 to $200 price.

Figure 7
Chip Opportunities in Video Games



Source: Dataquest (May 1996)

There is another important cost factor because of the use of a CD-ROM drive in the PlayStation and Saturn systems. In addition to the added cost from the drive itself, these designs also require additional chips and memory to be placed on the system board, which adds even more to the cost. In a cartridge-based system such as Nintendo's, there is no need for the added memory to support a CD-ROM drive. Instead of a combination of DRAM, VRAM, and ROM, which is a significant cost driver for Sony's PlayStation, the Nintendo 64 uses two Rambus chips. The Sega Saturn takes an even bigger hit on memory costs than the PlayStation.

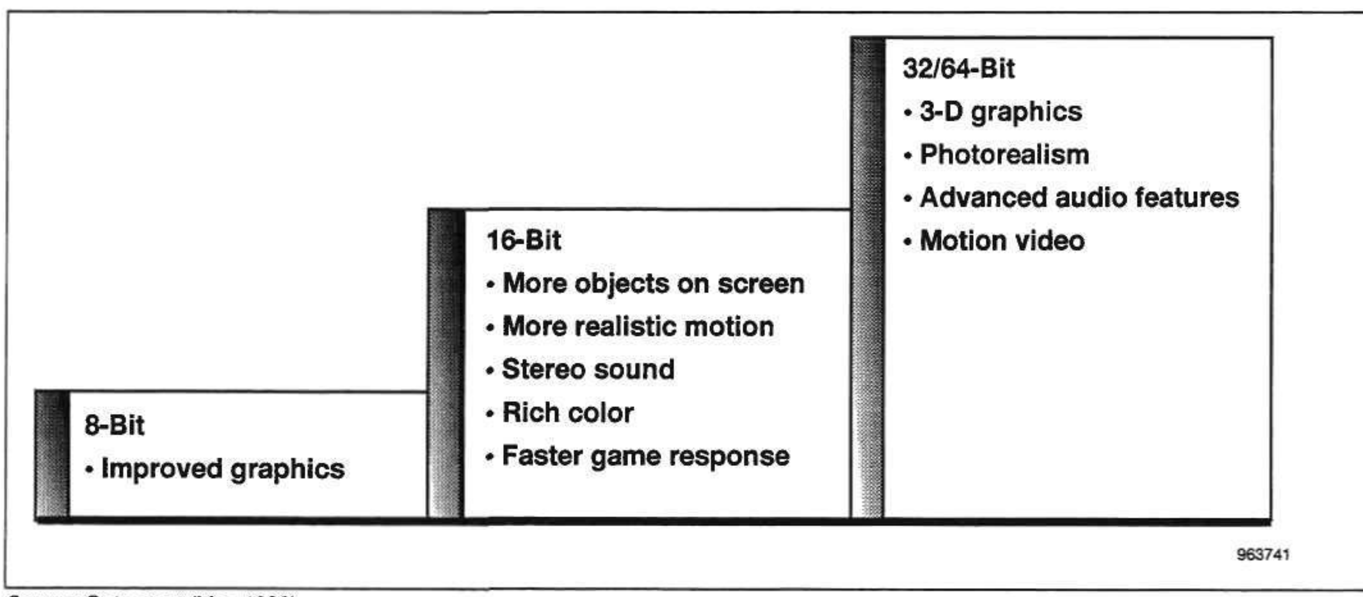
It is true that Nintendo is paying a different type of price for using a cartridge-based platform. Sega and Sony are indeed able to save on the cost to roll out the software itself and on the distribution and the production costs of the software. However, they are paying a price on the system side and the penetration they are able to make in the home market with their higher system prices. If online gaming and electronic delivery of titles takes off in this market, then Sony and Sega will even lose the cost advantage on software distribution.

Advanced Chips Delivering Next-Generation Features

Video games have really moved up the performance curve through each succeeding generation of platforms (see Figure 8). We have gone from the eight-bit world, where we had some improved functions coming into play, to the 16-bit world where systems were able to handle more objects on the screen and deliver more realistic motion, richer color, faster graphics, and stereo sound. Now with 32-bit processing capabilities, video games are able to perform 3-D processing, texture mapping, rotation and scaling, and full-motion video. These systems are also delivering advanced, CD-quality audio with 3-D sound. They are also improving the human control interface by offering wireless controls, virtual reality goggles, and memory cards. Memory cards have been used for upgrading the performance of the system, but now these systems also have a slot in the front where you can save an ongoing game on a card, take it down the street to your friend's house, plug the card into another system, and keep playing the same game.

Putting all of this functionality in a video game while dealing with all of the cost issues has created a challenge for the Japanese manufacturers of these products. The increasing value of the Yen has not helped matters either. This has lead the Japanese manufacturers to move production offshore into other Asia/Pacific countries to reduce costs. For example, Hitachi has been a major manufacturer of the Sega system. It is now offering to set up manufacturing facilities in other Asia/Pacific countries. However, Sega is discussing options with other manufacturers in addition to Hitachi as it evaluates its options for a next-generation system.

Figure 8
Advanced Chips Delivering Next-Generation Features



Source: Dataquest (May 1996)

What Does DVD Offer the Consumer?

DVD was the big story at the January Consumer Electronics Show. There was an intriguing battle played out throughout 1995 between competing standards in this realm. With agreement on a common standard, the door has been opened to the market for an exciting product that offers great opportunities to consumers, retailers, and electronics manufacturers. In discussing the improved features that DVD offers, we begin with the major advancements in audio and video quality. Using new digital technology, this system is able to deliver what is called "better-than-VHS" quality video. It also enables audio performance that is superior to CD-quality sound with digital home theater surround-sound. These improvements are probably the most meaningful for the typical consumer.

On top of these improvements, DVD makes it possible to put an entire movie on one CD-ROM-sized disk that stores 133 minutes of sound and video. The audio track can store three different languages. An additional four languages can be displayed in subpictures. Multiple aspect ratios can also be displayed using a DVD player including standard TV, wide screen, 3x4, or 16x9 aspect ratios.

Added to these features is the ability to provide copy protection that will be built-in to protect the interests of content developers in Hollywood, and parental lock-out control that is an improvement over the V-chip concept. Instead of only having the option to completely block out a particular movie, DVD allows the consumer to select what version of the movie to watch: R, PG-13, PG, or G. DVD also allows content developers and distributors to include related products with the videos on the disks. Developers can now include a video game based on the video that is recorded on the disk, and they can expand their marketing opportunities into the video game segment. With the recent highly successful movie *Toy Story*, viewers who went to the theater could also play the *Toy Story* video game in the theater arcade. Now this marketing concept can be brought right into the home.

As mentioned earlier, there was a pitched battle over standards that was played out during 1995. There was one camp lined up behind the Super Density (SD) format, led by Toshiba and Time Warner, and a separate group supporting the Multimedia CD (MMCD) standard, led by Sony and Philips. Each group worked aggressively on the development of their technology and in recruiting supporters of their standard in the manufacturing, semiconductor, and content-creation industries.

DVD Players Agree on Single Standard

The two camps were finally pushed together at the end of 1995 and agreed on one common standard. The main force driving the two groups into an agreement came from the "Group of Five" in the PC world. These companies saw the opportunity for applying DVD technology inside of PCs, and led by Compaq and Microsoft they pushed the players toward a single standard. The agreement on the DVD standard is what made it possible to have an upbeat Winter Consumer Electronics Show in January following a less-than-exciting holiday season for consumer electronics sales in the U.S. market.

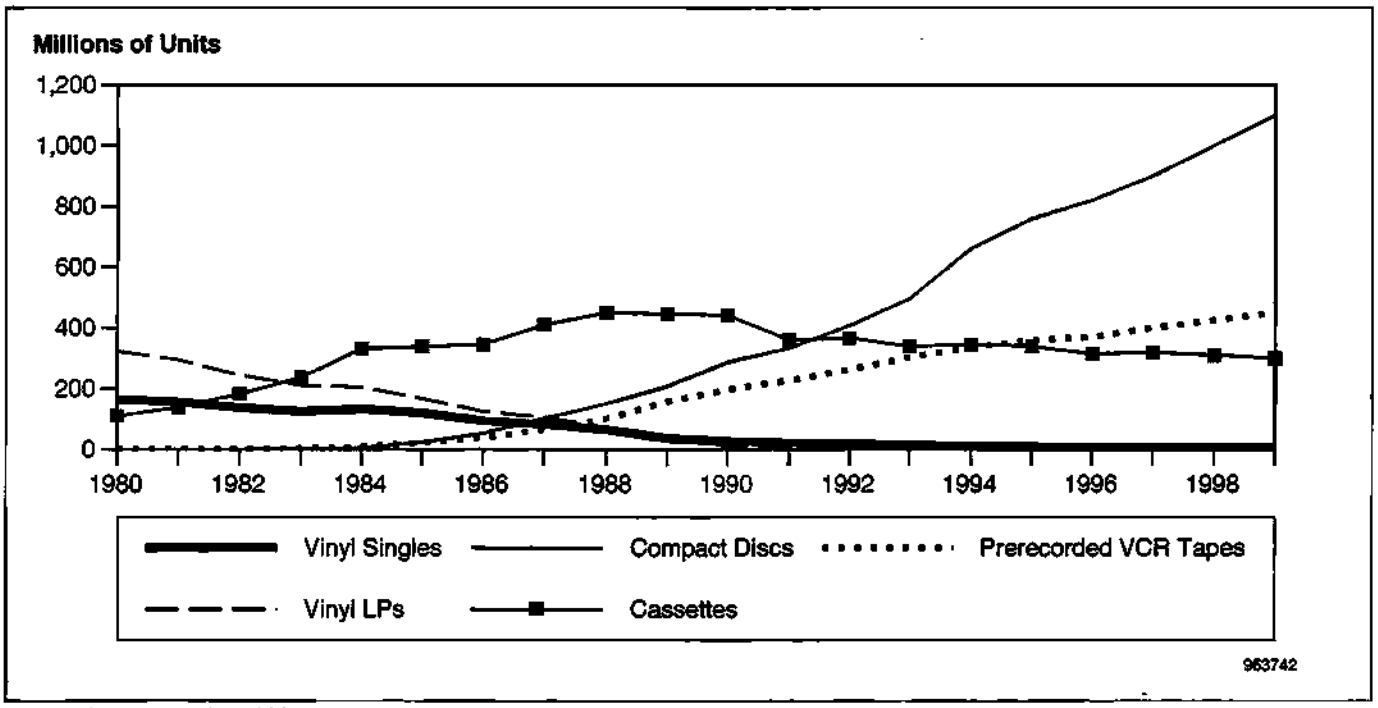
Remember that Sony and Toshiba were both demonstrating DVD players and DVD technology in the January 1995 Consumer Electronics Show. It was the announcement of this finalized standard that allowed almost a dozen additional manufacturers to announce or demonstrate DVD players in 1996. The new players included Matsushita, Philips, Thomson, Pioneer, Samsung, LG Electronics, Onkyo, Sanyo, Zenith, Hitachi, JVC, and Mitsubishi. All of them were either demonstrating players or announcing plans to build players for the DVD market.

Toshiba is leading the pack in coming to market with the introduction of two products, a $599 and a $699 DVD player that the company says will reach the market by Labor Day. Thomson also said that it will introduce a DVD player in 1996, and it vowed that it will still hit the original $499 price point. However, it is difficult to understand how Thomson will do that in light of another announcement. It has entered into a joint agreement with Matsushita in which Thomson will manufacture set-top boxes for Matsushita's Panasonic brand, which will be introduced in the United States in 1996. In return, Matsushita will manufacture DVD players for Thomson. This agreement will help each company enter the different markets until they develop their own manufacturing capabilities in these areas. Since Matsushita will actual produce the DVD players for Thomson initially, it will limit Thomson's ability to hit a $499 price.

As an interesting side note to the development of a DVD standard, there is no official agreement on what DVD stands for. The most common meaning assigned to DVD was Digital Video Disc. However, with applications for this technology in the PC and audio markets, the standards committees announced that they would just refer to the standard as DVD with no official meaning for the acronym. The market really wasn't satisfied with this decision, so the market has come up with its own name for DVD—Digital Versatile Disc. In the near term, DVD will be a read-only medium and its earliest applications will be in the video playback arena. As the technologies are developed, it will begin to move toward a writable capability, and eventually to an erasable/writable medium to make it a true RAM memory product.

There have been concerns about adequate supplies of some of the critical components for this product, such as the laser diodes. However, Dataquest believes that the market demand will not be great enough in the near term to make this an issue. There are some highly optimistic forecasts that are creating the concern over component supply that Dataquest does not support. While Dataquest does expect DVD to be a highly successful product, we differ with some of the manufacturers in their predictions on how quickly this market will ramp. In our preliminary forecast, we expect 60,000 unit shipments worldwide in 1996 of DVD-Video players. We expect the market to reach 2.5 million shipments in 1998 and about 10 million by the year 2000. While the DVD products for PCs will lag in their introduction to the market, we expect similar success for these products, with market shipments reaching 10 million by 2000 (see Figure 9).

Figure 9
Strong Support from Content Providers Should Push DVD Success



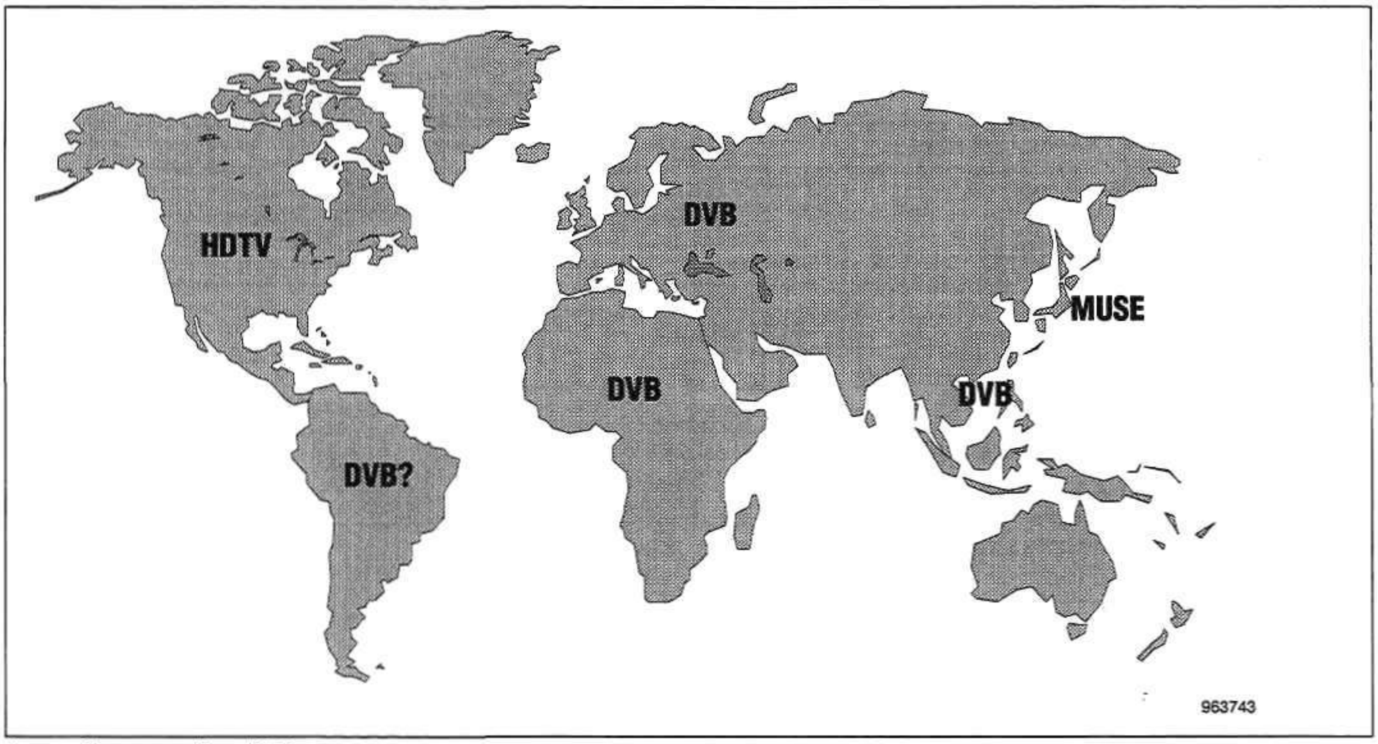
Source: Dataquest (May 1996)

There will be strong support from the content developers for DVD products, and this will be important for its success. About 250 movie titles are expected to be released on the DVD format when these are introduced in late 1996. The success of prerecorded VCR tapes and their penetration into the home market, as shown in Figure 9, is an important indicator of the potential for DVD. Combined with the popularity of the optical disc format, the delivery of movies and software content in a DVD format should be very popular.

What Is the Future of Digital TV?

We are seeing regional variations with regard to the future of digital television (see Figure 10). In the United States, efforts to develop an HDTV standard product continue, and in Japan the MUSE standard has been established. It had been announced that Japan would move to a digital system similar to HDTV, however there has been strong resistance from the manufacturers to this shift and we do not expect to see a major move to a digital HDTV product in Japan any time soon. There are claims that between 9 to 11 hours a day of HDTV satellite broadcasts have been provided in Japan over the past year. The reality is that the HDTV broadcast was more in the range of two to three hours a day, but they are gearing up for a big commercial rollout in 1997.

Figure 10
MUSE, HDTV, and DVB: Regional Variations on a Theme



Source: Dataquest (May 1996)

In Europe, broadcasters and equipment providers have chosen to skip efforts to develop an HDTV product and they have moved to developing the DVB, Digital Video Broadcast, standard. In this product, the same resolution is delivered as in current televisions but the additional available bandwidth is used to send out more channels. With the momentum that has been achieved in the development of DVB, this product could repeat the earlier success of digital GSM cellular telephones in becoming a de facto worldwide standard.

Significant Challenges Remain for Advanced Television and HDTV

In the United States, even the Grand Alliance has admitted that it will probably not be able to roll out HDTV products until 1998. Again, the government is looking at plans to auction off the spectrum for digital television broadcasts, and this has become the focus of intense lobbying in Washington D.C. There will be a pitched battle between the different interest groups and industries. On one side, the current TV broadcasters are arguing that they should receive their spectrum free since they provide a public service. However, other parties claim that this would be an unfair government giveaway and that broadcasters should compete with others in this new market and pay for their spectrum allocation. There was an attempt to include a specific provision for the TV spectrum auctions in the telecommunications legislation that was passed in Congress earlier this year. However, as part of a compromise to get the bill passed, it was decided that the issue of auctions would be dealt with in future negotiations. There are also different proposals that have been introduced for developing the digital TV market, including plans from the FCC and the White House. In the White House proposal, the introduction of digital video broadcasting would be set for 2005 and include vouchers to help consumers buy digital decode equipment or new digital TVs to receive the new digital broadcasts as the old analog signals are phased out.

There are various key technologies that are being leveraged from other products into the development of digital television, such as the MPEG-2 and AC3 compression and modulation standards like quadrature amplitude modulation (QAM) and vestigial side band (VSB). Once again, the question that must be answered in the development of advanced television products is, "Will the consumer be willing to pay the price for new products such as HDTV?" In order for these products to be successful they must be able to reach the right price point. One area that offers some promise for helping on the issue of cost is the development of new display technologies.

Display Technology Is the Focus of Intense R&D

There are a number of technologies that are being developed for flat panel displays such as plasma display panels (PDP), LED displays, flat thin cathode ray tubes, vacuum fluorescent displays (VFD), electroluminescent (EL) panels, and field emission displays (FED). One of the major hurdles in developing all of these products is moving from a successful prototype to full-scale production. Perhaps the biggest wild card in all of these technologies is the LED display. If a blue LED and a green LED with good reliability and performance are successfully developed at the right price, this could enable a major displacement of the LCD panels that currently dominate the mobile PC market, paving the way for a new consumer display market.

In addition to flat panel displays, there are other technologies out there, such as the digital micromirror display (DMD) developed by Texas Instruments with its digital light processing (DLP) technology. TI has shown that it can create 400,000 micromirrors on a chip 17 microns square. TI has demonstrated early prototype products with this technology, including a presentation at Dataquest's 1995 Semiconductor Conference. Sony and Thomson appear to be poised to help TI bring this product to market. There is also a Laser CRT and Direct Laser product under development. The United States continues to flirt with investments in the display arena to help the development of a U.S. display industry. This industrial investment debate revolves around whether the creation of a display industry in the United States is critical to the competitive stature of the United States or whether it would be better to leverage the R&D and production that is taking place in Japan and the Asia/Pacific region.

What's a Hot Chip Like You Doing in a Place Like This?

There are additional digital products that are beginning to emerge. A number of digital camcorders were introduced at the 1996 Consumer Electronics Show. While these are admittedly "prosumer" type products, they show the leading edge of where the market could eventually move. For example, JVC introduced a small digital camcorder based on the digital video (DV) standard, and Canon is marketing an eye-tracking camcorder. It is no small thing to track the eye, yet inside of a camcorder we now have eye-tracking technology.

The digital camera was targeted originally at more of a vertical market, but manufacturers have been pleasantly surprised by its acceptance and penetration into some of the consumer markets. It is currently being sold more as a PC peripheral that offers an effective way of capturing images and moving them into the PC. While digital cameras do not compete with the picture quality produced by film-based cameras, they offer better input mechanism for PCs. Using a standard camera it is necessary to take the picture, develop it, and then use a scanner to input the image to a PC. A digital camera greatly simplifies this process. Ricoh and Casio both have products on the market. Chinon has been manufacturing products under a number of U.S. brand labels for some time, and it rolled out its own brand at the Consumer Electronics Show. All of these manufacturers were moving aggressively to double and triple their manufacturing capacity during 1995 to meet market demand.

Networking is coming to your home entertainment system. The IEEE 1394 standard is being promoted as the networking solution for consumer products and as an interface between the PC and consumer worlds. Evidence of progress in the adoption of this standard is Sony's inclusion of a 1394 port on its new digital camcorder. The CEBus and LonWorks standards are competing to become the local area network in the home.

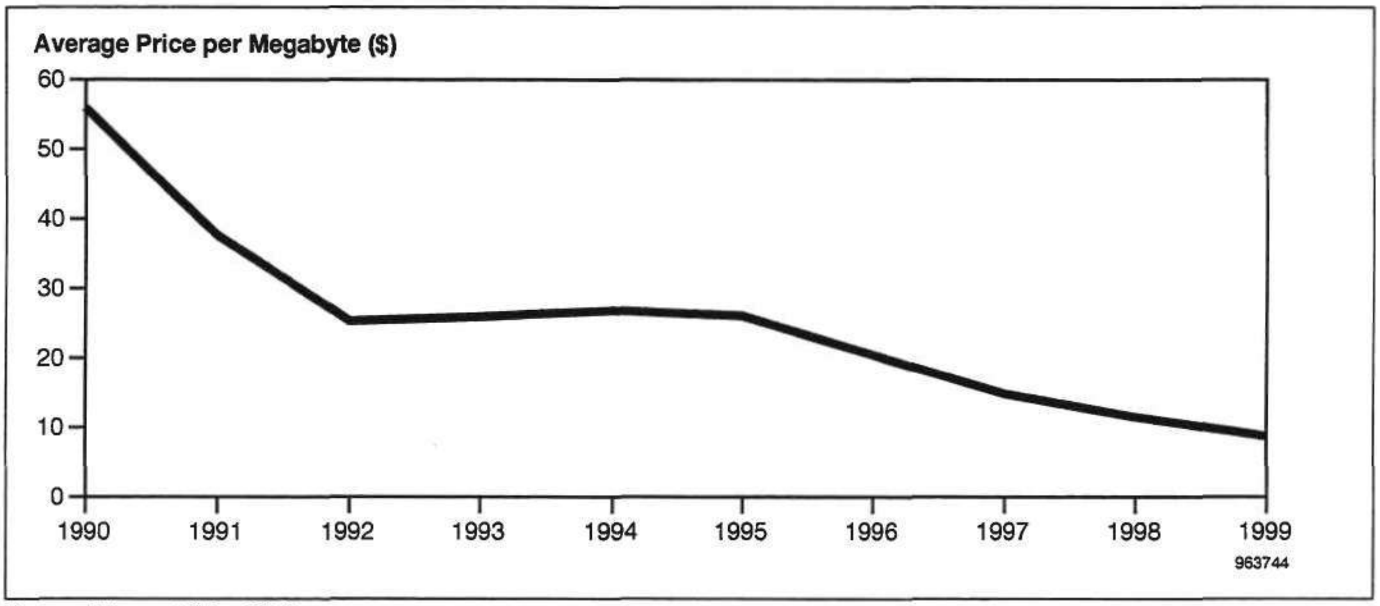
The personal portable stereo market continues to evolve with new features and enhancements. Sony continues to market the MiniDisc (MD) player and dropped the price for its playback-only product to $199. While MiniDisc products have been successful in Japan, they are still working for acceptance in the U.S. market.

Even watches have been impacted by digital technology. For more than a year Timex has been marketing a watch that is its own mini day planner on a wrist. This watch enables you to enter your schedule into your PC and then download that schedule into your watch by hitting a button and holding the watch up in front of some flashing bars on a PC monitor. The watch then serves as an intelligent reminder throughout the day of important appointments and times.

Dataquest Perspective

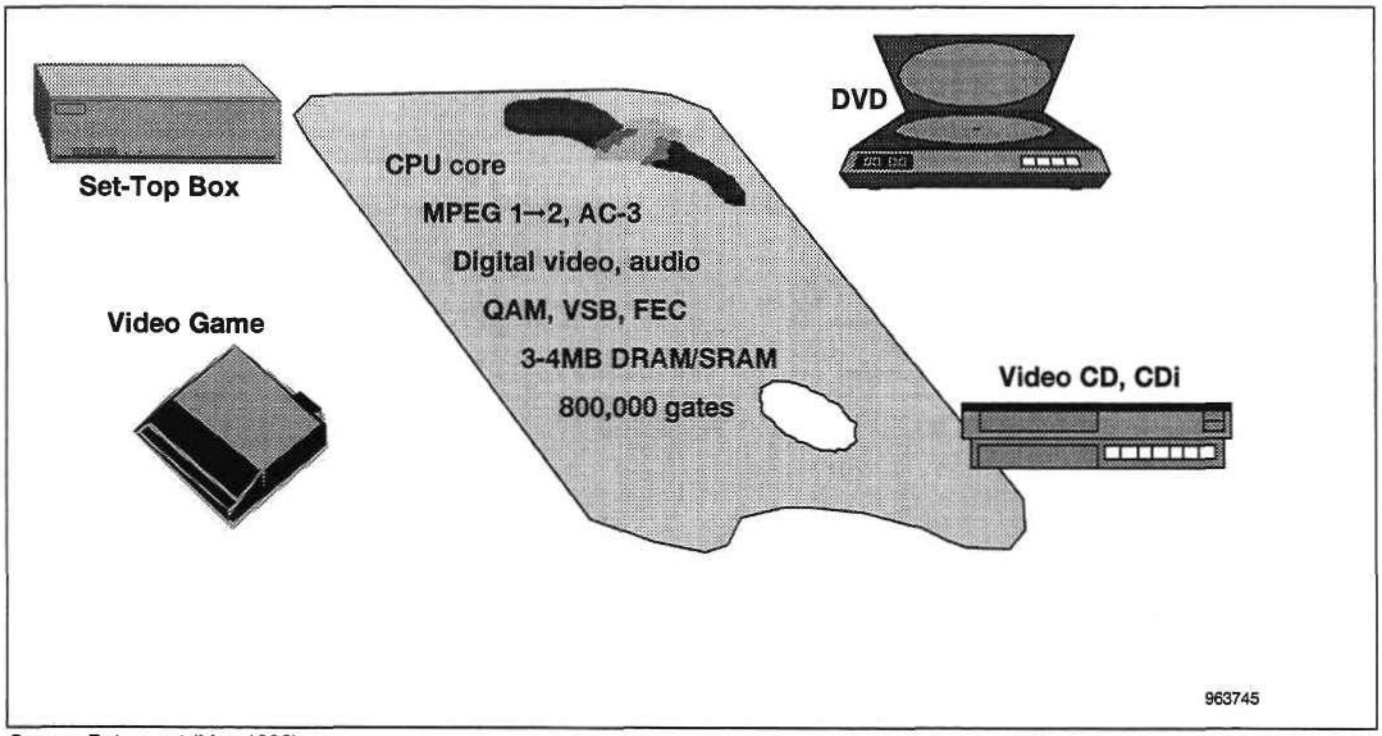
Figures 11 through 13 summarize some of the important issues related to the consumer electronics market and the impact of digital technology. Dataquest expects that DRAM manufacturers will find exciting new opportunities in consumer electronics products. Consumer electronics manufacturers are introducing the leading-edge DRAM architectures into their products to milk every ounce of performance out of them. Lower DRAM pricing will provide some relief to the manufacturers of these digital electronics products over time and will help them hit important consumer price targets.

Figure 11
New Consumer Electronics: Growing DRAM Opportunity



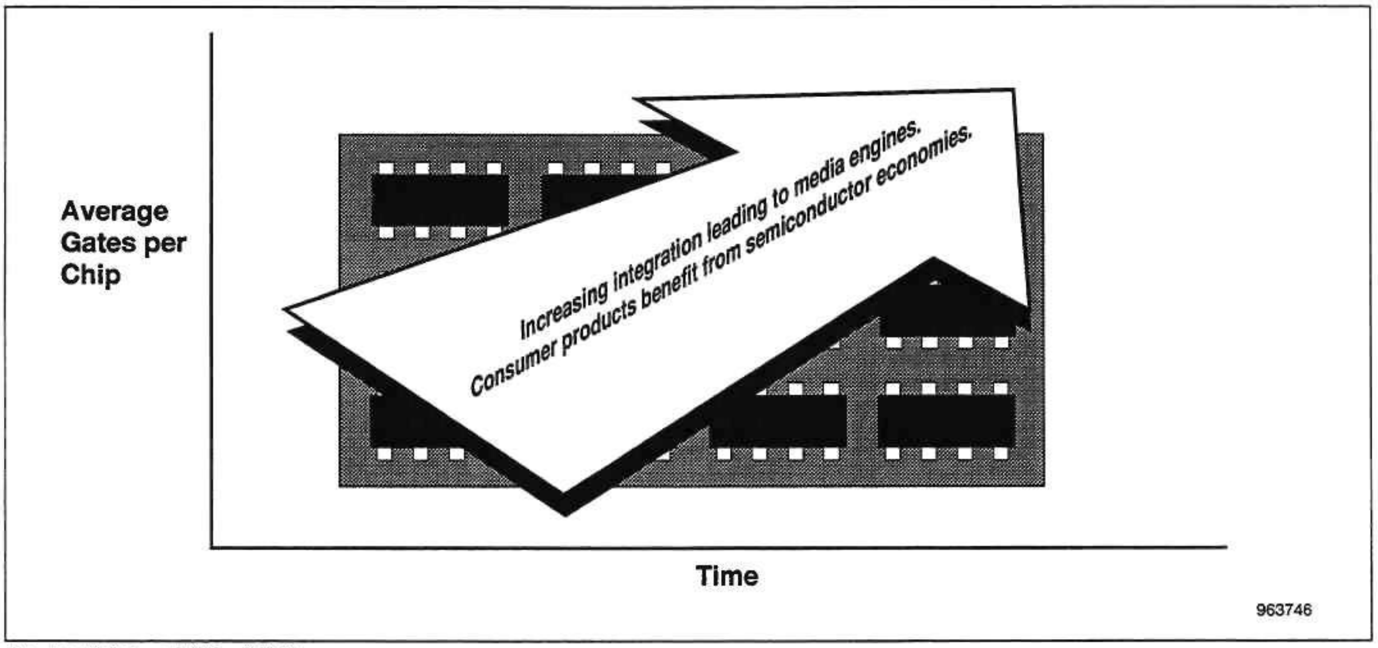
Source: Dataquest (May 1996)

Figure 12
Leveraging Technology and Chips across Multiple Platforms



Source: Dataquest (May 1996)

Figure 13
Semiconductors: Escalating Integration and Performance



Source: Dataquest (May 1996)

Semiconductor manufacturers have invested early in many of the core technologies that will be used in digital consumer electronics. Their investment will be leveraged into multiple consumer platforms. Consumer electronics manufacturers will be able to draw from a palette of technologies in developing their products, ranging from compression technologies such as MPEG1 and 2 and AC3, to modulation and the encryption technologies. The application of semiconductor industry economies to consumer electronics will allow these products to derive some of the same benefits that helped drive the PC market to the heights it has reached.

Finally, Dataquest believes that semiconductor manufacturers are moving the scope of their vision beyond just the PC. Many companies that have been devoting their development purely to the PC are now forming their own consumer electronics divisions to go after this market and take all of their eggs out of one basket. There are significant growth opportunities here for different MPU architectures, DSPs, memory, ASIC, and ASSP products.

We are going to see greater participation of North American and European companies in the consumer market than we've ever had before. Traditionally the Japanese companies have been recognized as the dominant players in this market. Now these consumer giants are turning to companies in the United States and Europe such as LSI Logic, VLSI Technology, Silicon Graphics, SGS Thomson, Texas Instruments, and so on for critical semiconductor technologies and solutions. Companies such as these will play a fundamental and important role in moving the consumer electronics market into the next century.

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Perspective

Consumer Multimedia Semiconductors and Applications Worldwide

Market Analysis

Digital Dominates the News at the 1996 Winter Consumer Electronics Show

Abstract: *Solid sales of multimedia PCs into the U.S. home market made the statistics on consumer electronics sale reported by the Consumer Electronics Manufacturers Association look good for the 1995 holiday season, but, otherwise, consumer electronics sales were slow. Retailers came to the 1996 Winter Consumer Electronics Show eager for new products that hold the potential to draw customers back to their stores in 1996. Manufacturers rolled out products and promotions that conveyed a clear message: The key for increasing sales is spelled D-I-G-I-T-A-L. This document provides information and analysis on the most significant product announcements and demonstrations at the 1996 Winter Consumer Electronics Show. Dataquest has launched a new program, Consumer Multimedia Semiconductors and Applications Worldwide, that will provide in-depth, detailed market research and analysis on the consumer electronics market and the semiconductor markets driven by products and technologies such as those described in this document. This document is being sent to all clients of Dataquest's semiconductor programs as an introduction to this exciting new program.*
By Dale Ford and Tom Starnes

Consumer Electronics Manufacturers Present a Vision of a Digital Future

More than 97,000 attended the 1996 International Winter Consumer Electronics Show (CES), held in Las Vegas from January 5 through 8. The Winter CES is the premier event for the consumer electronics industry's largest annual consumer electronics trade show, bringing together the highest concentration of manufacturers of consumer electronics with buyers, retailers, and other decision makers. This year, more than 1,800 exhibitors showed their products on over 1 million square feet of floor space.

Dataquest

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Filing: Perspective

Attendance at the 1996 Winter CES was significantly lower than in 1995 because of the withdrawal from the show of the major video game companies like Sega and Nintendo. The most visible video game company at the show was Fox Interactive, and it does not intend to return for the 1997 show. The video game companies launched their own show in Los Angeles during 1995. This new trade show, called Electronics Entertainment Expo (E3), is dedicated to the video game industry and will be held again May 16 through 18 at the Los Angeles Convention Center.

The CES is sponsored by the Consumer Electronics Manufacturers Association (CEMA), a sector of the Electronic Industries Association (EIA). According to CEMA, an estimated 750 facilities in the United States manufacture or assemble consumer electronics products, employing an estimated 180,000 people. Another 3.4 million people, with total wages estimated at $56 billion, are employed in the more than 130,000 stores that sell these products to the consumer. However, CEMA casts a wide net in defining consumer electronics. Its definition includes products such as PCs and cellular phones sold into the home, along with traditional consumer products such as TVs, VCRs, boom boxes, and cameras.

Solid sales of multimedia PCs into the U.S. home market made the U.S. statistics look good for the 1995 holiday season, but, otherwise, consumer electronics sales were slow. Retailers came to the show eager for new products that hold the potential to draw customers back to their stores in 1996. Consumer electronics manufacturers came to the show with products and promotions that conveyed a clear message: The key for increasing future sales is spelled d-i-g-i-t-a-l. Dataquest has launched a new program, Consumer Multimedia Semiconductors and Applications Worldwide, that will provide in-depth, detailed market research and analysis on the consumer electronics market and the semiconductor market driven by products and technologies such as those described in this document.

DVD Steals the Spotlight (Just Don't Ask What It Stands For)

So what was the hottest consumer electronics products at this year's CES? Without a doubt, digital video disc (DVD) players stole the show as almost a dozen of the world's major consumer electronics companies introduced, with a lot of fanfare, energy, and expense, either prototypes or plans to produce DVD players. The activity at the show surrounding DVD players, by both the manufacturers and the buyers, was truly astounding. After a disappointing Christmas season for retailers of traditional consumer electronics products, many hopes are being placed on this product. With the promotional efforts that are planned, consumers will soon be adding "DVD" to their household vocabulary. The following companies have jumped on the DVD bandwagon:

- Toshiba
- Sony
- Philips
- Matsushita
- Pioneer
- Samsung

- LG Electronics
- Thomson
- Onkyo
- Zenith
- Mitsubishi

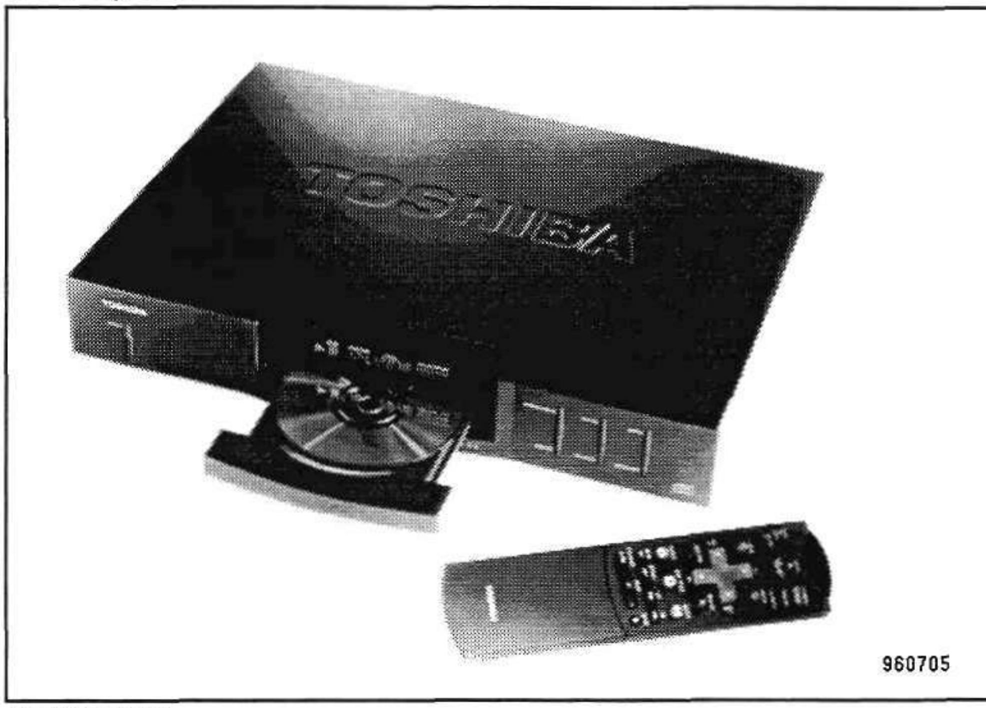
It should be remembered that both Sony and Toshiba were demonstrating DVD technology at the 1995 Winter CES. (Toshiba's demonstrations were behind closed doors.) Throughout 1995, the industry watched closely as intense competition was played out between two formats, Super Density (SD) and Multimedia CD (MMCD). Nobody wanted to see a repeat of the format wars that had hindered the early growth of other consumer electronics markets, and the two camps were finally pushed into negotiations on a common standard. The announcement of a final DVD specification allowed manufacturers to roll out their products with confidence at the 1996 Winter CES. If agreement had not been reached it could have been a gloomy show. However, the groundwork has been laid, and now the race to the market is on.

An interesting side note to the final DVD specification is that the term "DVD" was left undefined in the final agreement. Because of the potential application of DVD technology in products targeted at multiple markets, including the video playback market and the PC market, the major companies decided they did not want to define DVD as "digital video disc." Left with a term begging for a definition, the industry appears to be adopting the name "digital versatile disc."

Toshiba led the pack with the earliest announcements of product plans. It intends to bring its SD-1006 and SD-3006 to market by early September at prices of $599 and $699. (All prices given in this document are manufacturers' suggested retail prices.) Figure 1 shows the SD-3006 player. These players are targeted at the video playback market. A version of DVD has also been developed for PC storage called DVD-ROM, but the focus of the Winter CES was on the video playback market. Sony, Thomson, and Philips were other major players outlining product introductions for the fourth quarter of 1996. Matsushita/Panasonic was holding only closed-door discussions with selected retailers about their plans. Pioneer, which has been the standard bearer for Laser Disc (LD) technology, was showing a hybrid product that could play both LD and DVD. The best prospect for the success of this type of product is in the Asia/Pacific and Japanese markets, where LD has experienced stronger acceptance. It is also notable that Korean companies such as LG Electronics and Samsung were promoting plans for product introductions in late 1996 or early 1997.

Although early promises were made of introducing DVD players at a $499 price point, it was also expected that this target would be difficult to reach, so Toshiba's prices were not a surprise. However, Thomson still vows to reach $499 with its introductory product. It is not clear how it will do this in light of its manufacturing agreement with Matsushita. It was announced at the show that Matsushita will supply DVD players to Thomson for sale around the world and, in return, Thomson will provide Matsushita with DSS home satellite systems for sale under the Panasonic brand in the United States. Sometime after 1996, both companies will begin to manufacture their own products in each of these categories.

Figure 1
DVD System



Source: Toshiba

Some of the early predictions by manufacturers for the success of DVD might be called optimistic. In fact, some of them might be called wildly optimistic. Their projections of 2.5 million to 3 million shipments in the first year would make the early shipments of the highly successful Direct Broadcast Satellite (DBS) systems look small in comparison. Other manufacturers were trying to be more cautious in their forecasts, not wanting to let the hype set unrealistic expectations that, if unmet, could lead to a major letdown and fallout among critical supporters. A coordinated launch of this product is being orchestrated. Major Hollywood studios are preparing to release between 250 and 400 movie titles in the DVD format this fall. Dataquest does expect the DVD to be a highly successful product that will benefit from the combined support of manufacturers, retailers, and software providers. Preliminary projections of DVD unit shipments into the video playback market call for 60,000 units to be shipped in 1996, with sales accelerating rapidly to 2.5 million units in 1998. Dataquest's Consumer Multimedia Semiconductors and Applications Worldwide program will be publishing an in-depth analysis of DVD in the first quarter of 1996 that will provide more detailed information and a final forecast on this exciting product.

DBS Systems Celebrate the Past and Look to the Future

In second place in the hot product race were direct broadcast satellite (DBS) systems introduced by several manufacturers.

DSS

At the show, Thomson Consumer Electronics announced that it has shipped a total of 1.8 million Digital Satellite Systems (DSS) to dealers in its first

18 months of production. There were 600,000 units shipped in 1994, and an additional 1.2 million units shipped in 1995 under both the RCA and GE brand names. In December 1995, sales of DSS averaged 5,000 units per day. About 25 percent of DBS subscribers dropped their cable TV subscription in favor of DBS services. Thomson also announced that its factory inventory stands at less than one week. Its total manufacturing capacity is now 2 million units annually.

Thomson unveiled its second-generation DSS receivers at the Winter CES. Thomson now has three systems with the RCA brand: the DS7430RA top-of-the-line system for multiroom operation, the DS4430RA deluxe single-room system, and the entry-level DS3330RA system. These new models will begin shipping to dealers on January 15, 1996. At the end of January, Thomson will also have a DSS with its ProScan brand on it. Thomson plans to design a DSS receiver as a PC add-in card sometime in 1996.

Pay TV services for DSS are split between two different program suppliers, DirecTV and U.S. Satellite Broadcasting (USSB). DirecTV is owned by GM Hughes Electronics. USSB is owned by Hubbard Broadcasting Inc. News Datacom provides the conditional access service for both DirecTV and USSB.

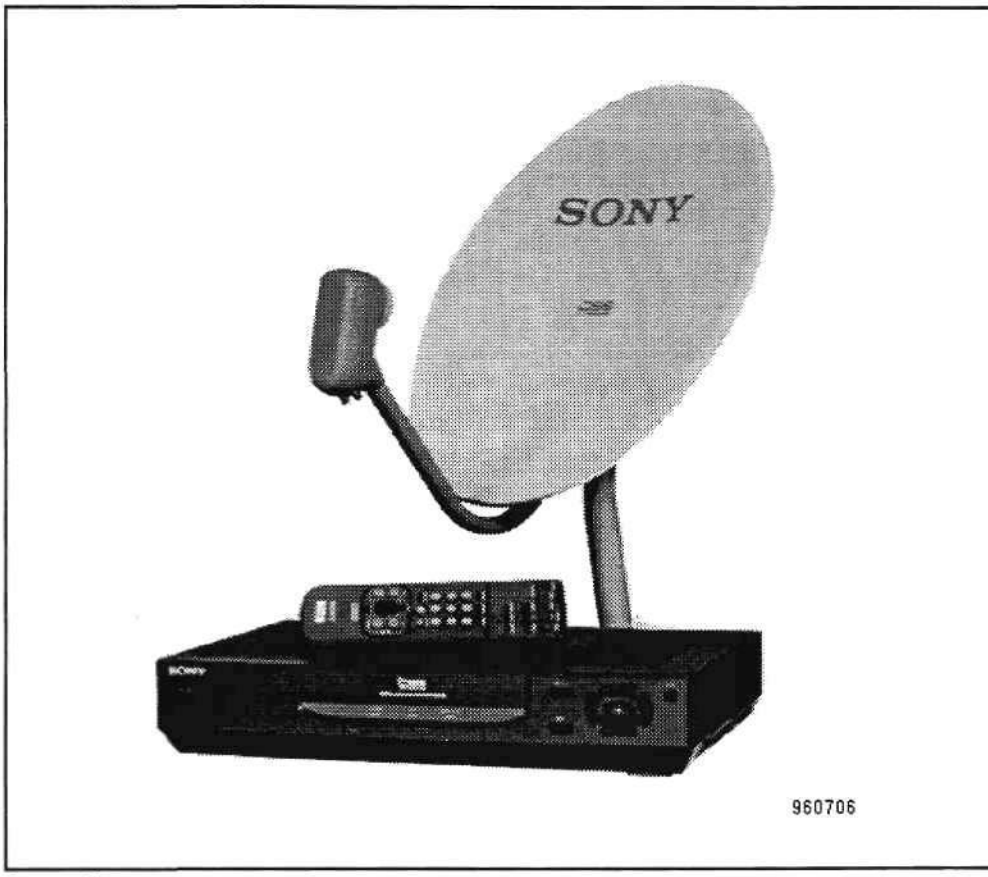
During the Winter CES keynote speeches, Joe Clayton, executive vice president of Thomson Consumer Electronics, said that there would be 11 different brands of DSS by the end of 1996 and two completely new DBS systems (AlphaStar by Tee-Comm and Digital Sky Highway—DISH—Network by EchoStar). At the Winter CES, Uniden unveiled its DSS receiver, the Uniden UDS 200. Uniden has been a leader in integrated receiver-decoders (IRDs) for the C-band satellite market. Table 1 shows manufacturers that have or plan to have DSS-compatible receivers. Figure 2 shows Sony's DSS system. DSS is now available at over 20,000 retail points of sale. Best Western plans to begin offering DirecTV in its hotel rooms in January 1996.

Table 1
Manufacturers of DSS-Compatible Receivers

Manufacturer	Introduction Date
Thomson Consumer Electronics (RCA)	June 1994
Sony Electronics Inc.	June 1995
Thomson (GE Brand)	September 1995
Hughes Network Systems	Early 1996
Uniden America Corporation	Mid-1996
Toshiba America Consumer Products Inc.	Mid-1996
Samsung Electronics Co. Ltd.	June 1996
Sanyo Electric Co. Ltd.	June 1996
Daewoo Electronics Co.	June 1996
Matsushita (Panasonic and Quasar Brands)	June 1996
Thomson (RCA ProScan Brand)	1996

Source: Dataquest (January 1996)

Figure 2
The Sony DSS System



Source: Sony

Primestar at the Winter CES

On January 5, 1996, Primestar Partners L.P. announced its 1 millionth subscriber. This milestone occurred 17 months after its national launch. Primestar claims to have a 45 percent share of the DBS market, which, by its estimates, would put the total number of DBS subscribers at just over 2 million. Primestar is owned by a consortium of cable operators, led by Tele-Communications Inc. with a 22 percent share. General Instrument manufactures the hardware for Primestar. The Digicipher-I video decoder and the audio chip for the Primestar receiver are made by Motorola.

Primestar plans to spend $150 million in advertising in 1996. The highlight of the campaign is two TV spots airing during the Super Bowl on January 28—one during the pregame show and the other during the game itself. Primestar is also sponsoring the American Red Cross with a donation of $1 million and has announced its intention of serving hotels through an alliance with LodgeNet Entertainment Corporation.

Comparing Primestar and DSS

The street price for DSS has dropped to $499. This is for the first-generation RCA or GE brand with a $100 manufacturer's rebate from Thomson Consumer Electronics. The first-generation standalone receiver (without a dish) has dropped to a street price of $405 (including Thomson's $50 manufacturer's rebate). Primestar's customer-premises equipment remains the property of Primestar. With DSS, customers can choose to install the equipment themselves with a kit costing $70 or choose professional installation costing $150 to $200. Primestar offers no choice—professional installation is required at a rate of $150 to $200.

Pay TV services for DSS are split between two program suppliers, DirecTV and USSB, whereas Primestar is the sole programming supplier for its system. DirecTV has more channel capacity than Primestar. Primestar has 10 pay-per-view channels and DirecTV has 60. Also, DirecTV has 28 digital music channels and Primestar has only 14.

EchoStar's New DISH Network

EchoStar Communications Corporation of Englewood, Colorado, successfully launched its first direct broadcast satellite, EchoStar-I, on December 28, 1995. The satellite, a series 7000 satellite from Lockheed Martin Corporation, was launched from China Great Wall Industry Corporation's launch facility in Xichang, China. The satellite's final location will be at 119 degrees west longitude to provide 75 channels of programming for EchoStar's DISH Television Network by mid-February. EchoStar plans to launch a second satellite next year that will increase its capacity to 150 channels.

EchoStar's DBS system uses an 18-inch dish just like the RCA system. The basic receiver and dish system has a price of $599. However, consumers also have the option of renting the hardware for $10 per month, added to the cost of the programming package. EchoStar hopes to become the low-cost DBS service provider, with 40 basic channels starting at $19.99 per month. The EchoStar receiver uses MPEG-2 compression and is fully compatible with the Digital Video Broadcast (DVB) standard. EchoStar has chosen Electronic Data Systems of Plano, Texas, to provide customer service and sales support.

EchoStar began making C-band satellite dishes in 1980. In 1995, the company's financial results suffered from the decline of the bigger dishes.

AlphaStar

AlphaStar Digital Television is a new home satellite system scheduled to begin late in the first quarter of 1996 for the U.S. and Canadian markets. The programming services are provided by AlphaStar Television Network Inc. in the United States and ExpressVu Inc. in Canada. The hardware is available now from Tee-Comm Electronics Inc. On August 21, 1995, AlphaStar announced that Samsung Electro-Mechanics Company would also be manufacturing hardware systems.

The AlphaStar system uses a dish that is either 24 inches, 30 inches, or 39 inches in diameter. The Star Trak 1000 digital receiver uses TV/Com International's Compression NetWORKS system architecture, which is fully DVB-compliant and uses MPEG-2 compression and Viterbi forward error correction. Similar to DSS, the Star Trak receiver has a built-in 2400-baud telephone modem for ordering programming and an ISO 7816 smart card with three levels of security. The receiver can accept satellite signals in either the C-band or the Ku-band. Unlike DSS, the Star Trak receiver does not allow for S-video output. The DirectStar satellite dish is being made by Winegard Company of Burlington, Iowa. The system costs $1,099 in Canada. There will also be a lease-to-own option available.

ExpressVu received a service license from the Canadian Radio-Television and Telecommunications Commission on December 20, 1995. To serve Canada with almost 100 channels of video and audio programming, ExpressVu has reserved transponder space on Telesat's Anik E1 satellite. ExpressVu plans to provide an entry-level service for as little as $7.95 per month. For the U.S. market, AlphaStar Television Network will use 14 transponders on AT&T's Telstar 402R satellite, which was launched on September 24, 1995. AlphaStar has chosen Turner Vision in Bluefield, West Virginia, to provide call center services.

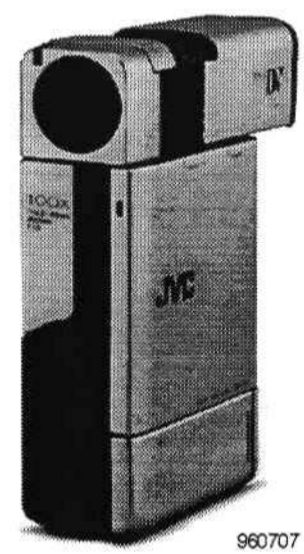
Camcorders

Common Digital Format Paves the Way for a New Generation

JVC introduced the world's smallest and lightest camcorder at the Winter CES, perfect for James Bond. JVC's GR-DV1 digital camcorder uses the new digital video cassette (DVC) format, which is now apparently going by just "DV." RCA debuted an identical model that it is sourcing from JVC. The RCA model number is CC900D. The JVC and RCA DVC camcorders will be available in the spring. Figure 3 shows the new JVC GR-DV1 digital camcorder.

It looks as if standards may still be in flux with these cameras, but the JVC/RCA models used a mini-DV cassette containing 30 minutes or 60 minutes of 1/4-inch tape. The cassette is about half the size of an 8mm tape. With a weight of only a pound (0.45 kg) and a very rectangular form of 1-3/4 x 3-1/2 x 5 3/4 inches (43 x 148 x 88mm), the camcorder is significantly smaller than its smallest analog cousins. A 3.6v lithium ion battery about the size of an AA battery runs the camcorder.

Figure 3
The JVC GR-DV1 Digital Camcorder



Source: JVC

The GR-DV1 has one 570,000-pixel, 1/3-inch charge-coupled device (CCD) that can pick out images in 1 lux of light. It has a digital image stabilizer that works extremely well, even when the 10x optical zoom and the 100x digital zoom are enabled. The DV format allows for a 500-line image, which betters S-VHS and Hi-8 by 20 percent and can produce a 16:9 or standard ratio image. However, the camcorder does not have a digital output and can transmit images only at S-video resolution.

So what's really digital? The image is digitized and compressed using discrete cosine transforms and variable length coding with an in-frame compression rate of 25 Mbps. The audio is pulse code modulated digital stereo, sampled at 48 kHz in a two-channel, 16-bit mode, or at 32 kHz in a four-channel, 12-bit mode. Each frame is incredibly sharp and can be edited, spliced, dubbed, and cut many times without sound or picture degradation.

The camcorder can be used to take digital still photographs, too, even in a timed sequence, and stores over 4,000 images on a tape, each digitally pure. The camera can be connected directly to a TV for playback. It also comes with a docking station for fancy editing. Besides the 12 digital special effects and 18 scene transitions available in the camera, the docking station brings editing capabilities up to professional standards. It adds time-code stamping, audio dubbing, and the ability to rearrange up to eight scenes at a time, along with a selection of effects and transitions. A Joint Level Interface Protocol (JLIP) in the docking station allows for sophisticated linking and control of the camcorder with a variety of audiovisual equipment and computers.

Although these digital camcorders are not an everyday consumer item, for the low-budget professional, serious amateur, or the gadget whiz with a little extra cash and some imagination, they are an impressive marvel. The size and weight are small enough to make it easy to leave this camcorder behind on a bus. But they are expensive. According to the EIA, the average selling price (ASP) for consumer camcorders in 1995 was $610. In Japan, the Ministry of Finance pegs that ASP at $482. Of course, these ASPs are the selling prices from manufacturers to dealers. An additional 33 percent can be added for the retailers' margin. Dataquest conducted a retail price survey in February 1995 and found name brand camcorders as low as $450 street price. The upper limit for the consumer market is $1,500. Prosumers will typically choose a Hi-8, S-VHS, or S-VHS-C model with one CCD for anywhere between $1,200 and $2,500. The industrial and broadcast markets choose cameras and camcorders in the $2,500-to-$100,000 range.

In addition to the JVC/RCA introduction, Sony, Panasonic, and Sharp digital camcorders were also presented at the show. Table 2 summarizes some of the information presented on these products. Hitachi also revealed its plans to introduce a digital camcorder that would not use DV cassettes but instead would use an entirely tapeless format. This pocket-size camcorder will be able to store 3,000 still frames and interface with a PC for editing and storage. Introduction is planned for the second half of 1996.

Table 2
Digital Camcorder Introductions

Model	Features	Price ($)	Availability
JVC GR-DV1	Single 570,000-pixel CCD, digital image stabilizer, editing functions	2,995	April 1996
RCA CC-900B	Single-CCD, editing functions	2,999	March or April 1996
Sony DCR-VX1000	Three-CCD imaging with 410,000 pixels per CCD, Super SteadyShot stabilization, and IEEE 1394 interface for editing/dubbing	4,199	Now
Sony DCR-VX700	Similar to DCR-VX1000, except for single 410,000-pixel CCD	2,999	Now
Panasonic PV-DV1000	Three-CCD imaging with 270,000 pixels per CCD, Digital Electronic Image Stabilizer, Digital Photo-Shot for still frames, and 16:9 recording mode	4,199	Now
Sharp VL-DH-5000	Three-CCD imaging with 410,000 pixels per CCD; 5-inch LCD color monitor	4,595	May 1996

Source: Dataquest (January 1996)

An Eye on Canon's Camcorder

Canon's feature products were its latest camcorders, with sophisticated eye-tracking circuitry. In these, an infrared light shines at the retina of the eye pressed against the viewfinder. After two calibration tests, the circuitry can then do an excellent job of following the eye's movements. This is most useful for identifying the object in the picture most critical to the focus, lighting, and color. This technique results in a very precise focusing in spite of the fact that nearer, farther, or larger objects appear in the viewfinder or that a chain link fence, net, window, or cable appears in front of the desirable image. The desired focal point does not have to be in the center of the picture, nor does it have to be motionless. The result is quite impressive. However, too long a glance at a less-desirable portion of the viewfinder image will cause refocusing on the new object. Of course, Canon then went wild and made it so that the eye movement could be used to select features within the camera, such as zoom and fade. This resulted in significant distraction from the primary purpose of having the eye in the eyepiece: following the objects in motion. It also tends to cause unnecessary strain on eyes being asked to do fairly unnatural things. A little more dexterity in the fingertips would provide the same functionality in a normal camcorder. The eye-movement-tracking capability has possibilities in many other applications, such as computer input alternatives. Some lessons in human behavior could be gained from such a device.

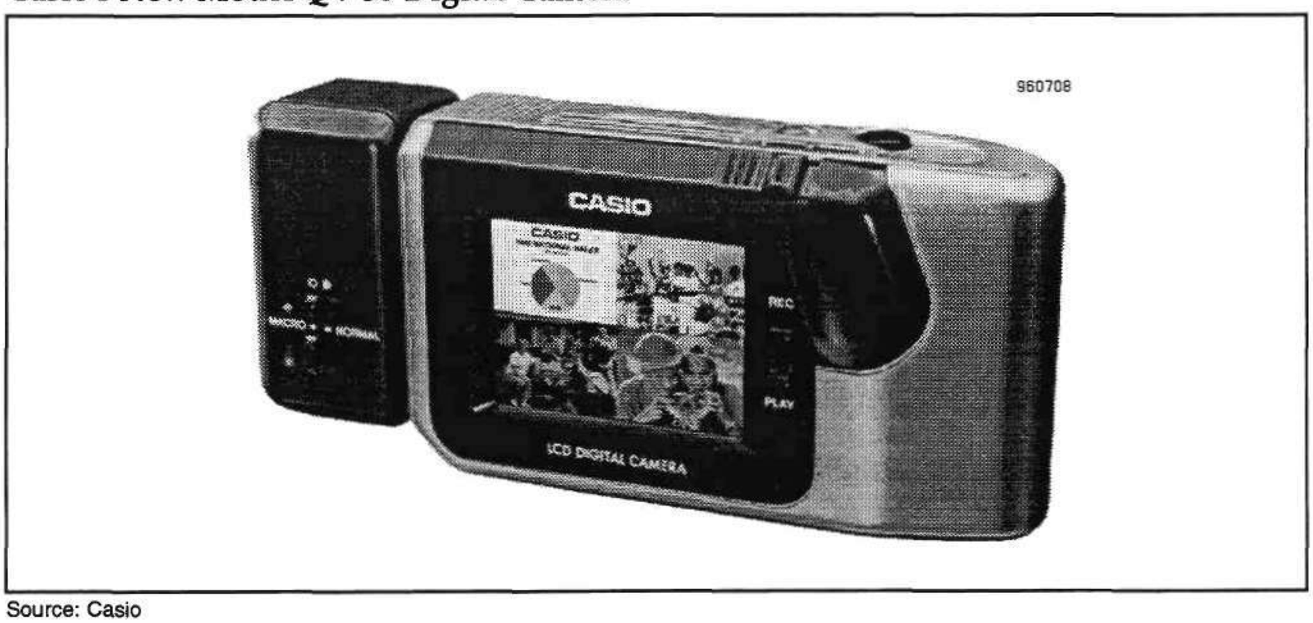
Say "Cheese" to Digital Cameras

Casio leads the developing digital camera field. The strength of the Casio brand, access through Casio sales channels, handy camera size, and selection meant that Casio's QV-10 model stayed in high demand and limited supply from its U.S. initial shipping date of September 1995. Casio started producing 3,000 cameras per month in March 1995 and boosted its monthly output to 10,000 units per month in September as its camera became one of the most popular models on the market. By the end of 1995, the company had invested another ¥300 million to expand production capacity to 30,000 units per month.

The 96 images that can be stored, the 1.3-inch color LCD monitor, and the ability to delete undesired shots in the camera add up to valuable in-the-field efficiencies offered by Casio's original QV-10 digital camera. Connected to a PC or Mac, the QV-10 allows photographs and computer-generated graphics to be downloaded into the camera for a small, portable presentation system. Electronic images can be output to PCs or directly to a TV. An ink jet color printer produces acceptable hard copies of the photos, although these are not "suitable for framing." In fall 1996, a color printer, the QG-100, will produce higher-density, color, 2-inch-to-3-inch hard copies that look a little more like a Polaroid. But, for $350, the QG-100 has a far more limited use than a similarly priced Hewlett-Packard ink jet printer.

Casio showed an improved model of the camera, dubbed the QV-30, at the Winter CES (see Figure 4). It expects to begin shipping this $1,000 camera in April 1996. Slightly larger than the QV-10, the lens can be made 46mm wide-angle or 105mm telephoto for more versatility. The resolution of the image is 300 lines, compared with the 200 lines of the QV-10, and the new model has a larger, 2.5-inch TFT LCD. An agreement with Adobe will make available a consumerized version of Photoshop called PhotoDeluxe, which will allow images transferred to a PC to be enhanced, manipulated, and cropped. The images can then be integrated with greeting cards, calendars, and other personal items.

Figure 4
Casio's New Model QV-30 Digital Camera



Source: Casio

Ricoh also showed its entry into the digital camera business. Although the Ricoh camera offers impressive features, it appeared that its designers had not seen the Casio model before putting this product together. The Ricoh RDC-1 will hold up to 492 still images in the biggest flash EPROM, but requires a PC to delete pictures. Some additional capabilities were available in the camera, such as a protocol to upload images to a remote PC over an add-on modem. The lens is equivalent to a 50mm-to-150mm lens, but the LCD screen was a cumbersome add-on rather than being molded into the back of the unit, as is Casio's. It, too, will have a small printer accessory and Photoshop-type PC software, perhaps included. Ricoh does have the ability to capture 10 seconds of audio with each photo, or to record up to 20 seconds of motion with sound, with each frame a complete compressed image. However, with U.S. availability in the spring and a big $1,800 price, Ricoh seems to be going for a higher-end, some-assembly-required market, and it is not likely to have Casio on the ropes soon.

The Casio cameras and the Ricoh have similar internal designs. Each uses a Hitachi SH-1 microcontroller in the camera, running 14 MHz out of code in the 64KB on-chip ROM, with 0.5MB DRAM for working space. The processor is aided by an individually developed ASIC that performs digital image compression. Ricoh uses JPEG as its image compression definition and consumes twice as much memory to store the data as Casio. However, the Ricoh can perform its compression fast enough to store 30 images per second continuously. Little real image enhancement takes place in the camera, as the processors primarily take what comes in off the CCD, set up the compression, and organize the bits in the flash EPROM. A digital camera by Sierra uses a MIPS microprocessor and actually performs digital signal processing (DSP) functions on the image to balance, correct, and enhance the image in the camera. Casio uses 2MB flash memory to hold 96 images, while Ricoh uses 2MB, 8MB, or 24MB of flash in a PCMCIA-type removable cartridge to store up to 492 stills.

Chinon has also been a major manufacturer of digital cameras, producing digital still cameras for U.S. makers on an OEM basis since 1992. It manufactures cameras for Apple, Kodak, and Logitech. In December 1995, it announced two new cameras under its own brand name, the ES-1000 and ES-3000. The ES-1000 is priced at $499 and will begin U.S. shipments in February 1996. The higher-end ES-3000 model is similar in size to a palmcorder and offers 3x zoom, with the highest-resolution image being 640 x 480 pixels. Storage capacity ranges from five images at 640 x 480 resolution to 40 images at 320 x 240 resolution in the internal 1MB of memory. Capacity can be increased with an optional flash memory card of 2MB, 4MB, 8MB, and 16MB. The 16MB card allows 689 images to be stored at 320 x 240 resolution. One of the main disadvantages of this product is the absence of a built-in or add-on display module. Images must be ported to a PC for viewing. Chinon has announced that it will triple its monthly production capacity from the 20,000 units per month it is estimated to have reached in December 1995.

Today, digital cameras are most popular with professionals such as insurance companies and real estate agents (who apparently are also besieged as the target markets for personal digital assistants), who may prefer the instant image and easy integration with a computer file or simply want an easy way to show a house. However, to the pleasant surprise of manufacturers, consumers are also beginning to purchase digital cameras and driving a stronger-than-expected market. The merger of the camera and a computer represents the easiest way to get photographs into a PC. Images can be transferred to the hard drive of a computer, where they can be viewed, edited, or added to documents. While the images created by digital cameras are inferior to the quality achieved by traditional film cameras, the image that can be captured in a PC through a digital camera is superior to the method of using a scanner to transfer a photo into a computer. The picture quality of the latest digital cameras is comparable to S-VHS or Hi-8 video images. Even with prices ranging from $500 to $1,800, Casio expects overall market sales of digital cameras to be four times higher in 1996 than in 1995.

What's on the Tube Tonight?

From the first day of television programming, viewers have been asking what there is to watch. TV listings in local papers satisfied some people's needs, and, in the United States, *TV Guide*, a separate magazine including listings, satisfied others. But television has changed drastically in the last decade, and the means of keeping up with programming is changing, as well. The VCR changed the viewing habits of the public, but a recent U.S. survey showed that one-third of VCR owners did not know how to record a TV show when they were not home. Now the program listings can be found on the TV itself, and recording a program on the VCR is finally easy.

There are many systems on the market in the United States that provide television program information electronically and simplify the use of the TV and VCR. VCR Plus started the process five years ago by giving users a means of programming their VCRs with a single six-digit code found in the printed TV listings, without having to program the channel, date, time, and duration separately. A VCR that supports VCR Plus will then record the right channel at the right time. A normal VCR can also take advantage of VCR Plus using a special remote control unit that will send the right signals to the VCR to perform the recording designated by the six-digit code. But that is now old hat.

Video Guide

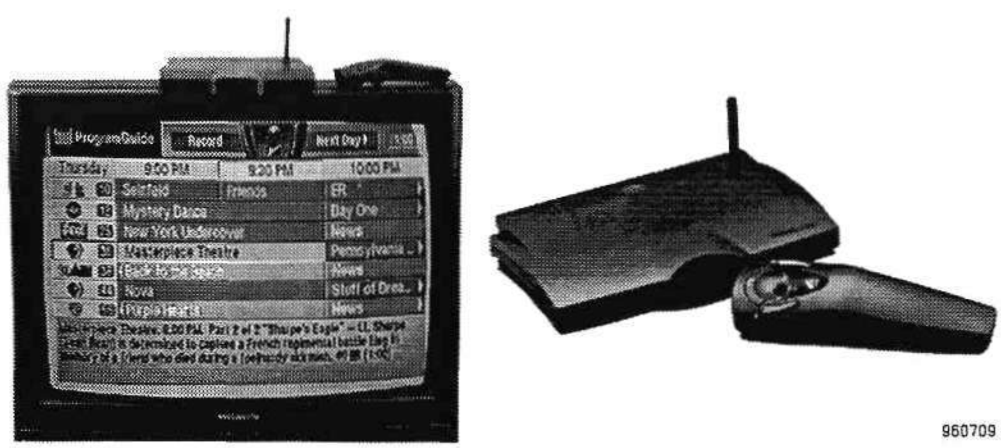
Radio Shack has been advertising the Video Guide, which is provided by a company called Video Guide. The system is available at other major retailers. Video Guide is interested in the installed base of already-purchased TVs and VCRs. As the latest entry into the market, it may want to provide the best set of features. It uses a small $100 unit near the TV/VCR in conjunction with an extremely simple remote control, which essentially can replace the remote control for most TVs and VCRs. For $50 a year, Video Guide distributes one week's worth of TV programming over a paging network in each region. The receiver intercepts the TV signal (on channel three) and can display upcoming programming on the screen.

Video Guide has the nicest-looking display of the three approaches (see Figure 5), but its fancy graphics may become less readable on a 13-inch or 9-inch screen (Dataquest has not seen this). Browsing the on-screen programming guide is helped by alphabetical listings and some search capability. It is easy to find all of the showings of "The Outer Limits" for the next week to be sure none are missed or to find all programs in the sports category. Video Guide even keeps up with a subscriber's most watched channels and prioritizes them in the listings. Once the wanted program is highlighted, pushing a button will cause the TV to tune it in if it is being shown at the time. If it is not being shown, pushing another button will schedule it to be recorded later by the VCR. A tiny wired "repeater" infrared link placed on the VCR assures that a desired program will be recorded properly.

Through Video Guide, not only is TV programming available over the airwaves, but for up to $50 a year more, a sports newswire and a news and weather listing can be obtained. These text-based services are quite handy, allowing the subscriber to scan headlines and get more detail and even to jump to the ball game in progress if it is showing on one of the available channels. The sports information keeps up with the score, quarter, and events—an advantage of using a paging transmission rather than TV channel space. With the public's ever-increasing appetite for sports and news (baseball strikes and politics notwithstanding, and with Olympic games and the O.J. Simpson trial whetting appetites), these extra services could offer a significant edge over other systems.

The Video Guide system uses a Motorola 68EC000 processor in the main chassis and a Microchip Technology microcontroller in the remote control. The services are provided by Video Guide over the paging network, and regional information is included in the TV, news, and sports data provided. Since its release in early November, an average of 1,000 systems a day have been sold, with a nice boost from holiday sales. With a little more word-of-mouth advertising and promotion, this number should grow substantially.

Figure 5
Video Guide Unit



960709

Source: Video Guide

StarSight

An earlier version of the TV program guide came from StarSight. StarSight focused its attention on the new-TV and new-VCR markets, although Magnavox has a standalone StarSight receiver for aftermarket opportunities. A StarSight receiver could add $35 to the cost of a TV or VCR and add $100 to the unit's selling price, plus a $50 annual subscription. When included with the TV or VCR, the only evidence of the circuit is a few extra buttons on the remote control. StarSight taps into the listings of *TV Guide* magazine, bringing that extra edge to its service. However, only TV program listings are provided, without the news and sports information available from Video Guide. Also, the receiver gets its data in the background of the local PBS affiliate broadcast, so for up-to-the-minute updates of news, sports, or weather, the PBS channel must be tuned in. StarSight does provide seven days of programming, expanded descriptions, category selection, and highlight-and-see/record capabilities.

StarSight's text on the TV screen has all the appeal of the Courier typewriter typeface with a little color highlighting, but it should be legible on any TV screen. The StarSight system does overlay the text on the TV program being watched—a benefit for the viewer who just can't stand missing a second of the program.

StarSight has been on the market for about a year. It has support from 14 major TV/VCR manufacturers, although relatively few TVs or VCRs today are shipped with StarSight. Thomson, with its GE, RCA, and ProScan brands in the United States, has invested $25 million in the company, so it is backing StarSight at a different level. The StarSight system uses specially designed chips from Zilog to receive the listings and place them on the TV screen.

A Baby Brother?

Gemstar, maker of VCR Plus+, has now introduced TV Guide Plus+. TV Guide Plus+ is offered as a free service after a properly equipped television or VCR is purchased. American Broadcasting Company (ABC) affiliates broadcast the electronic program guide to local broadcast areas, possibly covering a greater range than PBS or paging systems. The service also taps directly into listings of the "trusted" printed *TV Guide*. The simple dot matrix text display on the screen shows only two days of complete programming, although some listings show a longer period. A video window allows viewing of the current channel, some real-time information is possible, and VCR Plus+ has been turned into a one-button recording feature, but TV Guide Plus+ looks like the simplest form of electronic program listing. TV Guide Plus+ is primarily designed for inclusion in the TV or VCR. Magnavox is promoting TV Guide Plus+ in some of its TVs and VCRs, although other models sport StarSight.

Historical Reference

These systems for distributing TV programming, news, weather, sports, and information are reminiscent of the Teletext service that has been available in Great Britain since the early 1980s. This system started as an accessory to the TV but soon was incorporated into the set. An extra £100 (about

$100 in the early 1980s, now about $75) would buy a TV fitted with Teletext circuitry. The service was free in Great Britain, where advertising was found on only two of the four available channels and was generally regarded with disdain. Hundreds of "pages" of text were available to the user, providing news stories, weather, sports, air traffic information, and listings for programs. Subtitles for the hearing-impaired viewer were also transmitted over Teletext.

The British eagerly accepted this information system when only four TV channels were broadcast with almost no variation across the country and a hundred quid was a lot of money to most people. The textual information came over the transmission during the vertical blanking interval (as is done in many current systems), but this means the subtitles for the hearing-impaired do not record on a VCR. The desired information was brought up on the TV screen by entering the page number on the remote control. The system is still in place, and approximately 70 percent of TVs in Great Britain have Teletext. Some advances have been made in the service, simplifying navigation through the pages, but it does not provide a simplified link to the VCR.

It is not clear why a Teletext-type system never took hold earlier in the United States. Perhaps one of these new systems will have long-term success. Whether more than one will survive may be a test of standards, features, and marketing. Table 3 shows a comparison of TV program listing systems.

Table 3
Comparison of Electronic TV Program Listing Systems

System	Number of Days of Listings	Added Price ($)	Annual Service Charge ($)	Broadcast Medium	Integration With TV or VCR	Notes
Video Guide	7	100	50	Paging	External	Modem display, real-time sports and news available
StarSight	7	100	50	PBS	Internal/ external	Shows video
TV Guide Plus+	2	50	Free	ABC	Internal	No charge for service
VCR Plus+	7	40	Free	Newspaper	Internal/ external	Requires print media six-digit code
Teletext	1	65	Free	BBC	Internal	Closed captioning

Source: Dataquest (January 1996)

Voice Recording Systems

There were plenty of exhibitors showing voice recording systems, such as digital answering machines, digital voice recorders, and novelty recorders. For instance, Motorola was showing its new Tenor voice pager, which is capable of receiving voice messages through a pager network. The device can record up to four minutes of messages.

Parrot RCS S.A., a French company headquartered in Paris, was showing its new Parrot Speech Recognition Organizer. The Parrot Organizer combines a voice recorder and a phone directory that can be accessed with speech recognition. The product also features an automatic phone dialer and an optional interface to either a Macintosh or PC-compatible computer. The Organizer is assembled by IBM and retails for $279 in the United States.

The heart of the Parrot Organizer is a customized Texas Instruments TMS 320 C52 DSP at 40 MHz, capable of 20 mips. The DSP integrates Parrot's proprietary speech recognition software. The Organizer has 256KB of RAM and 256KB of ROM for voice prompts in five different languages. With compression, the Parrot Organizer is capable of 14 minutes of recording time at 2,400 bps. The Organizer also includes an ASIC for managing the energy and real-time clock that was designed and developed by Parrot and manufactured by Fujitsu. The Parrot Organizer is completely designed in 3.3V CMOS technology and runs on four AAA batteries.

Voice It Worldwide Inc. was showing its new Family Message Center, a digital note recorder with four separate channels for multiple users. The Message Center has a suggested retail price of $119. Voice It was also showing its extended line of Personal Note Recorders, the VT-40, VT-90, VT-180, and VT-240. The numbers indicate the seconds of recording time at the slowest recording speed. Voice It's Personal Note Recorders offer three different recording speeds, which allows the user a trade-off between recording time and audio quality. The recordings are always played back at the speed of normal speech. Figure 6 shows Voice It's VT-240 Personal Note Recorder.

The Flashback Digital Recorder from Norris Communications Corporation won a Popular Science Award in November of 1994. The product was featured in *Popular Science's* Best of What's New issue in the Audio and Video category. The Flashback features interchangeable memory cartridges called SoundClips that contain flash memory chips from Intel. Cartridges are available with 18 minutes or 36 minutes of recording time (a 72-minute version is also planned). The Flashback runs on two AA batteries. The product also features playback at three different speeds, with automatic pitch adjustment. The Flashback with one 36-minute cartridge lists for $249.

On November 10, 1995, Norris announced its intention to sell its Flashback technology to other OEMs. Norris also introduced its new SoundLink adapter. The SoundLink is a single-piece PCMCIA type II card that is essentially a PC docking port for Flashback SoundClips. Another product, introduced on November 13, 1995, was the Norris Flashfile System (NFS). The NFS is a development tool and file manager application program interface designed for other companies using flash memory in both primary and secondary storage applications. The NFS is a complete flash memory manager

Figure 6
The Voice It VT-240 Personal Note Recorder

Source: Voice It

with an MS-DOS redirector that takes only 13KB of ROM and 300 bytes of RAM to implement.

The 18-minute SoundClip contains 1MB of flash from Intel; the 36-minute version contains 2MB. The Flashback Digital Recorder also contains 512KB of DRAM used as a temporary buffer for compression and pitch adjustment during playback. The DRAM part used is a Micron 70ns 1Mx4. Other identifiable parts inside the Flashback included a 32Kx8 EPROM from Atmel, a codec from Oki, and a shift register from Harris.

Voice Recording Chips

The following five chip companies exhibited at this year's Winter CES:

- AT&T Microelectronics
- DSP Group Inc.
- Integrated Storage Devices
- National Semiconductor
- Zilog

All of these companies were showing chips designed for voice recording applications. National Semiconductor was previewing a 4MB serial flash part and voice processor chipset that it plans to introduce in the first quarter of 1996. The remaining four companies will be reviewed in detail in an upcoming Dataquest document.

Additional Show Highlights and Notes

An exhaustive report of all the new product introductions and developments at the Winter CES is not possible here. However, the following items demand at least a brief description.

Compaq and Fisher Price Invent the $2,000 Toy

Although the PC may have been accused of being nothing more than an expensive toy in the past, Compaq and Fisher Price have teamed up to create an innovative product that truly does turn a multimedia PC into a toy. This new product has drawn on the strengths of both companies to produce one of the more creative approaches to the home education/entertainment market. The Wonder Tools product line was designed for children from ages 3 to 7 and includes three categories: interactive computer toys, preschool-appropriate peripherals, and standalone software titles for children and families. The first products introduced at the Winter CES were the Wonder Tools Cruiser and Software, an innovative driving console and CD-ROM software that create an interactive experience for children (see Figure 7), and The Wonder Tools Keyboard, a keyboard with oversized keys, a mouse, and activity software that makes the computer easier and more fun to use for children. These products are designed to be used with any Windows-based PC and are scheduled to be available in the United States during the second half of 1996.

Figure 7
The Compaq/Fisher Price Wonder Tools System

960710.1

Source: Compaq/Fisher Price

Binaura Steps Up to Challenge Spatializer and Q-Sound

Spatializer Audio Laboratories and Q-Sound have been among the most recognized names in the world of 3-D or enhanced audio products for the multimedia PC. Although multimedia PCs have been the platform for early applications of this technology, the market for this type of product is much larger than just PCs. In theory, any electronics product that reproduces sound is a target for enhanced audio technology. At the Winter CES, Spatializer introduced its HTMS-2510 stereo surround sound system for the consumer market. By plugging an HTMS-2510 in line with TVs, stereos, and VCRs, consumers can bring 3-D surround sound capability into their homes. However, a more significant development in this area may have come from a company called Binaura that demonstrated its technology in a motor home outside the convention center.

Binaura has already announced major design-wins for its patented audio enhancement technology with Creative Labs and Diamond Multimedia. The Soundblaster and 3-D multimedia accelerator products introduced by Creative Labs and Diamond Multimedia in 1995 incorporated its technology. Binaura claims that it already has five licensees of its technology and expects the total to increase to 13 or 15 soon. Discussions with company executives indicate that Binaura is positioned to capture over 70 percent of the multimedia upgrade kit market in 1996.

At the Winter CES, the company was demonstrating a very simple, inexpensive box with a pair of speakers driven by a portable CD player. The sound enhancement was impressive when applied to both stereophonic and monophonic signals. The Binaura system is implemented with discrete components: one quadraphonic operational amplifier, one quadraphonic multiplexer, 20 resistors, and four capacitors. It plans to offer an ASIC version of the circuit in the first half of 1996. Its goal is to be a leader in audio enhancement technologies for consumer electronics, video games, automotive sound, home entertainment, and multimedia computing markets. Look for significant market developments from this small, aggressive company during 1996.

Sony Hopes Price Cuts Will Stimulate U.S. MiniDisc Sales

Sony announced a reduction in the price of its play-only MiniDisc (MD) portable to $199 with the introduction of its MZ-E40. This model is scheduled to begin U.S. shipments in July and would replace an earlier model with a suggested retail price of $349 (an average street price of $299). Sony claims to have sold 1.5 million car, home, and portable MD players worldwide, but the steep price has created a major barrier to its success in the U.S. market. The new model features a 10-second memory buffer and seven hours of playback on two AA batteries, compared with a three-second buffer and five hours of playing time on the previous model. Sharp has also begun to manufacture MiniDisc products, which it was showing at CES.

IEEE 1394 Begins to Make Inroads into the Consumer World

For over a year, the proponents of the IEEE 1394 standard have been promoting it as the future consumer electronics network. Evidence of progress in penetrating the consumer electronics world was seen at the Winter CES. The most notable products that included IEEE 1394 communications capability were Sony's digital camcorders. However, the marketing of IEEE 1394 appears to be an uphill battle still. The most frequent response when various representatives were asked if their product included an IEEE 1394 port was a blank stare. When pressed on the issue, most representatives were either uninformed or unconvinced of the merits of an IEEE 1394 port. Although Sony's incorporation of this port in its camcorders is encouraging, the day when this capability is a standard feature would appear to be distant.

Afraid of the Dark?

Although ITT's Night Quest product line has essentially no semiconductor content, the company did have one of the more intriguing products in the consumer's price range. ITT was showing its night vision monoculars and binoculars for the consumer market at the Winter CES. With technology developed (and paid for) for the military, these second- and third-generation viewers turn complete darkness into green daylight. Indoors, with imperceptible light, or outdoors, in starlight (not moonlight), these viewers show detail of everything, with nothing hiding in the shadows.

Night vision glasses such as these have been seen in spy movies and military exercises, but now are available for as little as $800, not the $5,000-to-$10,000 price range seen in military surplus catalogs. The company claims that these are far more sensitive than those used by the Russian military.

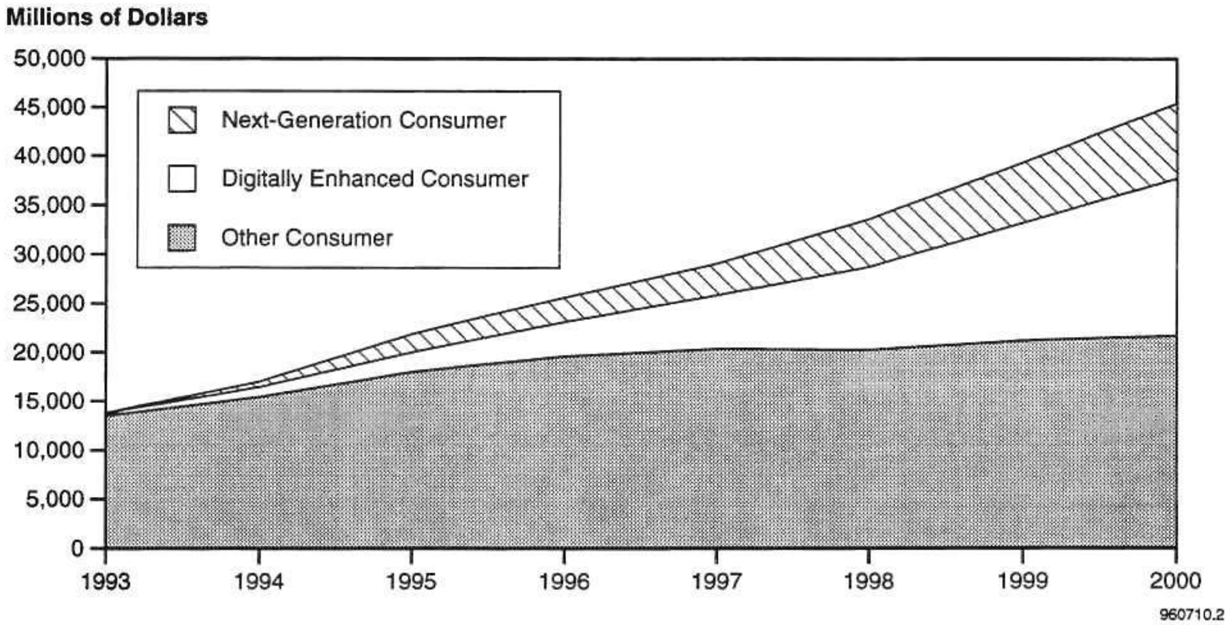
Last year, ITT sold these monoculars/binoculars successfully to the marine market, where they aid significantly in night boating. ITT is now bringing the glasses to a broader sporting goods market for use by hunters, campers, hikers, and others to see prowlers, animals, trails, lost people, and things that go bump in the night. These are slightly infrared-sensitive but do not depend on infrared for imaging (an infrared flashlight is offered for supplemental lighting).

The image on all models is amazingly clear and detailed. There is basically no magnification, so the field of view is maximized (52 degrees), and 2x and 3x lens attachments are available. Most models even float, so consumers won't lose their investment overboard, although another Night Viewer might be needed to see the first one bobbing along in the dark. The lowest cost model, the Night Quest 100, is a monocular weighing only 10 oz.

Summary

With DBS, MD, DVC, and DVD, the home digital revolution is in full swing. With the transition to digital, Dataquest expects that the value of semiconductors going into consumer electronics will grow from $22 billion in 1995 to $46 billion by 2000. (Note that this does not include the semiconductor market opportunity in home appliance/convenience products.) As shown in Figure 8, new digital products and digital enhancements to current consumer products will drive the growth in the consumer semiconductor market in the future. The digital products introduced at the 1996 Winter CES give added credence to this forecast.

Figure 8
Consumer Semiconductor Market Forecast: Digital Will Drive the Growth in Chips



Source: Dataquest (January 1996)

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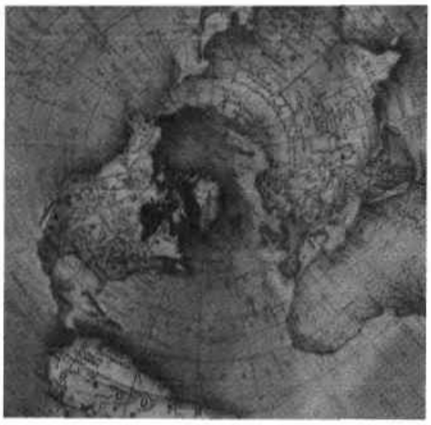

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Consumer Electronics Semiconductor Forecast: Next-Generation Products Promise Blockbuster Market

Market Trends

Program: Consumer Multimedia Semiconductors and Applications Worldwide
Product Code: MSAM-WW-MT-9603
Publication Date: December 9, 1996
Filing: Market Trends

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Chapter 1
The Consumer Electronics Chip Market Starts to Get Respect

Introduction

This document presents the Dataquest forecast for semiconductor consumption in consumer electronics equipment, along with the market for compression semiconductors in all types of equipment. With the emergence of a new digital consumer electronics era, the emphasis of this document and its forecasts is on the opportunity created by next-generation consumer electronics. These products, along with digitally enhanced consumer electronics, will drive the growth of semiconductors in this segment in the future. The forecasts in this report rely on systems forecasts established for major consumer electronics categories, along with predicted semiconductor trends and valuations in this equipment. Multiple analysts contributed to the creation of the forecasts and analysis presented in this document, as listed below.

Contributing Analysts: Dale Ford, Jonathan Cassell, Greg Sheppard, and Geoff Ballew

The Stars of the Show

The semiconductor market for consumer electronics is forecast to decline by $1.9 billion in 1996 from $26.1 billion in 1995. Two major factors play a role in the decline of the market. First, the overall consumer electronics equipment market was essentially flat from 1995 to 1996. The flat market combined with plummeting memory prices to result in an overall semiconductor market decline. The shrinking memory market accounted for $1.7 billion of the total market contraction, as shown in Table 1-1 and Figure 1-1. Japan and Asia/Pacific continue to dominate the consumption of semiconductors for consumer electronics. However, the European and Americas chip markets are expected to experience strong growth over the next five years, as shown in Table 1-2 and Figure 1-2.

Table 1-1
Worldwide Consumer Electronics Semiconductor Market Forecast by Device Type (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Total Equipment Factory Revenue	143,593	157,141	170,433	171,441	182,544	195,962	209,822	223,517	5.6
Total Semiconductor	17,406	21,507	26,071	24,185	27,015	31,881	38,185	45,746	11.9
Total IC	13,048	16,467	19,959	18,542	20,641	24,604	29,752	35,778	12.4
Bipolar Digital	223	211	161	98	79	63	50	39	-24.6
MOS Digital	7,416	9,664	12,615	11,478	12,843	15,762	19,448	23,537	13.3
MOS Memory	2,339	3,034	4,830	3,166	3,318	4,400	5,988	7,398	8.9
MOS Microcomponent	2,869	3,939	4,631	5,417	6,297	7,632	9,083	10,861	18.6

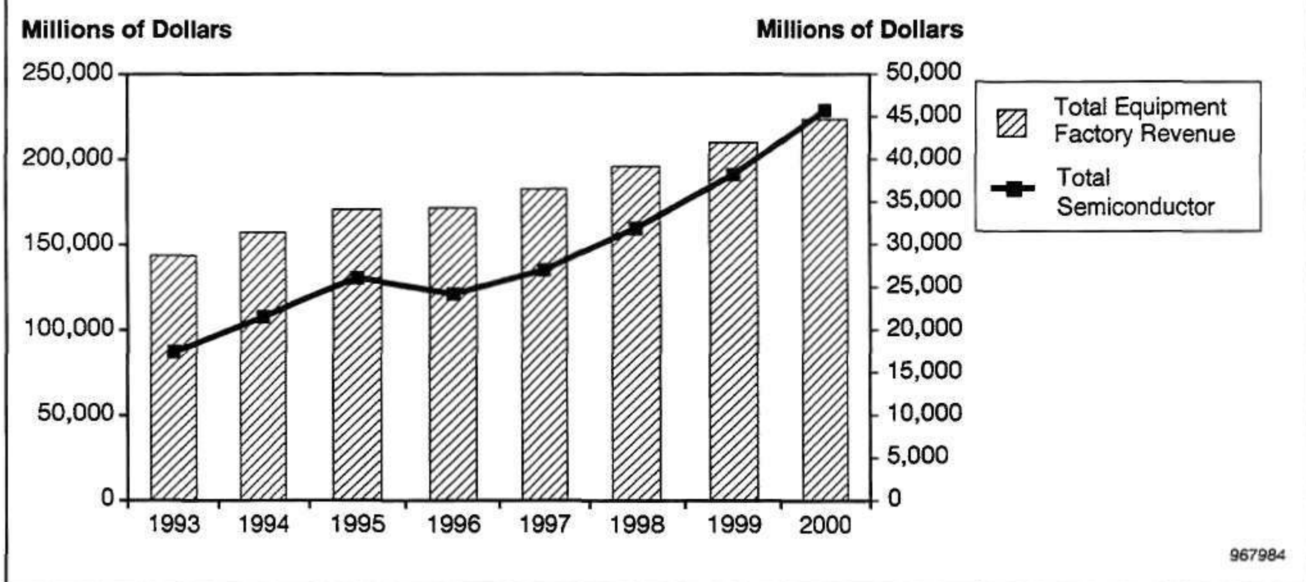
(Continued)

Table 1-1 (Continued)
Worldwide Consumer Electronics Semiconductor Market Forecast by Device Type (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
MOS Logic	2,208	2,691	3,154	2,895	3,228	3,730	4,377	5,278	10.8
Analog (Monolithic + Hybrid)	5,409	6,593	7,183	6,966	7,719	8,779	10,254	12,201	11.2
Total Discrete	3,160	3,610	4,390	4,067	4,581	5,263	6,118	7,234	10.5
Total Optoelectronic	1,198	1,431	1,722	1,576	1,792	2,014	2,315	2,734	9.7

Source: Dataquest (November 1996)

Figure 1-1
Worldwide Consumer Electronics and Semiconductor Market



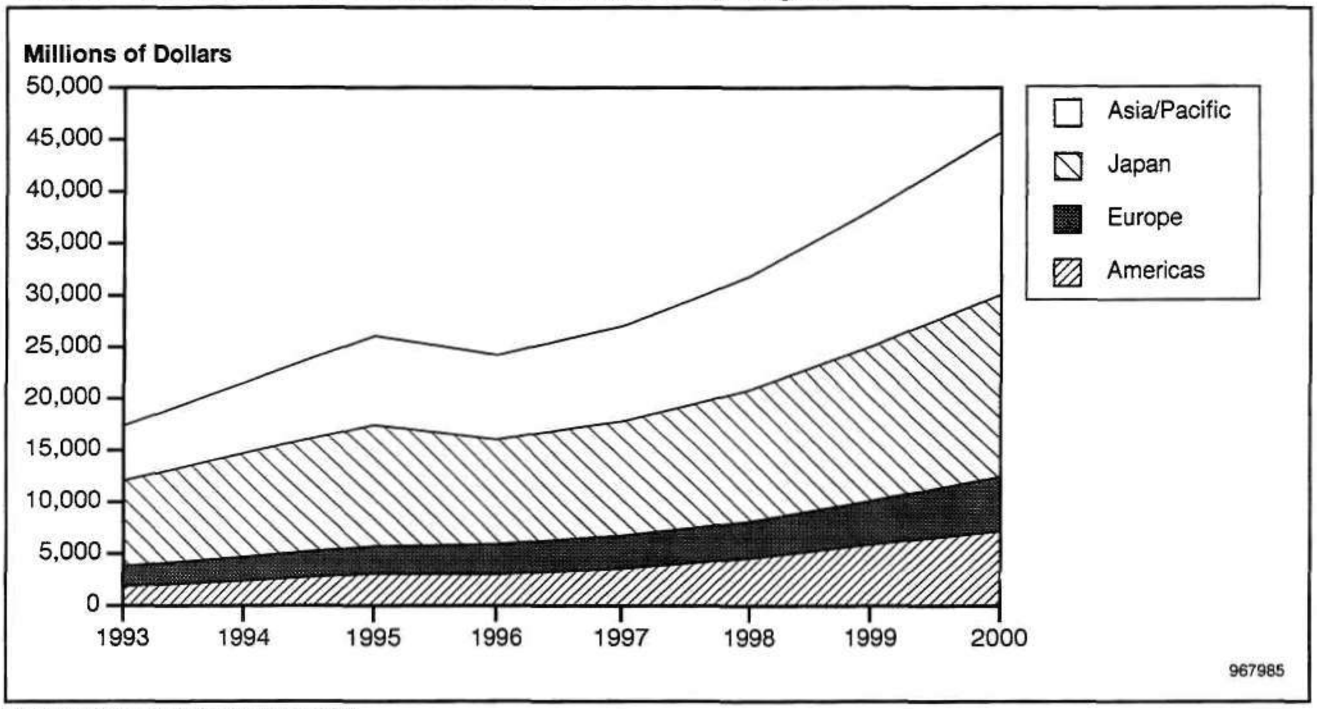
Source: Dataquest (November 1996)

Table 1-2
Worldwide Consumer Electronics Semiconductor Market Forecast by Region (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Americas	1,868	2,395	3,074	3,003	3,569	4,580	5,875	7,209	18.6
Audio	68	89	135	134	165	227	310	409	24.9
Video	735	1,020	1,456	1,512	1,907	2,574	3,463	4,392	24.7
Personal Electronics	21	31	46	45	54	66	81	97	16.0
Appliances	856	1,008	1,051	946	1,015	1,175	1,330	1,437	6.5
Other Consumer	188	248	385	366	428	538	691	874	17.8
Total	1,868	2,395	3,074	3,003	3,569	4,580	5,875	7,209	18.6
Europe	1,940	2,300	2,650	2,900	3,200	3,550	4,250	5,250	14.7
Audio	320	370	416	402	421	472	525	647	9.3
Video	1,270	1,535	1,817	2,109	2,396	2,683	3,269	4,064	17.5
Personal Electronics	182	209	213	191	180	176	200	225	1.0
Appliances	168	186	204	198	203	219	256	314	9.1
Other Consumer	0	0	0	0	0	0	0	0	NA
Total	1,940	2,300	2,650	2,900	3,200	3,550	4,250	5,250	14.7
Japan	8,298	10,018	11,713	10,143	11,024	12,749	14,935	17,612	8.5
Audio	1,337	1,591	1,797	1,419	1,515	1,648	1,801	1,991	2.1
Video	4,113	4,735	5,137	4,142	4,373	4,750	5,422	6,114	3.5
Personal Electronics	1,816	2,409	3,176	3,093	3,478	4,508	5,673	7,256	18.0
Appliances	626	798	1,016	1,058	1,196	1,360	1,539	1,717	11.1
Other Consumer	407	486	588	430	463	482	500	536	-1.9
Total	8,298	10,018	11,713	10,143	11,024	12,749	14,935	17,612	8.5
Asia/Pacific	5,299	6,794	8,634	8,139	9,222	11,003	13,125	15,674	12.7
Audio	1,241	1,859	2,443	2,314	2,609	3,203	3,784	4,629	13.6
Video	1,813	2,231	2,746	2,518	2,947	3,489	3,975	4,828	11.9
Personal Electronics	837	1,008	1,332	1,310	1,396	1,734	2,101	2,518	13.6
Appliances	938	1,141	1,480	1,394	1,567	1,718	2,300	2,523	11.3
Other Consumer	470	555	633	602	704	858	965	1,175	13.2
Total	5,299	6,794	8,634	8,139	9,222	11,003	13,125	15,674	12.7
Worldwide	17,406	21,507	26,071	24,185	27,015	31,881	38,185	45,746	11.9
Audio	2,966	3,909	4,790	4,269	4,710	5,551	6,420	7,676	9.9
Video	7,932	9,521	11,156	10,281	11,623	13,496	16,129	19,398	11.7
Personal Electronics	2,855	3,656	4,768	4,640	5,107	6,484	8,055	10,096	16.2
Appliances	2,588	3,132	3,750	3,597	3,980	4,472	5,424	5,991	9.8
Other Consumer	1,065	1,289	1,607	1,399	1,595	1,879	2,157	2,584	10.0

Source: Dataquest (November 1996)

Figure 1-2
Consumer Electronics Semiconductor Market by Region



Source: Dataquest (November 1996)

The real stars of the consumer electronics semiconductor show are next-generation consumer electronics and digitally enhanced consumer electronics. As shown in Table 1-3 and Figure 1-3, these products will drive the total chip market in this segment over $45 billion while chip shipments in legacy products remain relatively flat. The following points present definitions for each of the categories in these tables and figures:

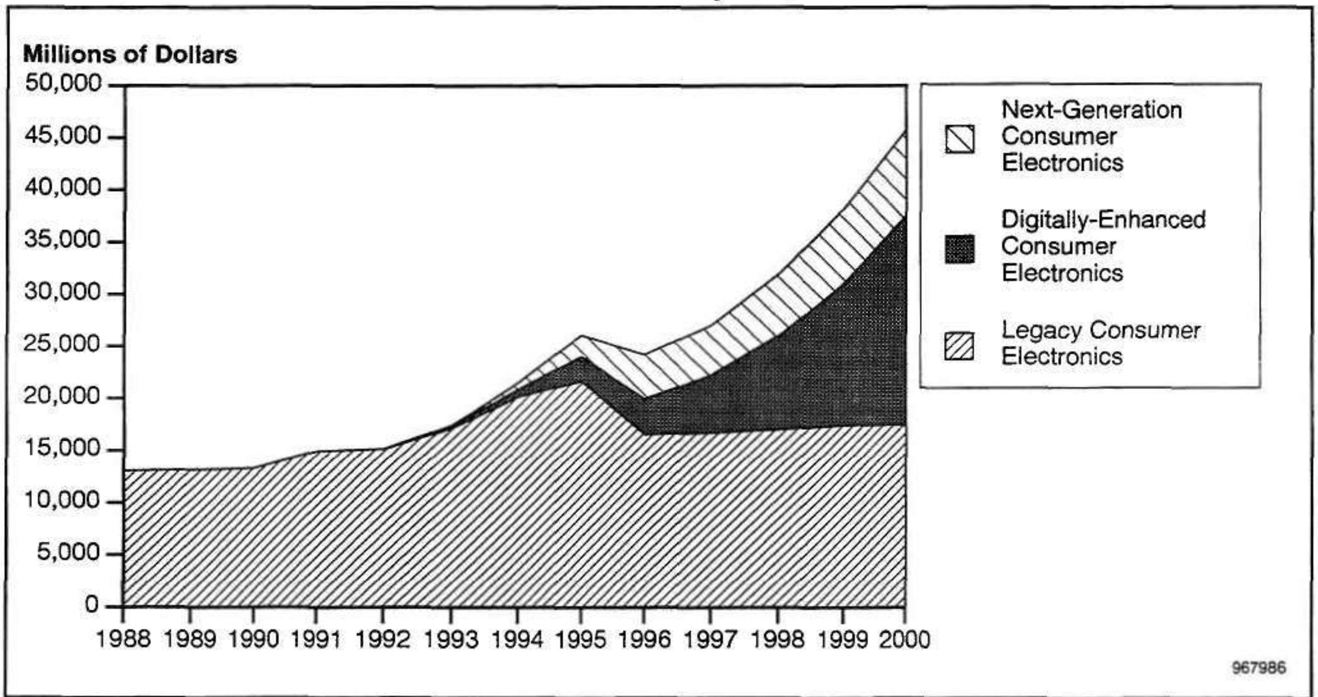
- Next-generation consumer electronics: Products that are included in this category are digital set-top boxes, digital satellite set-top boxes, 32/64-bit video game consoles, DVD video players, DVD audio players, digital still cameras, video CD players, HDTV-SDTV-ATV receivers, digital camcorders, and other products employing advanced semiconductor technologies. These products represent a new generation of consumer electronics.
- Digitally enhanced consumer electronics: These are consumer electronics products that have been enhanced by the addition of new digital technology. For example, camcorders that now employ motion compensation and digital zoom, TVs with V-chips (to block violent programming) and closed captioning, VCRs with Video Guide incorporated, and CD Audio players with additional memory and circuits to provide shock protection, among others. These are all products that have been in the home for many years but now have new, enhanced features delivered by digital technology.

Table 1-3
Worldwide Consumer Electronics Semiconductor Market Forecast by Product Generation (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Legacy Consumer Electronics	17,118	20,121	21,622	16,537	16,717	17,006	17,396	17,467	-4.2
Digitally Enhanced Consumer Electronics	250	750	2,400	3,400	5,500	9,000	13,600	20,000	52.8
Next-Generation Consumer Electronics	37	637	2,049	4,248	4,798	5,876	7,188	8,279	32.2
Total Consumer Electronics	17,406	21,507	26,071	24,185	27,015	31,881	38,185	45,746	11.9

Source: Dataquest (November 1996)

Figure 1-3
Consumer Electronics Semiconductor Market by Product Generation



Source: Dataquest (November 1996)

- Legacy consumer electronics: These are products that have been on the market for many years, such as standard color TVs, portable stereos, and VCRs, among others. They represent the current high-volume portion of the consumer electronics market and will continue to find markets at the mid-to-low-end segments. However, the chip market opportunities in these products are flat to declining.

Tables 1-4 through 1-6 and Figures 1-4 through 1-6 present summaries of the semiconductor forecasts for chips consumed in next-generation consumer electronics. More detailed forecasts for these products are presented in Chapter 2. The digital set-top box market is forecast to account for over 40 percent of the $8.3 billion semiconductor market in the year 2000. These products are followed by video CD and DVD video players, which will consume almost 25 percent of the chips in next-generation consumer electronics. Application-specific standard product (ASSP) and mixed-signal chips will lead the growth of this segment of the market, with forecast 106.8 percent and 63.3 percent compound annual growth rates (CAGR), respectively. Over half of the value created for semiconductors in the next generation comes from chips directly involved in processing audio, video, and graphics, as shown in Table 1-7. The chips counted in this category include products such as audio and video decoding chipsets, NTSC and PAL converters, and analog-to-digital (A/D) and digital-to-analog (D/A) converters.

Table 1-4
Worldwide Semiconductor Market Opportunity for Next-Generation Consumer Electronics Products (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Digital Cable Set-Top Box	4	5	13	83	260	441	852	1,287	150.1
Digital Satellite Set-Top Box	0	229	562	1,204	1,458	1,572	1,744	2,127	30.5
DVD Video Player	0	0	0	44	169	413	774	950	NA
Video CD Player	5	69	219	606	859	1,005	1,085	1,079	37.5
Next-Generation Video Game Console	21	314	1,142	1,812	1,353	1,513	1,717	1,705	8.3
HDTV-ADTV-SDTV Receiver	8	12	40	84	110	146	167	210	39.6
Digital Still Camera	0	7	52	202	299	451	458	463	54.8
Other Next-Generation Products*	0	0	21	213	291	336	393	459	85.0
Total	37	637	2,049	4,248	4,798	5,876	7,188	8,279	32.2

NA = Not applicable
*Other next-generation products includes digital VCRs, digital camcorders, DVD audio, and others.
Source: Dataquest (November 1996)

Table 1-5
Semiconductor Market Forecast for Next-Generation Consumer Electronics by Technology Type (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Digital	12	245	692	1,796	2,374	2,882	3,190	3,351	37.1
Analog, Discrete, and Opto	8	75	200	690	872	1,091	1,418	1,781	54.9
Mixed-Signal	2	37	163	446	705	1,021	1,525	1,889	63.3
Memory	15	281	995	1,315	847	883	1,056	1,259	4.8
Total	37	637	2,049	4,247	4,799	5,876	7,189	8,279	32.2

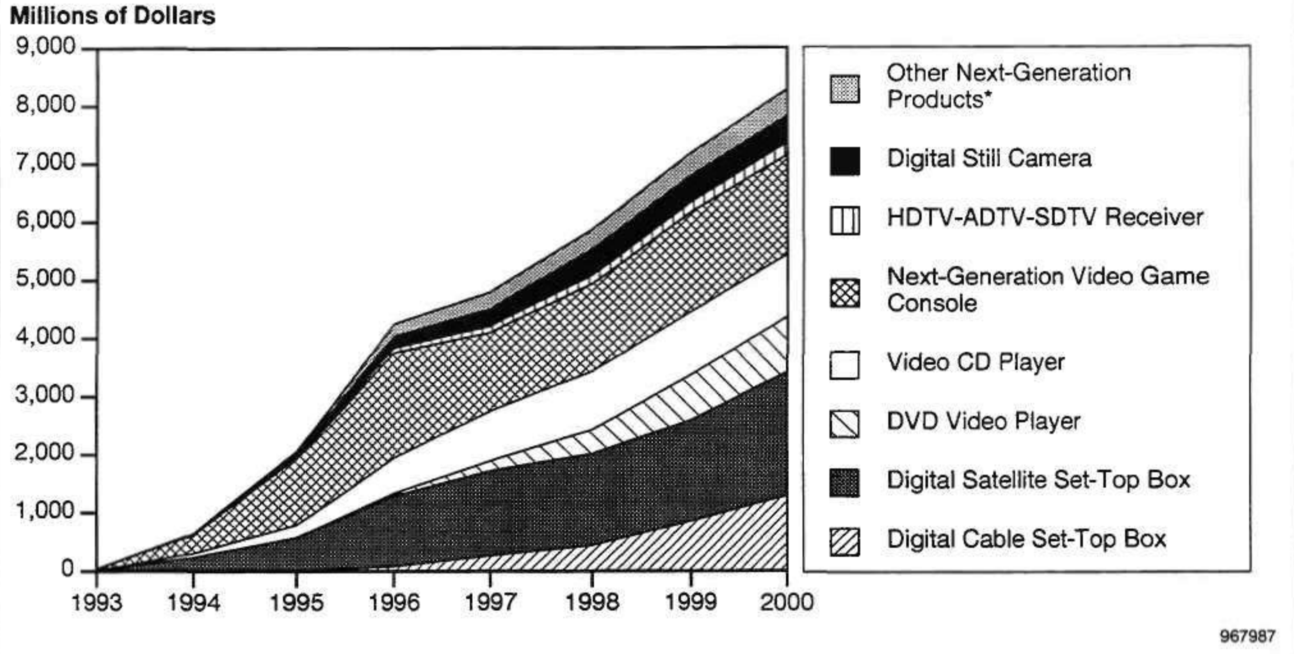
Source: Dataquest (November 1996)

Table 1-6
Semiconductor Market Forecast for Next-Generation Consumer Electronics by Integration Type (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
ASIC/ASSP	12	187	569	1,767	2,632	3,537	4,727	5,611	58.1
ASIC	12	169	461	1,139	1,377	1,576	1,685	1,545	27.3
ASSP	1	17	107	629	1,255	1,960	3,042	4,066	106.8
Standard IC or Discrete and Opto	11	169	485	1,165	1,320	1,457	1,406	1,409	23.8
Memory	15	281	995	1,315	847	883	1,056	1,259	4.8
Total	37	637	2,049	4,247	4,799	5,876	7,189	8,279	32.2

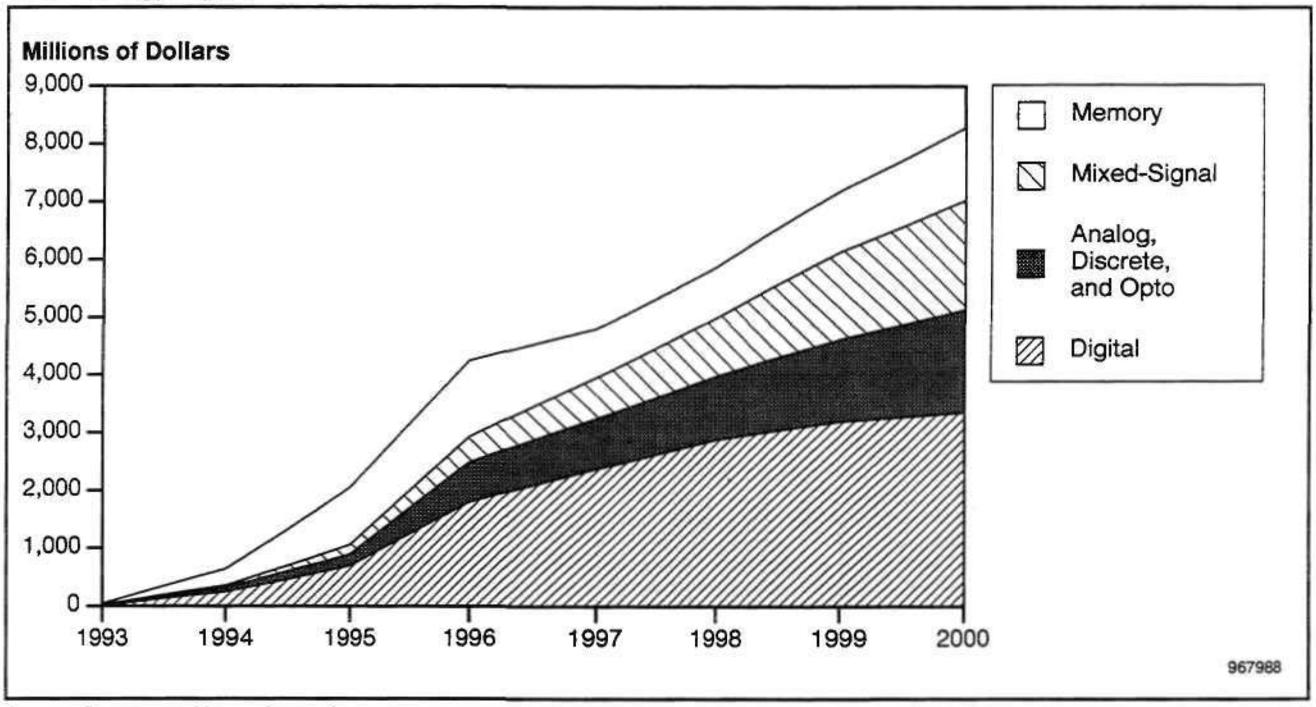
Source: Dataquest (November 1996)

Figure 1-4
Semiconductor Market Forecast for Next-Generation Consumer Electronics



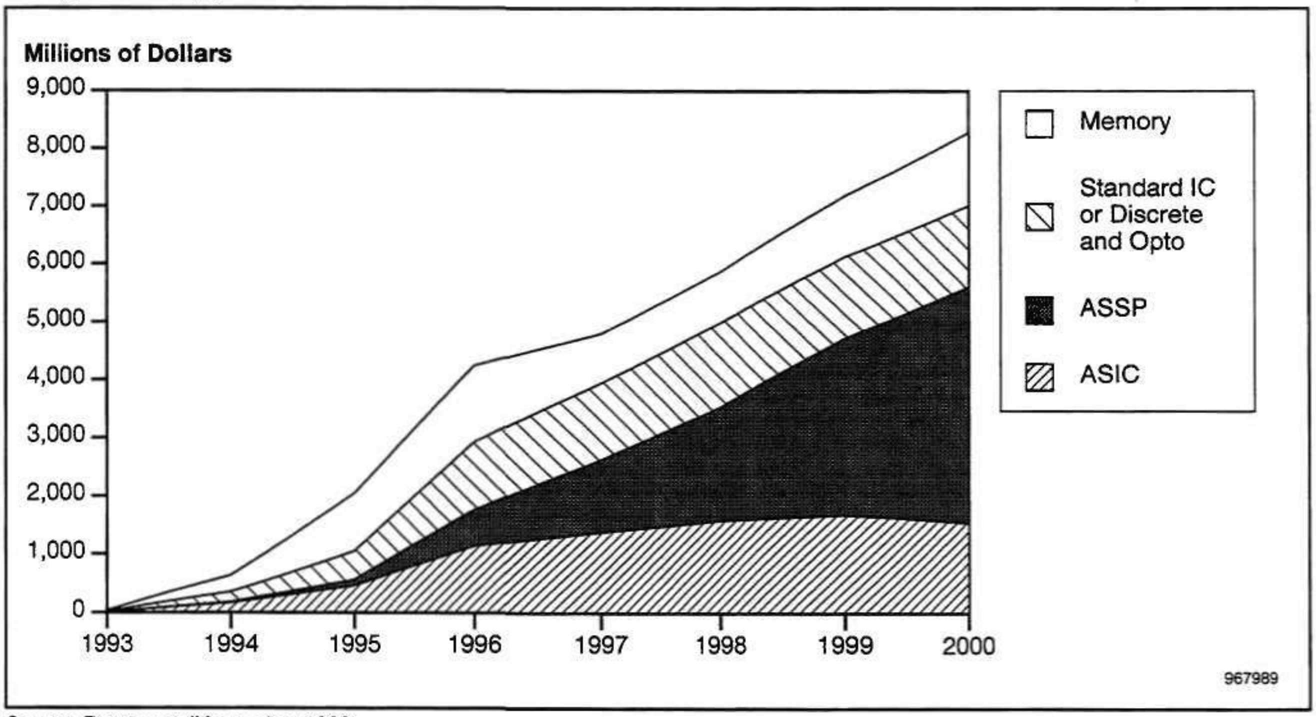
*Other next-generation products includes digital VCRs, digital camcorders, DVD audio, and others.
Source: Dataquest (November 1996)

Figure 1-5
Semiconductor Market Forecast for Next-Generation Consumer Electronics by Technology Type



Source: Dataquest (November 1996)

Figure 1-6
Semiconductor Market Forecast for Next-Generation Consumer Electronics by Integration Type



Source: Dataquest (November 1996)

Table 1-7
Worldwide Audio/Video/Graphics Processing Chip Market for Next-Generation Consumer Electronics Products (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Digital Cable Set-Top Box	2	3	8	48	132	214	406	613	137.4
Digital Satellite Set-Top Box	0	114	332	655	774	785	875	1,084	26.7
DVD Video Player	0	0	0	18	71	175	336	412	NA
Video CD Player	3	41	119	329	510	612	664	660	40.8
Next-Generation Video Game Console	6	90	302	621	728	987	1,132	1,129	30.2
HDTV-ADTV-SDTV Receiver	6	9	30	63	83	109	125	158	39.6
Digital Still Camera	0	5	42	161	239	336	337	341	52.3
Other Next-Generation Products	0	0	5	52	76	96	118	141	94.3
Total	17	262	838	1,947	2,613	3,315	3,992	4,539	40.2

Source: Dataquest (November 1996)

Chapter 2
The Next-Generation Consumer Electronics Semiconductor Market

This chapter explores the high growth opportunity presented by next-generation consumer electronics equipment. Because of the establishment of industry standards for most of these products, analog, digital, and mixed-signal ASSP products are expected to find extremely high growth opportunities. On the other hand, the continued price erosion in memory chips and lack of elasticity for memory demand in these systems will combine to keep memory growth in these products below 5 percent. Table 2-1 and Figure 2-1 present a summary of the detailed semiconductor forecast for each of the defined next-generation products in the following tables. It is important to note that these tables present the combined value of semiconductors on end-equipment shipping from the factory. In a high-growth market such as this, the actual units and value of chip shipments from semiconductor manufacturers to equipment manufacturers in a given year will typically be higher than the forecasts in these tables because of inventory and work-in-process.

Table 2-1
Worldwide Chip Market for Next-Generation Consumer Electronics Products by Semiconductor Type (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Digital ASIC	8	127	282	709	960	1,129	1,212	1,073	30.6
Digital Cable Set-Top Box	1	1	3	18	57	94	56	26	56.2
Digital Satellite Set-Top Box	0	37	49	108	153	110	87	36	-5.8
DVD Video Player	0	0	0	4	12	34	63	56	NA
Video CD Player	2	21	9	7	0	0	0	0	-100.0
Next-Generation Video Game Console	4	64	188	425	548	750	884	869	35.9
HDTV-ADTV-SDTV Receiver	1	1	4	8	11	14	15	16	31.8
Digital Still Camera	0	3	27	106	149	100	82	42	9.2
Other Next-Generation Products	0	0	3	32	29	27	24	28	56.8
Digital ASSP	0	10	80	406	696	1,028	1,375	1,721	84.5
Digital Cable Set-Top Box	0	0	0	5	26	60	170	311	NA
Digital Satellite Set-Top Box	0	0	0	150	233	330	401	510	NA
DVD Video Player	0	0	0	11	43	101	190	260	NA
Video CD Player	0	10	80	240	379	462	502	500	44.1
Next-Generation Video Game Console	0	0	0	0	0	0	0	0	NA
HDTV-ADTV-SDTV Receiver	0	0	0	0	0	3	8	15	NA
Digital Still Camera	0	0	0	0	0	45	61	68	NA
Other Next-Generation Products	0	0	0	0	15	27	43	55	NA

(Continued)

Table 2-1 (Continued)
Worldwide Chip Market for Next-Generation Consumer Electronics Products by Semiconductor Type (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Digital Standard IC or Discrete	4	108	330	681	718	726	603	558	11.1
Digital Cable Set-Top Box	0	0	1	27	62	55	102	154	171.9
Digital Satellite Set-Top Box	0	60	138	325	408	377	174	91	-7.8
DVD Video Player	0	0	0	2	7	16	27	28	NA
Video CD Player	0	3	10	27	37	40	41	42	33.6
Next-Generation Video Game Console	3	42	170	257	139	145	163	155	-1.8
HDTV-ADTV-SDTV Receiver	1	1	4	8	11	17	17	17	34.5
Digital Still Camera	0	1	6	19	32	52	54	46	52.9
Other Next-Generation Products	0	0	2	17	23	23	24	23	68.6
Analog ASIC	4	42	93	222	211	169	144	140	8.5
Digital Cable Set-Top Box	0	0	1	9	26	26	26	26	77.8
Digital Satellite Set-Top Box	0	37	73	157	117	63	35	21	-21.9
DVD Video Player	0	0	0	0	0	0	0	0	NA
Video CD Player	0	0	0	0	0	0	0	0	NA
Next-Generation Video Game Console	0	0	1	1	1	2	2	2	16.0
HDTV-ADTV-SDTV Receiver	3	5	16	34	44	53	54	59	30.3
Digital Still Camera	0	0	0	0	0	0	0	0	NA
Other Next-Generation Products	0	0	2	21	23	25	28	32	72.4
Analog ASSP	0	2	7	147	256	405	698	1,011	173.9
Digital Cable Set-Top Box	0	0	0	0	27	66	183	296	NA
Digital Satellite Set-Top Box	0	0	0	118	175	258	401	574	NA
DVD Video Player	0	0	0	2	7	18	34	42	NA
Video CD Player	0	2	6	21	30	36	40	40	46.5
Next-Generation Video Game Console	0	0	0	0	0	0	0	0	NA
HDTV-ADTV-SDTV Receiver	0	0	0	0	0	2	8	17	NA
Digital Still Camera	0	0	0	0	0	0	0	0	NA
Other Next-Generation Products	0	0	1	6	17	25	31	41	130.6
Analog Standard IC or Discrete	4	23	73	197	221	237	234	237	26.7
Digital Cable Set-Top Box	0	0	1	5	21	13	9	9	60.6
Digital Satellite Set-Top Box	0	11	28	64	29	16	12	13	-14.6
DVD Video Player	0	0	0	1	2	5	9	11	NA
Video CD Player	0	4	14	47	66	75	82	82	41.9
Next-Generation Video Game Console	0	2	8	20	25	36	41	39	35.8

(Continued)

Table 2-1 (Continued)
Worldwide Chip Market for Next-Generation Consumer Electronics Products by Semiconductor Type (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
HDTV-ADTV-SDTV Receiver	3	5	16	34	44	53	54	59	30.2
Digital Still Camera	0	1	4	13	18	22	11	10	NA
Other Next-Generation Products	0	0	1	15	16	17	16	14	56.2
Mixed-Signal ASIC	0	0	86	207	206	278	329	332	31.0
Digital Cable Set-Top Box	0	0	0	0	0	0	0	0	NA
Digital Satellite Set-Top Box	0	0	0	0	0	0	0	0	NA
DVD Video Player	0	0	0	8	14	34	59	61	NA
Video CD Player	0	0	0	0	0	0	0	0	NA
Next-Generation Video Game Console	0	0	82	157	149	204	235	239	23.8
HDTV-ADTV-SDTV Receiver	0	0	0	0	0	0	0	0	NA
Digital Still Camera	0	0	0	0	0	0	0	0	NA
Other Next-Generation Products	0	0	4	43	44	40	35	32	51.7
Mixed-Signal ASSP	0	6	20	76	304	527	969	1,334	130.8
Digital Cable Set-Top Box	0	0	0	0	0	39	132	206	NA
Digital Satellite Set-Top Box	0	0	0	0	146	189	384	574	NA
DVD Video Player	0	0	0	9	48	115	217	272	NA
Video CD Player	0	6	20	67	95	113	120	120	42.5
Next-Generation Video Game Console	0	0	0	0	0	0	0	0	NA
HDTV-ADTV-SDTV Receiver	0	0	0	0	0	2	7	17	NA
Digital Still Camera	0	0	0	0	0	36	46	58	NA
Other Next-Generation Products	0	0	0	0	15	34	63	87	NA
Mixed-Signal Standard IC	2	31	56	162	195	215	226	222	31.8
Digital Cable Set-Top Box	0	0	0	0	0	0	0	0	NA
Digital Satellite Set-Top Box	0	0	0	0	0	0	0	0	NA
DVD Video Player	0	0	0	0	0	0	0	0	NA
Video CD Player	0	8	28	97	134	152	162	162	42.4
Next-Generation Video Game Console	1	23	26	44	32	36	41	37	7.4
HDTV-ADTV-SDTV Receiver	0	0	0	0	0	0	0	0	NA
Digital Still Camera	0	0	0	0	0	0	0	0	NA
Other Next-Generation Products	0	0	2	21	29	27	24	23	61.1

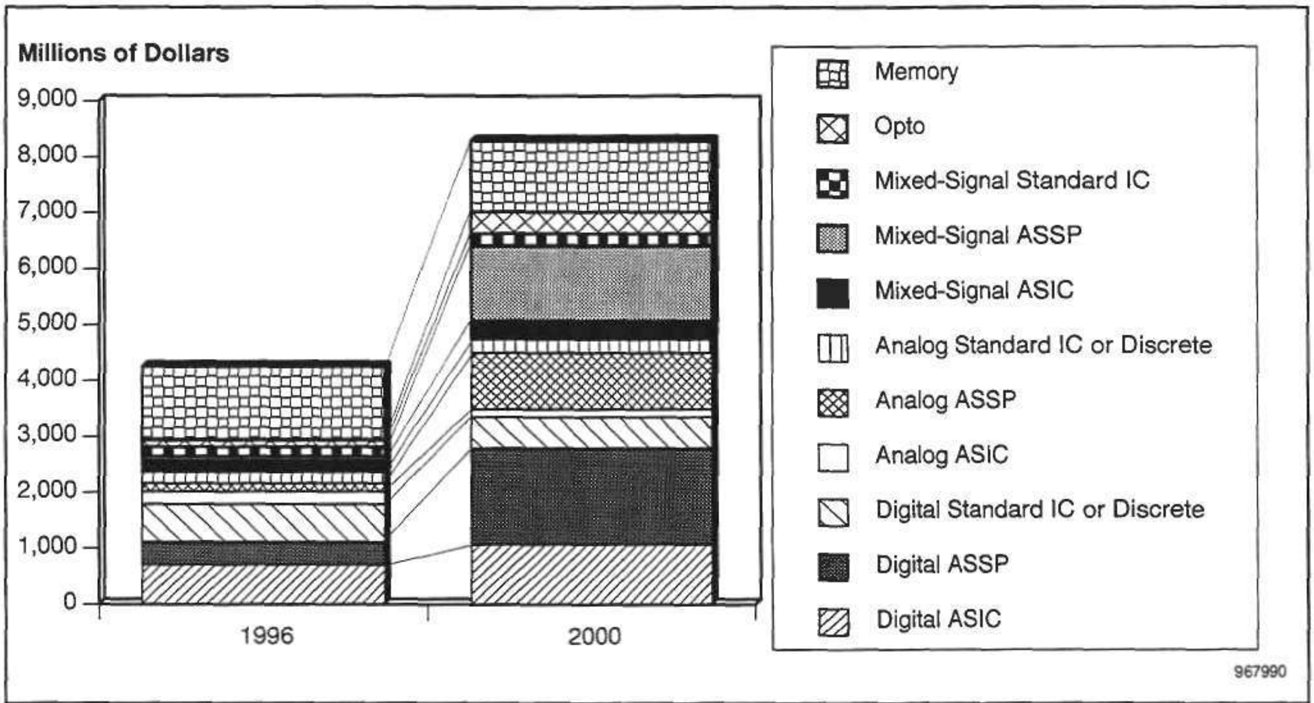
(Continued)

Table 2-1 (Continued)
Worldwide Chip Market for Next-Generation Consumer Electronics Products by Semiconductor Type (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Opto	1	8	27	124	185	279	342	393	70.3
Digital Cable Set-Top Box	0	0	0	0	0	0	0	0	NA
Digital Satellite Set-Top Box	0	0	0	0	0	0	0	0	NA
DVD Video Player	0	0	0	4	15	37	70	89	NA
Video CD Player	0	5	14	44	57	64	70	70	38.8
Next-Generation Video Game Console	0	2	0	2	5	6	7	5	NA
HDTV-ADTV-SDTV Receiver	0	0	0	0	0	0	0	0	NA
Digital Still Camera	0	1	10	32	48	99	105	120	NA
Other Next-Generation Products	0	0	4	43	61	73	89	108	93.8
Memory	15	281	995	1,315	847	883	1,056	1,259	4.8
Digital Cable Set-Top Box	2	3	7	19	42	88	174	259	105.5
Digital Satellite Set-Top Box	0	85	274	281	197	230	249	307	2.3
DVD Video Player	0	0	0	5	21	54	105	131	NA
Video CD Player	0	10	38	56	61	62	66	63	10.3
Next-Generation Video Game Console	12	181	667	907	455	333	343	358	-11.7
HDTV-ADTV-SDTV Receiver	0	0	0	0	0	2	5	9	NA
Digital Still Camera	0	1	6	32	52	97	98	119	80.3
Other Next-Generation Products	0	0	2	15	19	17	16	14	45.7
Total Market	37	637	2,049	4,247	4,799	5,876	7,189	8,279	32.2
Digital ASIC	8	127	282	709	960	1,129	1,212	1,073	30.6
Digital ASSP	0	10	80	406	696	1,028	1,375	1,721	84.5
Digital Standard IC or Discrete	4	108	330	681	718	726	603	558	11.1
Analog ASIC	4	42	93	222	211	169	144	140	8.5
Analog ASSP	0	2	7	147	256	405	698	1,011	173.9
Analog Standard IC or Discrete	4	23	73	197	221	237	234	237	26.7
Mixed-Signal ASIC	0	0	86	207	206	278	329	332	31.0
Mixed-Signal ASSP	0	6	20	76	304	527	969	1,334	130.8
Mixed-Signal Standard IC	2	31	56	162	195	215	226	222	31.8
Opto	1	8	27	124	185	279	342	393	70.3
Memory	15	281	995	1,315	847	883	1,056	1,259	4.8

NA = Not applicable
Source: Dataquest (November 1996)

Figure 2-1
Summary of Chip Market for Next-Generation Consumer Electronics Products by Chip Type



Source: Dataquest (November 1996)

Digital Satellite and Cable Set-Top Boxes

Digital set-top boxes represent a fast-growing market for video and audio compression and processing devices. They also are significant consumers of memory, mainly DRAM, although SRAM and flash also are used in such systems. The primary type of video compression used in both cable and satellite systems is MPEG-2. For audio, both the MPEG-1 and MPEG-2 standards are used, although some systems are beginning to adopt Dolby's AC-3 compression technology. In addition to decompression, digital set-top boxes perform a variety of different types of video and audio processing, including demultiplexing, graphics control and acceleration, and NTSC/PAL encoding.

In a quest for cost reduction, the market as a whole is transitioning away from a mix of ASICs and standard parts and toward highly integrated ASSPs. Analog, digital, and mixed-signal ASSPs all are playing an increasingly important role in new and future set-top boxes and will account for an ever-larger percentage of value in those systems. The cost of memory used in digital set-top boxes significantly decreased in 1996 as DRAM prices plunged. DRAM costs will continue to decline as more use is made of integrated video processing ASSPs that employ unified memory architectures (UMAs).

Because of a price war in the digital satellite set-top box market, makers of those systems are aggressively cutting costs through integration. Because so far they have not been a large-volume product, digital cable set-top boxes are lagging behind their satellite counterparts on the integration front. Digital cable boxes also tend to possess a larger amount of differentiation, more microprocessing horsepower, and a higher level of audio/visual processing than satellite systems. Near the end of the century, some new cable boxes will include audio and video compression capabilities to support two-way communication and data storage applications. Tables 2-2 and 2-3 present detailed semiconductor market forecasts for digital cable and digital satellite set-top boxes, respectively.

Table 2-2
Worldwide Chip Market for Digital Cable Set-Top Boxes by Semiconductor Type (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Digital ASIC	1	1	3	18	57	94	56	26	56.2
Digital ASSP	0	0	0	5	26	60	170	311	NA
Digital Standard IC or Discrete	0	0	1	27	62	55	102	154	171.9
Analog ASIC	0	0	1	9	26	26	26	26	77.8
Analog ASSP	0	0	0	0	27	66	183	296	NA
Analog Standard IC or Discrete	0	0	1	5	21	13	9	9	60.6
Mixed-Signal ASIC	0	0	0	0	0	0	0	0	NA
Mixed-Signal ASSP	0	0	0	0	0	39	132	206	NA
Mixed-Signal Standard IC	0	0	0	0	0	0	0	0	NA
Opto	0	0	0	0	0	0	0	0	NA
Memory	2	3	7	19	42	88	174	259	105.5
Total	4	5	13	83	260	441	853	1,287	150.1

NA = Not applicable
Source: Dataquest (November 1996)

DVD Video Players

After a long delay that has created high anticipation among consumer electronics retailers, manufacturers, and consumers, DVD video players began shipping to the market in Japan and Korea on November 1, 1996. Shipments are expected in the United States and other countries by early 1997 at the latest. These video players are based on MPEG-2 and AC-3 compression technology and use shorter-wavelength diodes to allow playback of full-length movies from one CD-ROM-size disc. Although early video players will employ a variety of ASICs and ASSPs in a low-integration solution, there will be a shift to second-generation products quickly that employ highly integrated ASSP and ASIC solutions. Many chip companies are targeting this opportunity with competitive digital and mixed-signal ASSP solutions. The advanced optical storage technology employed in these products drives higher costs for the optical electronics and motor drivers. The channel and video processing requirements in these systems are 2.5MB of DRAM. These initial video players are playback devices only and use decoder technology that combines MPEG-2 and AC-3 as mandatory standards with other optional compression standards.

Table 2-3
Worldwide Chip Market for Digital Satellite Set-Top Boxes by Semiconductor Type (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Digital ASIC	0	37	49	108	153	110	87	36	-5.8
Digital ASSP	0	0	0	150	233	330	401	510	NA
Digital Standard IC or Discrete	0	60	138	325	408	377	174	91	-7.8
Analog ASIC	0	37	73	157	117	63	35	21	-21.9
Analog ASSP	0	0	0	118	175	258	401	574	NA
Analog Standard IC or Discrete	0	11	28	64	29	16	12	13	-14.6
Mixed-Signal ASIC	0	0	0	0	0	0	0	0	NA
Mixed-Signal ASSP	0	0	0	0	146	189	384	574	NA
Mixed-Signal Standard IC	0	0	0	0	0	0	0	0	NA
Opto	0	0	0	0	0	0	0	0	NA
Memory	0	85	274	281	197	230	249	307	2.3
Total	0	229	562	1,203	1,458	1,572	1,743	2,127	30.5

NA = Not applicable
Source: Dataquest (November 1996)

Although the cost for MPEG-2 compression chipsets ranges in the thousands of dollars currently, Dataquest's forecast for this market anticipates the development of low-cost MPEG-2 encoding chipsets that would enable a mass market for recordable DVD video players. Full read/write-capable players that employ codecs are expected to reach the market by late 1998 or early 1999. There are also opportunities to create hybrid set-top box and DVD products because of the common compression technologies employed in these products. This forecast does not attempt to project the market for these hybrid products. Table 2-4 presents a detailed semiconductor market forecast for DVD video players.

Video CD Players

Although relatively unknown in the Americas and Europe, video CD players have achieved high-volume shipments in Japan and Asia/Pacific, approaching a production rate of 10 million units in 1996. With their application in karaoke products and the support of a large number of low-cost movie titles, these players are expected to continue on a strong growth path over the next three to four years even in the face of the DVD video player introduction. These players are based on MPEG-1 compression technology. C-Cube Microsystems Inc. has been a leader in enabling this market with its MPEG-1 chipsets. The combined drop in price of CD-ROM drives and MPEG-1 chips during the latter part of 1995 and 1996 led to a significant drop in the price for video CD players, which helped push market demand up significantly. The chips in these players are highly integrated, and even with the introduction of a new video CD standard, the technology is maturing and has the potential for further cost reductions. The channel/video processing in these players only requires 4Mb of memory, which could eventually be integrated with the other logic in the next level of integration. Table 2-5 presents a detailed semiconductor market forecast for video CD players.

Table 2-4
Worldwide Chip Market for DVD Video Players by Semiconductor Type (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Digital ASIC	0	0	0	4	12	34	63	56	NA
Digital ASSP	0	0	0	11	43	101	190	260	NA
Digital Standard IC or Discrete	0	0	0	2	7	16	27	28	NA
Analog ASIC	0	0	0	0	0	0	0	0	NA
Analog ASSP	0	0	0	2	7	18	34	42	NA
Analog Standard IC or Discrete	0	0	0	1	2	5	9	11	NA
Mixed-Signal ASIC	0	0	0	8	14	34	59	61	NA
Mixed-Signal ASSP	0	0	0	9	48	115	217	272	NA
Mixed-Signal Standard IC	0	0	0	0	0	0	0	0	NA
Opto	0	0	0	4	15	37	70	89	NA
Memory	0	0	0	5	21	54	105	131	NA
Total	0	0	0	44	169	413	774	950	NA

NA = Not applicable
Source: Dataquest (November 1996)

Table 2-5
Worldwide Chip Market for Video CD Players by Semiconductor Type (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Digital ASIC	2	21	9	7	0	0	0	0	-100.0
Digital ASSP	0	10	80	240	379	462	502	500	44.1
Digital Standard IC or Discrete	0	3	10	27	37	40	41	42	33.6
Analog ASIC	0	0	0	0	0	0	0	0	NA
Analog ASSP	0	2	6	21	30	36	40	40	46.5
Analog Standard IC or Discrete	0	4	14	47	66	75	82	82	41.9
Mixed-Signal ASIC	0	0	0	0	0	0	0	0	NA
Mixed-Signal ASSP	0	6	20	67	95	113	120	120	42.5
Mixed-Signal Standard IC	0	8	28	97	134	152	162	162	42.4
Opto	0	5	14	44	57	64	70	70	38.8
Memory	0	10	38	56	61	62	66	63	10.3
Total	5	69	219	606	859	1,005	1,085	1,079	37.5

NA = Not applicable
Source: Dataquest (November 1996)

Next-Generation Video Game Consoles

With the introduction of the Nintendo 64, the industry has completed its shift from 16-bit hardware to an emphasis on shipments of next-generation 32- and 64-bit video game consoles by all three major players, Sega, Sony, and Nintendo. All of these systems employ ASICs extensively. However, the Nintendo 64 has achieved the highest level of integration in its design and the most efficient use of DRAM. The Nintendo 64 uses two Rambus RDRAM chips, while the Sega Saturn and Sony PlayStation use a variety of DRAM and VRAM. The high cost of memory in these systems was a major cost driver until the major DRAM price erosion in 1996. This drop in memory costs helped offset losses experienced by the manufacturers in selling these systems for $199. One of the main differentiators between the Sony and Sega systems and the Nintendo system is their use of a CD-ROM instead of cartridges for software delivery. There is no compression technology employed in any of these systems today. There has been some discussion of eventual migration to DVD drives, but Dataquest does not expect this to happen until late 1998 at the earliest. Table 2-6 presents a detailed semiconductor market forecast for next-generation video game consoles.

Table 2-6
Worldwide Chip Market for Next-Generation Video Game Consoles by Semiconductor Type (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Digital ASIC	4	64	188	425	548	750	884	869	35.9
Digital ASSP	0	0	0	0	0	0	0	0	NA
Digital Standard IC or Discrete	3	42	170	257	139	145	163	155	-1.8
Analog ASIC	0	0	1	1	1	2	2	2	16.0
Analog ASSP	0	0	0	0	0	0	0	0	NA
Analog Standard IC or Discrete	0	2	8	20	25	36	41	39	35.8
Mixed-Signal ASIC	0	0	82	157	149	204	235	239	23.8
Mixed-Signal ASSP	0	0	0	0	0	0	0	0	NA
Mixed-Signal Standard IC	1	23	26	44	32	36	41	37	7.4
Opto	0	2	0	2	5	6	7	5	NA
Memory	12	181	667	907	455	333	343	358	-11.7
Total	21	314	1,142	1,812	1,353	1,513	1,717	1,705	8.3

NA = Not applicable
Source: Dataquest (November 1996)

HDTV/ATV/SDTV

The market for next-generation television currently consists of analog high-definition TV (HDTV) receivers in Japan. However, by 1998, advanced television digital broadcast standards should be finalized in the United States and in Europe, paving the way for the sale of digital HDTV systems. In the intervening years, advanced television systems will use predominately analog components. After that, both digital HDTV and digital standard definition television (SDTV) platforms should begin to trickle into the market. Such systems will have a semiconductor content resembling some digital set-top boxes to a degree, with MPEG-2 video decompression, AC-3 or MPEG-2 audio decompression, and some DRAM for decompression buffering. Table 2-7 presents a detailed semiconductor market forecast for HDTV/SDTV/ATV receivers.

Table 2-7
Worldwide Chip Market for HDTV/SDTV/ATV Receivers by Semiconductor Type (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Digital ASIC	1	1	4	8	11	14	15	16	31.8
Digital ASSP	0	0	0	0	0	3	8	15	NA
Digital Standard IC or Discrete	1	1	4	8	11	17	17	17	34.5
Analog ASIC	3	5	16	34	44	53	54	59	30.3
Analog ASSP	0	0	0	0	0	2	8	17	NA
Analog Standard IC or Discrete	3	5	16	34	44	53	54	59	30.2
Mixed-Signal ASIC	0	0	0	0	0	0	0	0	NA
Mixed-Signal ASSP	0	0	0	0	0	2	7	17	NA
Mixed-Signal Standard IC	0	0	0	0	0	0	0	0	NA
Opto	0	0	0	0	0	0	0	0	NA
Memory	0	0	0	0	0	2	5	9	NA
Total	8	12	40	84	110	146	167	210	39.6

NA = Not applicable
Source: Dataquest (November 1996)

Digital Still Cameras

Sales of digital cameras are expected to grow rapidly as prices decline. The year 1998 is expected to show the strongest unit growth through the end of the century as mainstream camera prices drop into the range of $200 or less. Although digital cameras can replace conventional film cameras, most consumers through the end of the century will use them exclusively to import images into PCs. Because of this, the available market for digital cameras is expected to be limited to PC owners and PC buyers through the end of the century. Graphics processing accounts for the majority of the value of the semiconductor content in a digital camera. The charge-coupled device (CCD) is the single most expensive component in most digital cameras, although learning curve reductions in CCD prices should help reduce digital camera average selling prices (ASPs) significantly in the future. To maximize memory efficiency, digital cameras also include compression engines that use JPEG or a proprietary algorithm. The compressed images are stored in flash memory. Flash memory cost reductions also should help to further drive down the price of digital cameras. Current digital cameras, which are in their first or second generation, make heavy use of standard digital products. However, as cameras evolve, they are expected to make increasing use of more cost-effective ASSPs. Table 2-8 presents a detailed semiconductor market forecast for digital still cameras.

Other Next-Generation Consumer Electronics Products

Products included in the other category of this forecast include digital camcorders based on the digital videocassette (DVC) standard, DVD audio players, and other advanced consumer devices that may be introduced over the next five years. This forecast does not attempt to measure the size of the DVC compression chip market in digital camcorders. Because the specification for DVD audio is still under discussion, it is not possible to present a detailed forecast for this product.

Table 2-8
Worldwide Chip Market for Digital Still Cameras by Semiconductor Type (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Digital ASIC	0	3	27	106	149	100	82	42	9.2
Digital ASSP	0	0	0	0	0	45	61	68	NA
Digital Standard IC or Discrete	0	1	6	19	32	52	54	46	52.9
Analog ASIC	0	0	0	0	0	0	0	0	NA
Analog ASSP	0	0	0	0	0	0	0	0	NA
Analog Standard IC or Discrete	0	1	4	13	18	22	11	10	NA
Mixed-Signal ASIC	0	0	0	0	0	0	0	0	NA
Mixed-Signal ASSP	0	0	0	0	0	36	46	58	NA
Mixed-Signal Standard IC	0	0	0	0	0	0	0	0	NA
Opto	0	1	10	32	48	99	105	120	NA
Memory	0	1	6	32	52	97	98	119	80.3
Total	0	7	52	202	299	451	458	463	54.8

NA = Not applicable
Source: Dataquest (November 1996)

Chapter 3
The Expanding Market for Compression Chips

Compression technology sits at the heart of most advanced consumer electronics products, and these products are driving a strong market demand for compression. However, compression products are finding important markets in other areas beyond the consumer electronics category, such as PCs, PC add-in cards, videoconferencing equipment, and broadcast/head-end/postproduction equipment. In order to present a more complete forecast of the compression market opportunity, this report presents a forecast for the use of compression in these products in addition to the consumer electronics products.

Compression Standards

Forecasts for the major compression standards of JPEG, Motion JPEG, MPEG-1, MPEG-2, AC-3, Indeo, DigiCipher, and H.261/H.263 are presented in this chapter. A brief discussion of these standards and their applications is presented in the following sections.

JPEG and Motion JPEG

JPEG stands for Joint Picture Experts Group and is the nickname for the committee that defined this standard. This standard was defined as a still-image compression standard, but it is also used extensively for video compression and is referred to as Motion JPEG in these applications. In Motion JPEG, each video frame is compressed independently of all others, which is different from the MPEG and H.261 standards that employ interframe and intraframe compression. Because each frame is entirely independent of the others, Motion JPEG performs well in applications where random access or the ability to recover easily from lost frames is required, such as video editing or high-quality videoconferencing on normal packet LANs.

MPEG-1

The MPEG acronym stands for Motion Picture Experts Group, the committee that established the standard. The MPEG-1 standard was developed for delivery of movies at encoded data rates of about 1.5 Mbps. This rate fits well with applications such as single-speed CD-ROMs and T1 connections. In a single-speed CD-ROM application, the compressed video stream occupies about 1.1 Mbps of the overall data rate, with audio and overhead processing consuming the remaining bandwidth. The compression artifacts of MPEG-1 appear as "blockiness" at the edges of 8 x 8-pixel blocks and other image degradation is inherent in this algorithm. Because the encoding process is so processor intensive, dedicated hardware encoding systems range in price from a few thousand dollars to more than $50,000. The video CD standard uses MPEG-1 for video and audio encoding.

MPEG-2 and AC-3

The MPEG-2 standard is a superset of the MPEG-1 standard and offers a greater variety of options and higher-quality reproduction of video and audio. The primary MPEG-2 applications are digital cable and satellite set-top boxes, DVD video players and PC add-in cards, and HDTV. The DVD standard specifies a combination of MPEG-2 video compression and AC-3 audio compression with an optional, undefined third compression standard. The AC-3 audio compression standard was developed by Dolby Laboratories, working closely with Zoran Corporation. The use of AC-3 compression in DVD and set-top boxes applications and the related MPEG-2/AC-3 market is included in this forecast. The AC-3 chips are used in home theater surround sound stereo systems also. However, these stereo implementations do not employ the compression element of the algorithm and are not counted in this forecast.

H.261

This Integrated Telecommunications Union standard has become the mainstream method of compressing video information in room, rollabout, and PC-based videoconferencing systems. The mainstreaming of this technology has supplanted or complemented a variety of proprietary algorithms employed by companies like PictureTel, Compression Labs, and Intel (Proshare/Indeo). H.261 is part of an overall H.320 standard that specifies all of the aspects of protocol and control involved in establishing and maintaining a videoconferencing session. H.261 is oriented toward operating with ISDN bearer channels (at 64 Kbps) and fractional T1 and E1 rates up to 2 Mbps. H.261 is similar to MPEG in that it uses digital cordless telephony (DCT) algorithms to eliminate redundant visual information.

H.263

This DCT-based algorithm is designed to work with the H.324 plain old telephone service (POTS) standard. Designed to operate over a 28.8-Kbps dial-up modem, the standard can work with 88 x 72-pixel images up to four times standard NTSC TV resolution. It was tailored to be visually effective at low bit rates, but many believe it is better than H.261 at higher bit rates and therefore could possibly supplant that standard eventually.

Indeo and Proprietary Algorithms

Before the broad international support of H.261 and H.263 appeared, a variety of proprietary compression algorithms existed in videoconferencing. As noted above, each major videoconferencing vendor had its own approach. These algorithms were used as one of the points of product differentiation, as the vendors claimed theirs had the better quality. The problem was that the algorithms were not interoperable with each other—one had to have PictureTel and Compression Labs systems in all conferencing locations in order to communicate. Intel's support for Indeo was largely motivated by its desire to ensure that a MIPS-consuming application would be enabled on the desktop PC. For the most part, these proprietary approaches have been phased out or remain as backwardly compatible options on videoconferencing systems.

Content Creation and Distribution Encoding Systems

In the creation of video-based content there are a variety of systems employed. These systems prepare the content for publication or storage and help in the editing and mastering process. In the process, these systems encode or compress the video (and audio) content using one of a variety of compression standards. Key content examples include CD-ROM titles (games, reference, and so on), video CD (primarily video karaoke), and the emerging market of DVD movie titles. The systems span the range from PC-based add-in cards and software (including soft codecs), to rack-mounted editing and production systems costing $100,000 or more for Hollywood film editing and mastering. The bulk of desktop PC (or workstation) systems today deal with MPEG-1 and other PC-oriented algorithms such as CinePak. The emerging opportunity is for systems that employ MPEG-2 algorithms to create DVD movie titles.

There are also systems that are oriented toward real-time (or near-real-time) encoding of broadcast television and private satellite links. The primary purpose of these systems in to conserve bandwidth and push more content through the same bandwidth. Key standards employed in these systems are MPEG-2, DigiCipher (1 and 2), and other proprietary versions from companies like Compression Labs. These are mostly expensive rack-mounted systems costing tens of thousands of dollars each. These systems can be employed by:

- Direct broadcast satellite services (like DirectTV or PerfecTV)
- Remote live news gathering (like the Cable News Network)
- Terrestrial broadcast and cable TV back-haul and distribution
- Local ad insertion by CATV and multipoint, multichannel distribution systems (MMDS) systems
- Private satellite links

Compression Technologies in PC Applications

Video compression technologies will see much greater use in PC applications in the future. This is driven by a combination of faster PCs, higher-quality software codecs, improved video acceleration features in graphics chips, and new types of high-density, removable mass storage. The CD-ROM made digital video content economical to deliver to end users, but performance limitations of the drives as well as the PCs limited playback quality and therefore limited acceptance.

Digital video playback has been hindered by perceptions of low quality (lower than broadcast TV), which was caused by PC performance and codec compatibility issues. This is changing as Pentium and Pentium Pro microprocessors get higher clock rates and with use of Intel's MMX multimedia instruction set. Faster PCs, together with higher-quality software codecs and faster CD-ROM drives, will drive greater use of digital video on PCs. Hardware codecs will benefit from this trend as greater use of digital video creates awareness and causes more PC users to purchase hardware accelerators. Many of the compatibility issues with MPEG-1 hardware in the past appear to have been solved, and this will increase the perception of utility and value for those products.

MPEG-2 usage will be driven by the availability of DVD drives and software content. MPEG-2 codecs require much greater processing power than MPEG-1 codecs and will realistically require some degree of hardware acceleration outside the host CPU for the next 18 to 24 months.

Audio compression technologies will rise in use as audio chip vendors continue to add value to the digital controllers for audio subsystems. One application that will drive a need for audio compression in the corporate computing environment is videoconferencing. Other applications of audio compression are tied to consumer and entertainment applications. MPEG audio and AC-3 will be tied to use of MPEG digital video and are expected to grow as use of those video compression technologies grows.

Audio and video compression technologies will see greater use in PCs because all of the pieces of the puzzle are in place. Fast CPUs, quality software codecs, inexpensive hardware codecs, and high-speed, high-density, inexpensive mass storage all create an environment where the PC users' expectation of quality can be reasonably achieved. TV-quality (or better) digital video is becoming affordable because of these compression technologies, and that will drive greater usage for business and consumer applications.

It is important to note that a significant portion of the compression opportunity in PCs will be created by the use of media engines in PCs rather than discrete decoders and codecs. In this case, compression processing will be performed by a media processor besides the main CPU. However, the compression function will be a subset of a larger video processing chip and accomplished through a combination of hardware and software processing. In these applications, the value of the compression silicon is discounted from the forecast cost of discrete decoder and codec solutions.

The Compression Semiconductor Opportunity

Tables 3-1, 3-2, and 3-3 present the forecast of systems shipping that include some form of hardware compression content. Because the possible chip implementations of compression can range from multichip solutions through single-chip products to embedded functions in larger processors and ASSPs, the unit shipments in these tables are not intended to represent actual chip shipment numbers. It is important to understand that these tables present system shipments and not chip shipments. Also, Tables 3-4 and 3-5 present separate shipment numbers for systems with video and audio compression, respectively. Because most systems include both audio and video compression, the total compression shipments are not additive, as can be seen in the summary shown in Table 3-1. It should be noted that increased use of MPEG-2 and AC-3 decoding software in PCs could result in decreased sales of systems with hardware video and audio compression content. This phenomenon could result in shipments falling somewhat below the forecasts for systems with MPEG-2 and AC-3 decoders and codecs presented in the following tables.

The forecast of market value for compression semiconductor products is presented in Tables 3-4, 3-5, 3-6, and 3-7, as well as Figures 3-1 and 3-2. As explained in the previous paragraph, the silicon implementation of the compression function can take many forms. In valuing the compression market, these forecasts assign a value to the chips or portion of the chip actually implementing the decoding or codec function. If the compression function is part of a larger ASIC or ASSP, only the estimated value of the compression silicon is included in the market value, instead of the price of the complete chip. Tables 3-6 and 3-7 present separate market value numbers for video and audio compression, respectively. In this case, the total value of the separate audio and video compression markets is additive, as shown in the summary in Table 3-2. The value of silicon employed in compression applications is forecast to grow from $327 million in 1995 to over $1.9 billion by the year 2000. The combined market for compression in DVD video players and DVD encode/decode boards for the PC will grow to represent over one-third of the silicon compression market, followed by digital set-top boxes, with slightly less than one-third of the market.

Table 3-1
Worldwide Compression Semiconductor Function Shipment Summary by Standard (Thousands of Units)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Decoders	85	2,518	9,075	21,758	34,507	51,831	69,388	86,426	57.0
MPEG-1 Decoder	77	1,625	6,170	14,342	20,234	27,452	32,759	38,081	43.9
MPEG-2/AC-3/Other Decoder	9	524	1,825	6,416	13,273	23,879	36,630	48,345	92.6
DigiCipher	0	370	1,080	1,000	1,000	500	0	0	-100.0
Codecs	181	317	690	1,681	3,362	9,459	17,654	29,760	112.3
JPEG, Motion JPEG Codec	31	69	180	484	973	1,989	2,842	3,599	82.1
MPEG-1 Codec	31	126	206	252	740	2,958	6,441	10,794	120.7
MPEG-2/AC-3/Other Codec	0	0	0	1	3	1,094	4,103	9,454	798.4
Indeo Codec	8	18	26	18	0	0	0	0	-100.0
H.261/H.263 Codec	6	58	100	206	382	688	1,240	2,269	86.9
Other Codecs	105	47	178	722	1,264	2,729	3,028	3,644	82.9
Total Decoders and Codecs	266	2,835	9,764	23,439	37,869	61,290	87,042	116,186	64.1

NA = Not applicable
Source: Dataquest (November 1996)

Table 3-2
Worldwide Video Compression Semiconductor Function Shipments by Standard (Thousands of Units)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
JPEG (Codec)	-	6	51	297	663	1,454	1,994	2,392	116.1
Digital Still Camera	-	6	51	297	663	1,454	1,994	2,392	116.1
Motion JPEG (Codec)	31	63	129	187	310	536	848	1,207	56.4
PC/Workstation	-	-	8	11	15	19	24	27	29.2
PC/Workstation Add-In Card Aftermarket	31	63	121	176	295	516	825	1,179	57.6
MPEG-1 (Decoder)	69	748	3,601	10,594	15,749	22,467	27,596	33,452	56.2
PC	-	-	250	350	1,700	5,567	8,556	13,669	122.5
PC Add-In Card Aftermarket	31	63	770	844	550	700	1,040	1,284	10.8
Video CD Player	38	685	2,580	9,400	13,500	16,200	18,000	18,500	48.3
MPEG-1 (Codec)	31	126	206	252	740	2,958	6,409	10,773	120.6
PC	-	-	-	-	410	2,505	5,704	9,568	NA
PC Add-In Card Aftermarket	31	126	206	252	330	452	705	1,205	42.4
MPEG-2 (Decoder)	9	524	1,825	6,416	13,273	23,879	36,630	48,345	92.6
Digital Cable Set-Top Box	8	20	63	437	1,500	3,199	5,803	8,324	165.3
Digital Satellite Set-Top Box	1	504	1,761	5,579	8,655	12,403	15,295	20,255	63.0
DVD Decode/Encode for PC	-	-	-	40	1,623	4,603	9,629	12,787	NA
DVD Video Player	-	-	-	360	1,495	3,631	5,797	6,769	NA
HDTV-ADTV-SDTV	-	-	-	-	-	43	106	210	NA

(Continued)

Table 3-2 (Continued)
Worldwide Video Compression Semiconductor Function Shipments by Standard (Thousands of Units)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
MPEG-2 (Decoder)	9	524	1,825	6,416	13,273	23,879	36,630	48,345	92.6
Digital Cable Set-Top Box	8	20	63	437	1,500	3,199	5,803	8,324	165.3
Digital Satellite Set-Top Box	1	504	1,761	5,579	8,655	12,403	15,295	20,255	63.0
DVD Decode/Encode for PC	-	-	-	40	1,623	4,603	9,629	12,787	NA
DVD Video Player	-	-	-	360	1,495	3,631	5,797	6,769	NA
HDTV-ADTV-SDTV	-	-	-	-	-	43	106	210	NA
MPEG-2 (Codec)	-	-	0	1	3	1,094	4,103	9,454	798.4
Digital Cable Set-Top Box	-	-	-	-	-	-	645	2,081	NA
DVD Decode/Encode for PC	-	-	-	-	-	758	1,480	3,824	NA
DVD Video Player	-	-	-	-	-	325	1,957	3,514	NA
Broadcasting/Head-End	-	-	0	1	3	11	21	36	194.2
Indeo (Codec)	8	18	26	18	-	-	-	-	-100.0
Videoconferencing (PC-Based)	8	18	26	18	-	-	-	-	-100.0
H.261/H.263 (Codec)	6	58	100	206	382	688	1,240	2,269	86.9
Videoconferencing (PC-Based)	6	7	14	47	113	238	477	957	131.5
Videoconferencing (Rollabout)	-	1	15	26	30	31	30	29	13.8
Videoconferencing (Telephone)	-	50	70	133	239	419	733	1,283	78.9
DigiCipher (Decoder)	-	370	1,080	1,000	1,000	500	-	-	-100.0
Digital Satellite Set-Top Box	-	370	1,080	1,000	1,000	500	-	-	-100.0
Others (Codec)	105	47	178	722	1,264	2,729	3,028	3,644	82.9
Digital Still Camera	-	18	152	693	1,232	2,700	2,991	3,589	88.1
Videoconferencing (PC-Based)	14	11	7	7	13	13	25	50	47.5
Videoconferencing (Rollabout)	8	13	15	16	12	6	3	1	-37.5
Videoconferencing (Telephone)	83	6	-	-	-	-	-	-	NA
Broadcasting/Head-End	-	-	3	6	8	11	9	4	5.2
Total	258	1,958	7,195	19,692	33,385	56,305	81,846	111,536	73.0
PC	-	-	258	361	2,124	8,092	14,283	23,264	146.0
PC Add-In Card Aftermarket	93	251	1,098	1,272	1,175	1,669	2,570	3,668	27.3
Digital Cable Set-Top Box	8	20	63	437	1,500	3,199	6,447	10,405	177.5
Digital Satellite Set-Top Box	1	874	2,841	6,579	9,655	12,903	15,295	20,255	48.1
DVD Decode/Encode for PC	-	-	-	40	1,623	5,361	11,108	16,611	NA
DVD Video Player	-	-	-	360	1,495	3,956	7,755	10,282	NA
Video CD Player	38	685	2,580	9,400	13,500	16,200	18,000	18,500	48.3
HDTV-ADTV-SDTV	-	-	-	-	-	43	106	210	NA
Digital Still Camera	-	24	203	990	1,895	4,154	4,984	5,981	96.7
Videoconferencing (PC-Based)	28	35	48	72	125	251	502	1,007	83.8
Videoconferencing (Rollabout)	8	14	30	42	42	37	33	30	0
Videoconferencing (Telephone)	83	55	70	133	239	419	733	1,283	78.9
Broadcasting/Head-End	-	-	3	6	12	21	30	40	65.0

NA = Not applicable
Source: Dataquest (November 1996)

Table 3-3
Worldwide Audio Compression Semiconductor Function Shipments by Standard (Thousands of Units)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
MPEG-1 (Decoder)	77	1,625	6,170	14,342	20,234	27,452	32,759	38,081	43.9
PC	-	-	250	350	1,700	5,567	8,556	13,669	122.5
PC Add-In Card Aftermarket	31	63	770	844	550	700	1,040	1,284	10.8
Digital Cable Set-Top Box	8	20	63	135	257	437	808	780	65.3
Digital Satellite Set-Top Box	-	857	2,507	3,613	4,228	4,548	4,355	3,848	9.0
Video CD Player	38	685	2,580	9,400	13,500	16,200	18,000	18,500	48.3
MPEG-1 (Codec)	31	126	206	252	740	2,958	6,441	10,794	120.7
PC	-	-	-	-	410	2,505	5,704	9,568	NA
PC Add-In Card Aftermarket	31	126	206	252	330	452	705	1,205	42.4
Digital Cable Set-Top Box	-	-	-	-	-	-	32	21	NA
MPEG-2 (Decoder)	1	17	334	2,966	5,399	7,551	9,132	12,197	105.3
Digital Satellite Set-Top Box	1	17	334	2,966	5,399	7,529	9,079	12,092	105.0
HDTV-ADTV-SDTV	-	-	-	-	-	21	53	105	NA
AC-3 (Decoder)	-	-	-	-	28	847	1,915	4,413	NA
Digital Satellite Set-Top Box	-	-	-	-	28	826	1,862	4,308	NA
HDTV-ADTV-SDTV	-	-	-	-	-	21	53	105	NA
AC-3/MPEG-2/Others (Decoder)	-	-	-	702	4,361	10,996	20,420	27,099	NA
Digital Cable Set-Top Box	-	-	-	303	1,243	2,762	4,994	7,544	NA
DVD Decode/Encode for PC	-	-	-	40	1,623	4,603	9,629	12,787	NA
DVD Video Player	-	-	-	360	1,495	3,631	5,797	6,769	NA
AC-3/MPEG-2/Others (Codec)	-	-	-	-	-	1,083	4,049	9,397	NA
Digital Cable Set-Top Box	-	-	-	-	-	-	612	2,060	NA
DVD Decode/Encode for PC	-	-	-	-	-	758	1,480	3,824	NA
DVD Video Player	-	-	-	-	-	325	1,957	3,514	NA
Others (Codec)	-	-	-	20	38	83	100	120	NA
Digital Still Camera	-	-	-	20	38	83	100	120	NA
Total	108	1,767	6,711	18,282	30,800	50,970	74,816	102,102	72.4
PC	-	-	250	350	2,110	8,073	14,260	23,237	147.5
PC Add-In Card Aftermarket	62	189	976	1,096	880	1,152	1,745	2,489	20.6
Digital Cable Set-Top Box	8	20	63	437	1,500	3,199	6,447	10,405	177.5
Digital Satellite Set-Top Box	1	874	2,841	6,579	9,655	12,903	15,295	20,249	48.1

(Continued)

Table 3-3 (Continued)
Worldwide Audio Compression Semiconductor Function Shipments by Standard
(Thousands of Units)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
DVD Decode/Encode for PC	-	-	-	40	1,623	5,361	11,108	16,611	NA
DVD Video Player	-	-	-	360	1,495	3,956	7,755	10,282	NA
Video CD Player	38	685	2,580	9,400	13,500	16,200	18,000	18,500	48.3
HDTV-ADTV-SDTV	-	-	-	-	-	43	106	210	NA
Digital Still Camera	-	-	-	20	38	83	100	120	NA

NA = Not applicable
Source: Dataquest (November 1996)

Table 3-4
Worldwide Compression Semiconductor Market Summary by Standard
(Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Decoders	4	69	218	482	681	898	1,069	1,126	38.9
MPEG-1 Decoder	3	39	127	249	262	296	287	276	16.8
MPEG-2/AC-3/Other Decoder	0	18	55	204	395	594	782	850	72.9
DigiCipher Decoder	0	12	36	30	24	9	0	0	-100.0
Codecs	56	65	109	145	191	315	515	806	49.1
JPEG and Motion JPEG Codec	3	5	9	14	20	31	37	39	35.4
MPEG-1 Codec	39	44	59	64	85	89	100	113	14.1
MPEG-2/AC-3/Other Codecs	0	0	1	2	6	79	244	474	267.0
Indeo Codec	1	2	3	2	0	0	0	0	-100.0
H.261/H.263 Codec	1	5	13	24	33	48	71	111	53.9
Other Codecs	12	9	26	39	46	67	63	69	21.9
Total Decoders and Codecs	59	133	327	627	872	1,213	1,584	1,932	42.6

Source: Dataquest (November 1996)

Table 3-5
Worldwide Compression Semiconductor Market Summary by System (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Total	59	133	327	627	872	1,213	1,584	1,932	42.6
PC	0	0	8	8	69	123	139	168	84.6
PC Add-In Card Aftermarket	43	51	88	91	57	36	38	43	-13.4
Digital Cable Set-Top Box	0	1	2	17	52	88	165	248	155.3
Digital Satellite Set-Top Box	0	38	109	228	282	306	310	354	26.5
DVD Decode/Encode for PC	0	0	0	2	58	177	307	418	NA
DVD Video Player	0	0	0	14	53	122	245	293	NA
Video CD Player	2	27	76	197	208	220	211	189	19.9
HDTV-ADTV-SDTV	0	0	0	0	0	1	3	4	NA
Digital Still Camera	0	1	5	21	34	66	67	73	72.8
Videoconferencing (PC-Based)	4	4	6	7	10	18	33	63	61.8
Videoconferencing (Rollabout)	6	8	14	18	16	13	11	9	-9.1
Videoconferencing (Telephone)	4	3	4	8	13	21	32	47	61.2
Broadcasting/Head-End	0	0	14	17	19	22	23	25	11.9

NA = Not applicable
Source: Dataquest (November 1996)

Table 3-6
Worldwide Video Compression Semiconductor Market by Standard (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
JPEG (Codec)	-	0	1	4	8	14	15	15	74.0
Digital Still Camera	-	0	1	4	8	14	15	15	74.0
Motion JPEG (codec)	3	5	8	9	12	17	22	25	26.2
PC/Workstation	-	-	0	1	1	1	1	1	4.3
PC/Workstation Add-In Card Aftermarket	3	5	7	9	12	17	21	24	27.1
MPEG-1 (Decoder)	2	22	77	148	148	182	182	186	19.3
PC	-	-	5	5	14	33	34	48	55.1
PC Add-In Card Aftermarket	1	2	16	12	4	4	4	4	-22.8
Video CD Player	1	20	55	132	130	144	144	133	19.4
MPEG-1 (Codec)	37	38	52	57	74	74	77	86	10.8
PC	-	-	-	-	41	63	68	77	NA
PC Add-In Card Aftermarket	37	38	52	57	33	11	8	10	-28.5

(Continued)

Table 3-6 (Continued)
Worldwide Video Compression Semiconductor Market by Standard
(Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
MPEG-2 (Decoder)	0	18	49	147	251	359	451	474	57.5
Digital Cable Set-Top Box	0	1	2	10	29	49	71	82	115.2
Digital Satellite Set-Top Box	0	17	47	128	166	190	188	198	33.3
DVD Decode/Encode for PC	-	-	-	1	29	67	118	125	NA
DVD Video Player	-	-	-	7	27	53	71	66	NA
HDTV-ADTV-SDTV	-	-	-	-	-	1	1	2	NA
MPEG-2 (Codec)	-	-	1	2	6	56	170	327	240.6
Digital Cable Set-Top Box	-	-	-	-	-	-	24	67	NA
DVD Decode/Encode for PC	-	-	-	-	-	31	56	124	NA
DVD Video Player	-	-	-	-	-	13	74	113	NA
Broadcasting/Head-End	-	-	1	2	6	11	16	22	99.4
Indeo (Codec)	1	2	3	2	-	-	-	-	-100.0
Videoconferencing (PC-Based)	1	2	3	2	-	-	-	-	-100.0
H.261/H.263 (Codec)	1	5	13	24	33	48	71	111	53.9
Videoconferencing (PC-Based)	1	1	1	4	8	16	30	55	107.6
Videoconferencing (Rollabout)	-	1	7	11	12	11	10	8	3.3
Videoconferencing (Telephone)	-	3	4	8	13	21	32	47	61.2
DigiCipher (Decoder)	-	12	36	30	24	9	-	-	-100.0
Digital Satellite Set-Top Box	-	12	36	30	24	9	-	-	-100.0
Others	-	-	-	-	-	-	-	-	NA
Others (Codec)	12	9	26	39	46	67	63	68	21.6
Digital Still Camera	-	1	4	16	26	51	51	57	72.0
Videoconferencing (PC-Based)	2	2	1	1	2	2	4	8	47.5
Videoconferencing (Rollabout)	6	7	7	7	5	2	1	0	-43.2
Videoconferencing (Telephone)	4	0	-	-	-	-	-	-	NA
Broadcasting/Head-End	-	-	14	15	13	11	7	2	-28.7
Total	56	110	264	462	601	825	1,051	1,290	37.4
PC	-	-	6	5	55	97	103	125	84.9
PC Add-In Card Aftermarket	41	44	75	77	49	32	34	38	-12.6
Digital Cable Set-Top Box	0	1	2	10	29	49	96	149	142.7
Digital Satellite Set-Top Box	0	29	83	158	190	199	188	198	19.1
DVD Decode/Encode for PC	-	-	-	1	29	98	174	249	NA
DVD Video Player	-	-	-	7	27	66	145	180	NA
Video CD Player	1	20	55	132	130	144	144	133	19.4

(Continued)

Table 3-6 (Continued)
Worldwide Video Compression Semiconductor Market by Standard
(Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
HDTV-ADTV-SDTV	-	-	-	-	-	1	1	2	NA
Digital Still Camera	-	1	5	20	34	65	66	72	72.4
Videoconferencing (PC-Based)	4	4	6	7	10	18	33	63	61.8
Videoconferencing (Rollabout)	6	8	14	18	16	13	11	9	-9.1
Videoconferencing (Telephone)	4	3	4	8	13	21	32	47	61.2
Broadcasting/Head-End	-	-	14	17	19	22	23	25	11.9

NA = Not applicable
Source: Dataquest (November 1996)

Table 3-7
Worldwide Audio Compression Semiconductor Market by Standard
(Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
MPEG-1 (Decoder)	1	17	50	100	115	114	105	90	12.4
PC	-	-	2	2	7	13	16	19	56.4
PC Add-In Card Aftermarket	0	1	6	6	2	2	2	2	-22.2
Digital Cable Set-Top Box	0	0	1	1	1	2	3	2	35.3
Digital Satellite Set-Top Box	-	9	20	25	25	21	16	12	-10.8
Video CD Player	0	7	21	66	79	76	67	56	21.4
MPEG-1 (Codec)	2	6	7	8	11	15	23	27	31.0
PC	-	-	-	-	6	13	20	24	NA
PC Add-In Card Aftermarket	2	6	7	8	5	2	2	3	-15.5
Digital Cable Set-Top Box	-	-	-	-	-	-	0	0	NA
MPEG-2 (Decoder)	0	0	6	44	67	76	87	110	78.7
Digital Satellite Set-Top Box	0	0	6	44	67	75	86	109	78.4
HDTV-ADTV-SDTV	-	-	-	-	-	0	1	1	NA
AC-3 (Decoder)	-	-	-	-	0	11	20	36	NA
Digital Satellite Set-Top Box	-	-	-	-	0	11	19	35	NA
HDTV-ADTV-SDTV	-	-	-	-	-	0	1	1	NA
AC-3/MPEG-2/Others (Decoder)	-	-	-	13	76	148	225	230	NA
Digital Cable Set-Top Box	-	-	-	5	22	37	55	64	NA
DVD Decode/Encode for PC	-	-	-	1	28	62	106	109	NA
DVD Video Player	-	-	-	6	26	49	64	58	NA

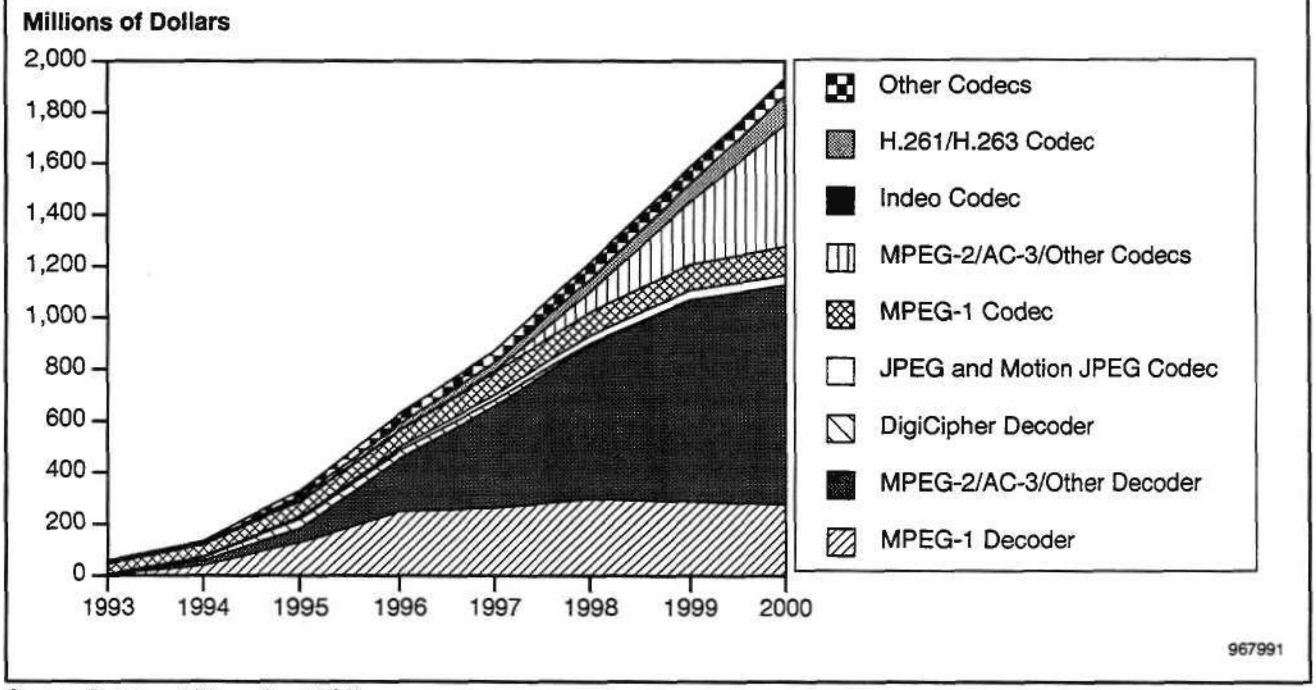
(Continued)

Table 3-7 (Continued)
Worldwide Audio Compression Semiconductor Market by Standard
(Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
AC-3/MPEG-2/Others (Codec)	-	-	-	-	-	24	74	148	NA
Digital Cable Set-Top Box	-	-	-	-	-	-	11	32	NA
DVD Decode/Encode for PC	-	-	-	-	-	16	27	60	NA
DVD Video Player	-	-	-	-	-	7	36	55	NA
Others (Codec)	-	-	-	0	0	1	1	1	NA
Digital Still Camera	-	-	-	0	0	1	1	1	NA
Total	3	23	63	165	271	388	533	642	58.9
PC	-	-	2	2	14	26	36	43	83.9
PC Add-In Card Aftermarket	2	7	13	13	7	4	4	5	-18.4
Digital Cable Set-Top Box	0	0	1	6	23	39	69	99	186.0
Digital Satellite Set-Top Box	0	9	26	70	93	107	121	156	42.5
DVD Decode/ Encode for PC	-	-	-	1	28	79	133	169	NA
DVD Video Player	-	-	-	6	26	56	100	113	NA
Video CD Player	0	7	21	66	79	76	67	56	21.4
HDTV-ADTV-SDTV	-	-	-	-	-	1	1	2	NA
Digital Still Camera	-	-	-	0	0	1	1	1	NA

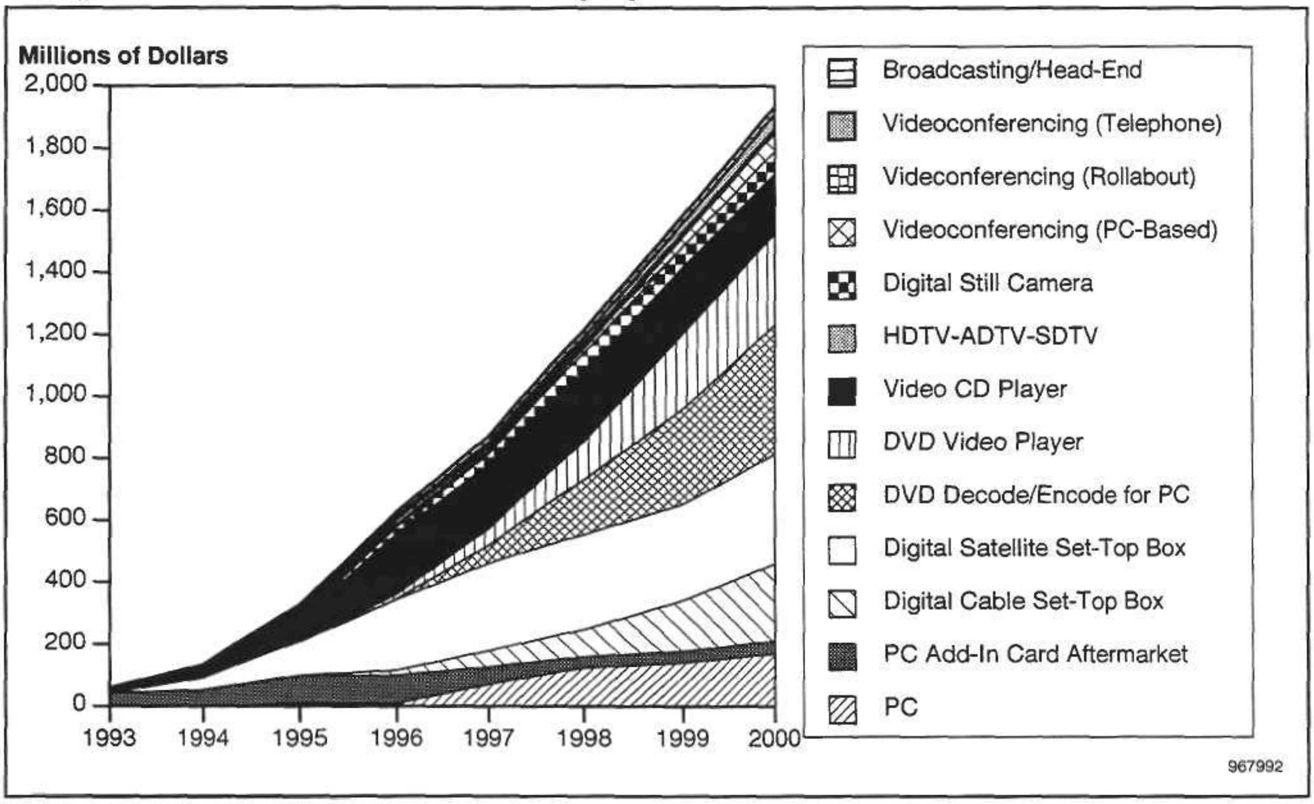
NA = Not applicable
Source: Dataquest (November 1996)

Figure 3-1
Compression Semiconductor Market by Standard



Source: Dataquest (November 1996)

Figure 3-2
Compression Semiconductor Market by System

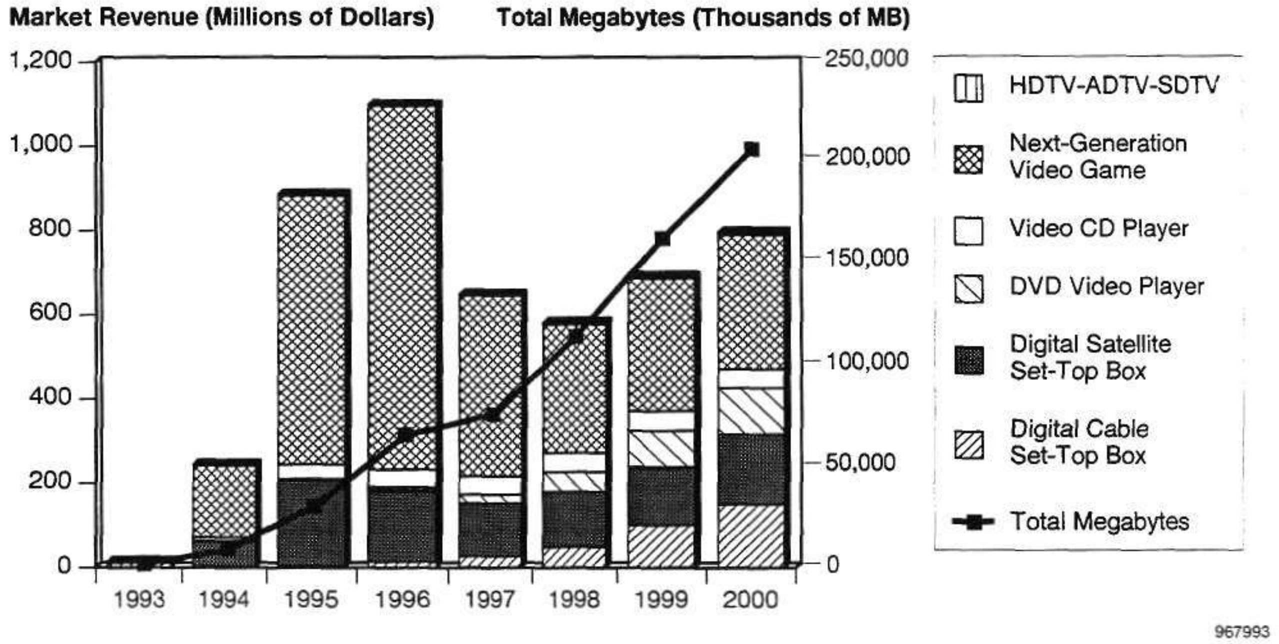


Source: Dataquest (November 1996)

Chapter 4
DRAM Drops into Digital Consumer Electronics

The new generation of digital consumer electronics presents a significant demand for DRAM over the next five years. However, the forecast decline in DRAM prices and the inelasticity of DRAM demand in these products will combine to keep DRAM revenue declining over the forecast period, as shown in Figure 4-1 and Table 4-1.

Figure 4-1
Worldwide DRAM Memory Market in Next-Generation Consumer Electronics



Source: Dataquest (November 1996)

Table 4-1
Worldwide DRAM Memory Market in Next-Generation Consumer Electronics

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Average Megabytes per System									
Digital Cable Set-Top Box	12.0	6.0	4.0	4.0	3.5	3.5	4.0	4.0	0
Digital Satellite Set-Top Box	3.0	3.0	3.0	3.0	2.4	2.3	2.3	2.3	-5.6
DVD Video Player	-	-	-	2.5	2.5	2.7	2.9	3.0	NA
Video CD Player	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0
Next-Generation Video Game	3.0	3.0	3.7	3.4	2.8	3.2	3.5	3.7	0
HDTV-ADTV-SDTV	-	-	-	-	-	2.3	2.3	2.3	NA
Total Megabytes (K)	417	7,794	29,038	63,967	74,089	112,430	160,935	204,850	47.8
Digital Cable Set-Top Box	96	121	253	1,749	5,250	11,197	25,789	41,620	177.5
Digital Satellite Set-Top Box	2	2,621	8,522	19,737	23,172	29,032	34,414	45,574	39.8
DVD Video Player	-	-	-	900	3,738	10,524	22,256	30,847	NA
Video CD Player	19	343	1,290	4,700	6,750	8,100	9,000	9,250	48.3
Next-Generation Video Game	300	4,710	18,972	36,880	35,179	52,615	68,284	75,984	32.0
HDTV-ADTV-SDTV	-	-	-	-	-	963	1,193	1,575	NA
Total Market Revenue ($M)	13	241	885	1,097	646	583	690	796	-2.1
Digital Cable Set-Top Box	2	3	6	15	28	50	102	151	90.0
Digital Satellite Set-Top Box	0	62	205	168	125	130	136	165	-4.2
DVD Video Player	-	-	-	8	21	47	87	111	NA
Video CD Player	0	9	34	42	43	45	47	44	5.3
Next-Generation Video Game	11	168	639	864	429	305	314	319	-13.0
HDTV-ADTV-SDTV	-	-	-	-	-	4	5	6	NA

NA = Not applicable
Source: Dataquest (November 1996)

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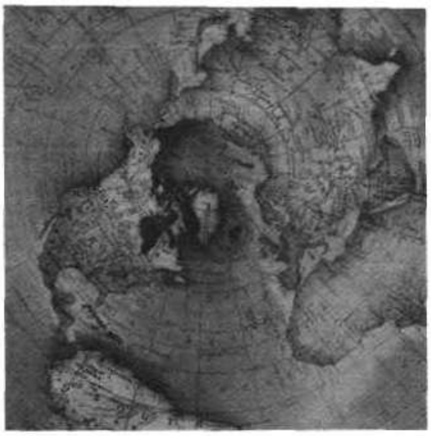

Dataquest

Consumer Electronics Semiconductor Application Markets

Market Trends

Program: Consumer Multimedia Semiconductor and Applications Worldwide
Product Code: MSAM-WW-MT-9602
Publication Date: October 14, 1996
Filing: Market Trends

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Chapter 1
Introduction

This document is the fifth in a series of six that provide reference information and analysis about the principal system application markets for semiconductors. The six areas are data processing, wireline communications, wireless communications, consumer electronics, automotive electronics, and a combined document on industrial and military and civil aerospace electronics. Each document brings forth basic information about the opportunity offered by particular systems:

- System market size (in production terms) in revenue, units, and average selling price
- System market and product feature trends
- Hardware architecture trends and semiconductor device opportunities
- Semiconductor content and market forecast
- A listing of key OEMs

The information in this report is gathered from both primary and secondary sources. Primary sources include surveys and interviews of industry vendors and customers, as well as analyst knowledge and opinion. Some of the primary sources include Dataquest's own services. Secondary sources include various governmental and trade sources on sales, production, trade, and public spending. Semiconductor content assumptions are based on both surveys of producing OEMs and physical teardown evaluations by Dataquest analysts of representative systems.

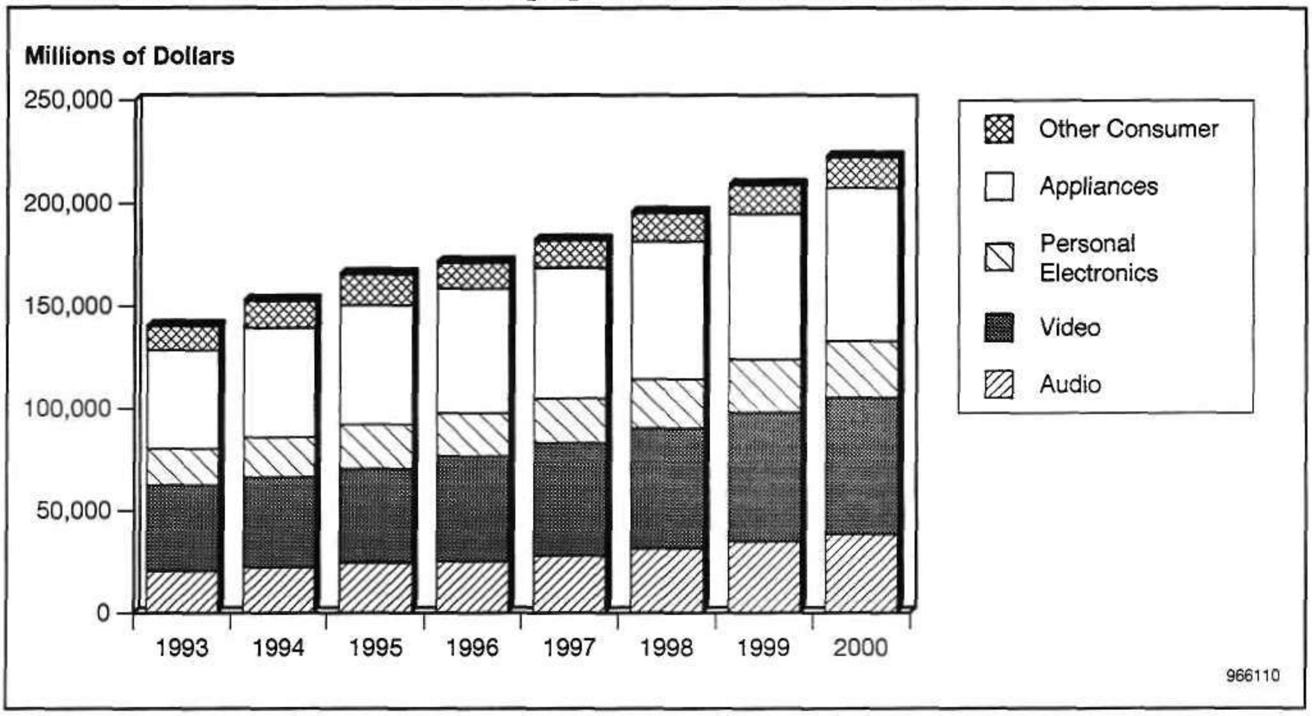
The forecast methodology is based on various methods and assumptions, depending on the area. To form a solid basis for projecting system demand, capital, government, and consumer spending assumptions are made for various regions of the world. For specific markets, saturation and displacement dynamics are considered as well. Key exogenous factors such as new software introductions, exchange rate changes, and government policies also are considered. Semiconductor content forecasts are based on interviews of system marketers and designers (including makers of enabling semiconductor technology), along with an analysis of historical trends.

Project Analysts: Dale Ford, Jonathan Cassell, and Xavier Pucel

Chapter 2
Executive Summary

The consumer electronic equipment market represents a significant opportunity for semiconductor applications (see Figure 2-1 and Table 2-1 for Dataquest's forecast for consumer electronic equipment production). Although the worldwide market for consumer electronic equipment is projected to have a compound annual growth rate (CAGR) of 6.1 percent for the next five years, the semiconductor market for consumer electronic products will have a CAGR of more than 13 percent in this same time frame (see Figure 2-2). This difference is driven by the digitization of consumer products, from VCRs to dishwashers. New products being introduced—high-definition television (HDTV), digital VCRs, Video-CD and DVD Video players, MiniDisc (MD) players, digital cable/satellite set-top boxes, and interactive video games—are boosting the opportunities for semiconductor products.

Figure 2-1
Worldwide Consumer Electronic Equipment Production Revenue Forecast



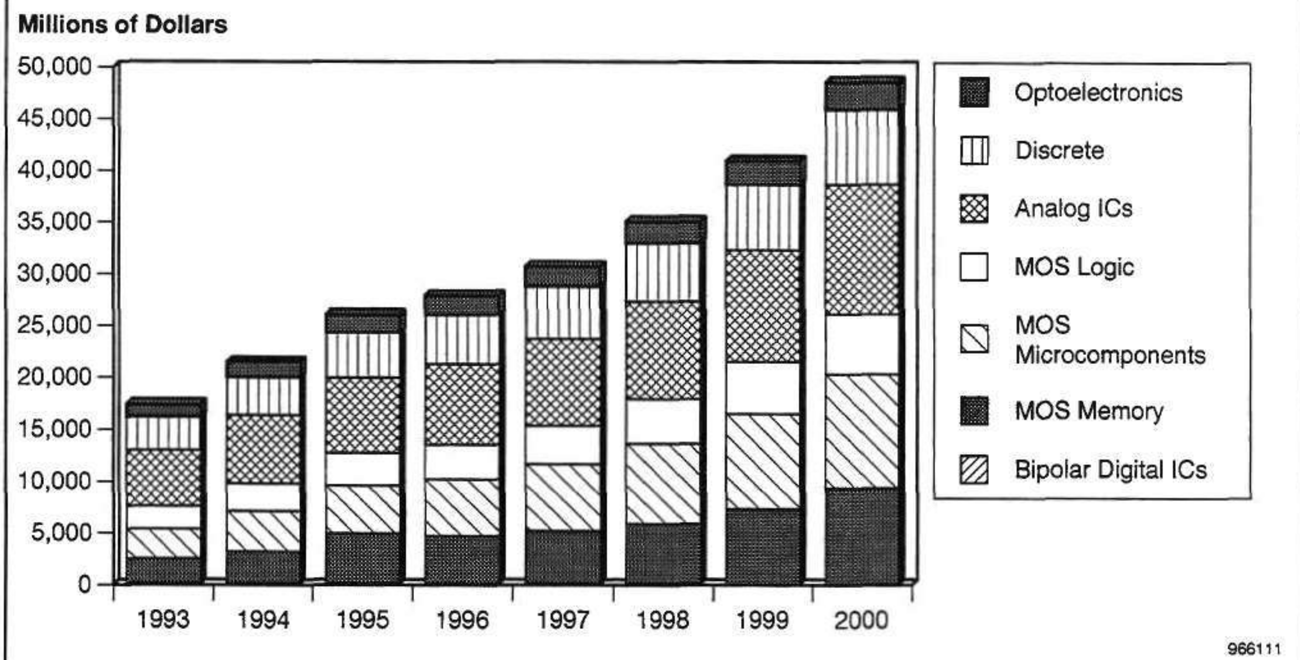
Source: Dataquest (September 1996)

Table 2-1
Worldwide Consumer Electronics Equipment Production Revenue Forecast (Millions of Dollars)

Segment	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Audio	20,588	22,616	24,711	25,461	28,290	31,470	35,025	38,668	9.4
Video	42,015	43,872	45,894	51,055	54,872	58,991	63,168	66,912	7.8
Personal Electronics	17,755	19,569	21,793	21,349	21,955	23,923	25,811	27,516	4.8
Appliance	48,218	53,443	58,104	60,628	63,661	67,269	70,829	74,578	5.1
Other Consumer	11,869	13,098	14,931	12,648	13,335	13,772	14,109	14,791	-0.2
Total	140,445	152,599	165,433	171,140	182,113	195,425	208,942	222,465	6.1

Source: Dataquest (September 1996)

Figure 2-2
Worldwide Semiconductor Consumption for Consumer Electronics Equipment Production, by Device



Source: Dataquest (September 1996)

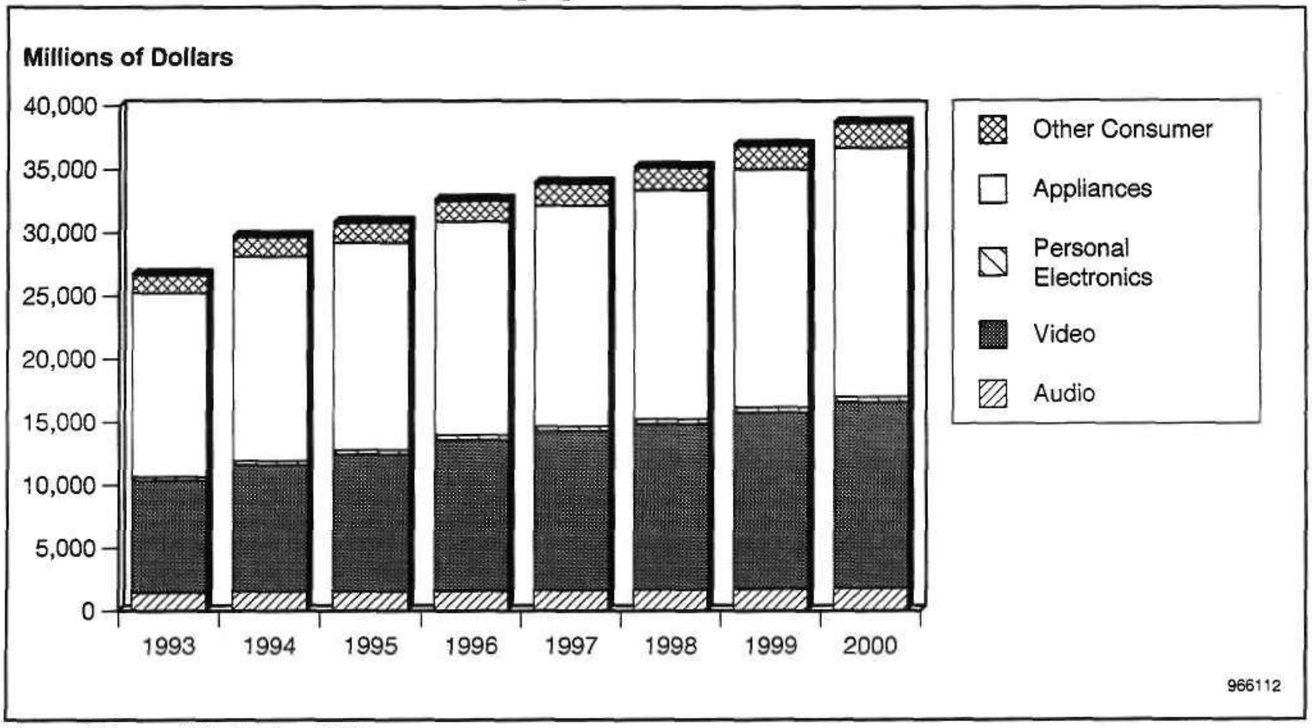
This worldwide trend is accentuated in the Americas production arena. Table 2-2 and Figure 2-3 show that consumer electronic equipment production in the Americas will grow at a 4.6 percent CAGR through the year 2000. However, semiconductor consumption for consumer equipment production will grow at a 20.1 percent CAGR at the same time (see Figure 2-4). The importance of the consumer electronics market is even greater in Japan and the Asia/Pacific region than in North America. Figure 2-5 shows that almost 70 percent of consumer electronics production takes place in these regions.

Table 2-2
Americas Consumer Electronics Equipment Production Revenue Forecast (Millions of Dollars)

Segment	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Audio	1,498	1,575	1,575	1,622	1,677	1,737	1,792	1,855	3.3
Video	8,919	10,054	10,923	12,054	12,653	13,175	14,015	14,788	6.2
Personal Electronics	270	306	325	340	358	375	390	403	4.4
Appliance	14,548	16,209	16,388	16,895	17,489	18,086	18,818	19,664	3.7
Other Consumer	1,429	1,527	1,583	1,640	1,705	1,775	1,847	1,923	4.0
Total	26,664	29,671	30,794	32,551	33,882	35,148	36,861	38,633	4.6

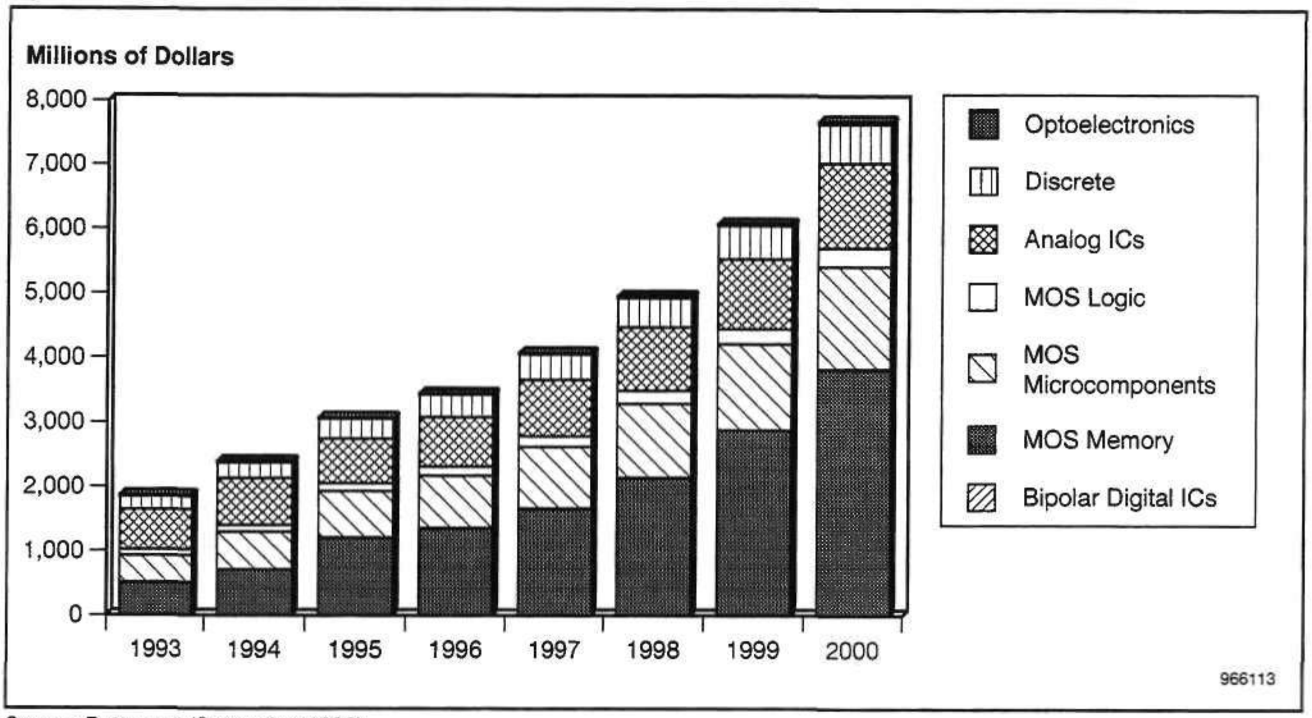
Source: Dataquest (September 1996)

Figure 2-3
Americas Consumer Electronics Equipment Production Revenue Forecast



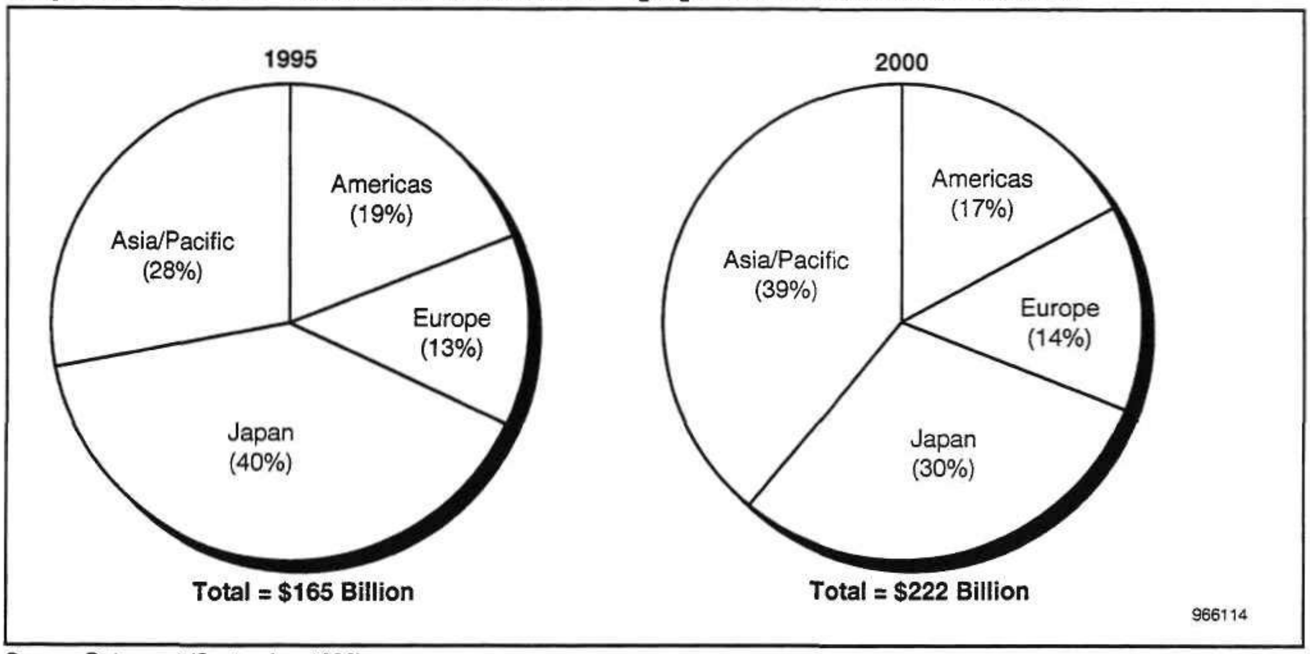
Source: Dataquest (September 1996)

Figure 2-4
Americas Semiconductor Consumption for Consumer Equipment Production, by Device



Source: Dataquest (September 1996)

Figure 2-5
Regional Share of Consumer Electronics Equipment Production Revenue

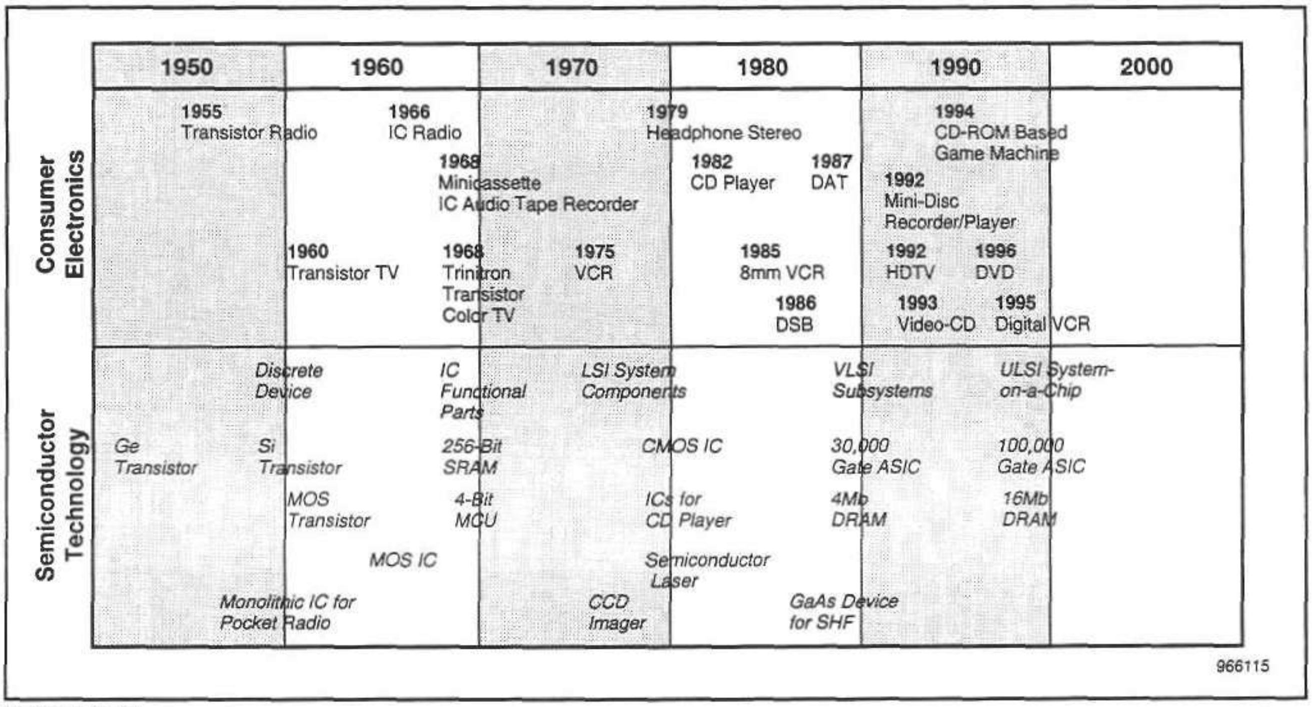


Source: Dataquest (September 1996)

Figure 2-6 shows the relationship between the development of semiconductor technologies and products and the evolution of consumer electronics products. Semiconductors play a fundamental enabling role in the development of next-generation consumer electronics markets. Figure 2-7 provides an overview of the penetration of major consumer electronics products into U.S. homes. Although some products, such as televisions, have reached near-saturation, other products still have room for significant expansion. The market for high-penetration products such as TVs is mainly found in replacements and upgrades. New technology developments targeted at existing products will drive an increase in upgrades of these products.

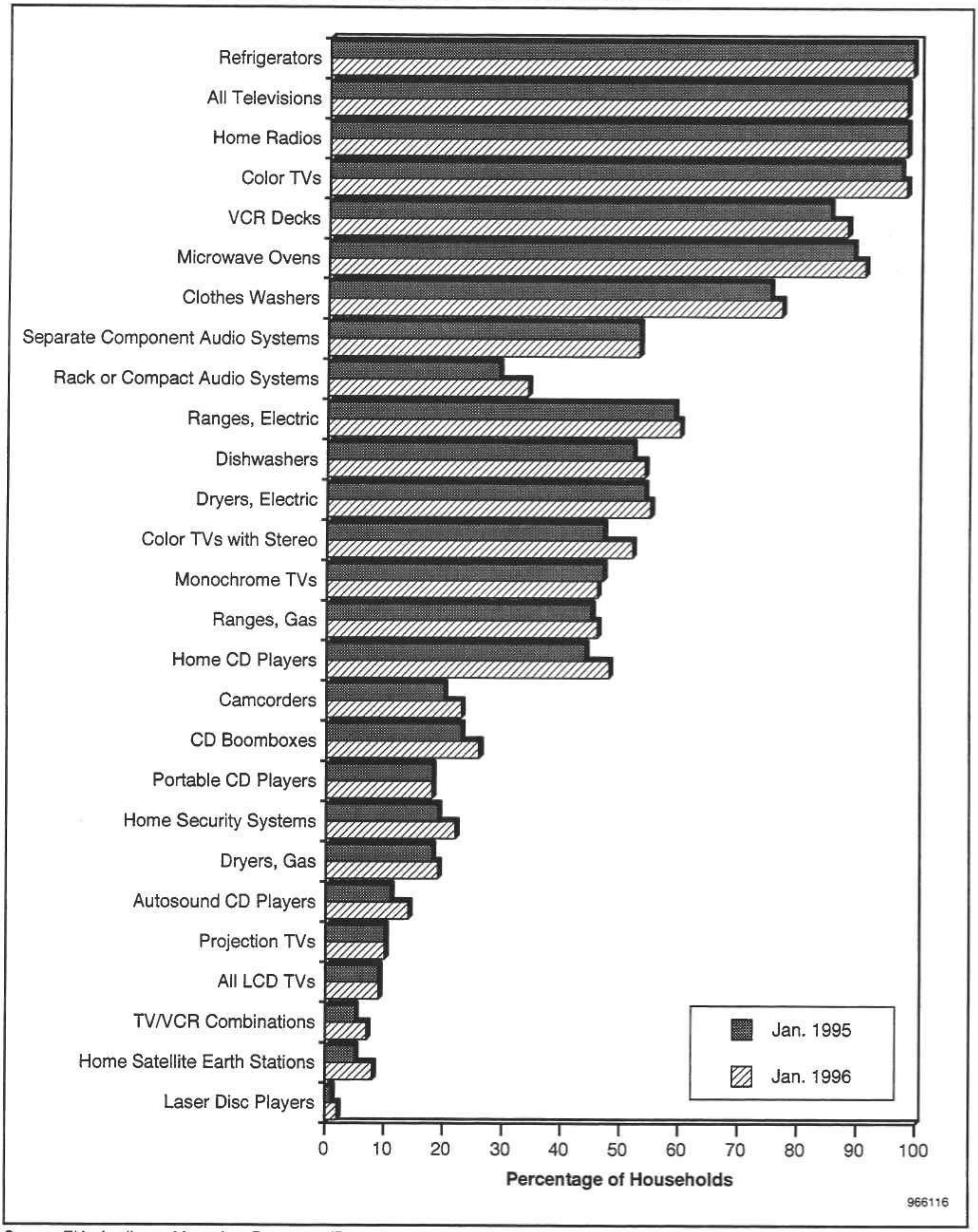
Several new, exciting products will take the stage in consumer electronics markets during the next five years. This report provides information on many of these new products.

Figure 2-6
Semiconductor and Consumer Electronics Milestones



Source: Sony

Figure 2-7
U.S. Household Penetration of Consumer Electronics Products



Source: EIA, Appliance Magazine, Dataquest (December 1995)

Chapter 3
Audio Equipment

Worldwide audio equipment production is expected to grow at a healthy 9.4 percent CAGR through 2000. Audio system sales in the United States, in particular, will help drive this growth. Portable products and digital technology continue to have the most significant impact on the audio electronics market. Decreases in memory prices and an explosion of innovative features are resulting in growing replacement sales and growing demand for step-up products. Examples of this are the multiple disc changer-equipped compact disc (CD) systems that are replacing single-CD systems, reintroduction of the MiniDisc (MD), and the future entry of DVD-Audio players. Coupled with new or improved digital products, adoption of new technologies (such as Dolby Surround AC-3 and Home THX) is opening new avenues for semiconductor applications (see further discussion of emerging opportunities in Chapter 7). Although Dolby Pro Logic technology is becoming prevalent in deluxe audio/video (A/V) receivers and rack systems, only 5 percent of the minisystems feature this technology. While some manufacturers (such as Aiwa) are taking advantage of this untapped market, all audio system vendors are offering AC-3 compatible systems in view of exploding demand.

As digital formats become more widely available, performance differences between products will fade. Manufacturers will strive to differentiate their products in terms of added features and ease of use. Adoption of universal bus interfaces such as Universal Serial Bus and IEEE 1394 will ensure plug-and-play capability between consumer electronics equipment (including audio) and multimedia computer applications (see further discussion in Chapter 7).

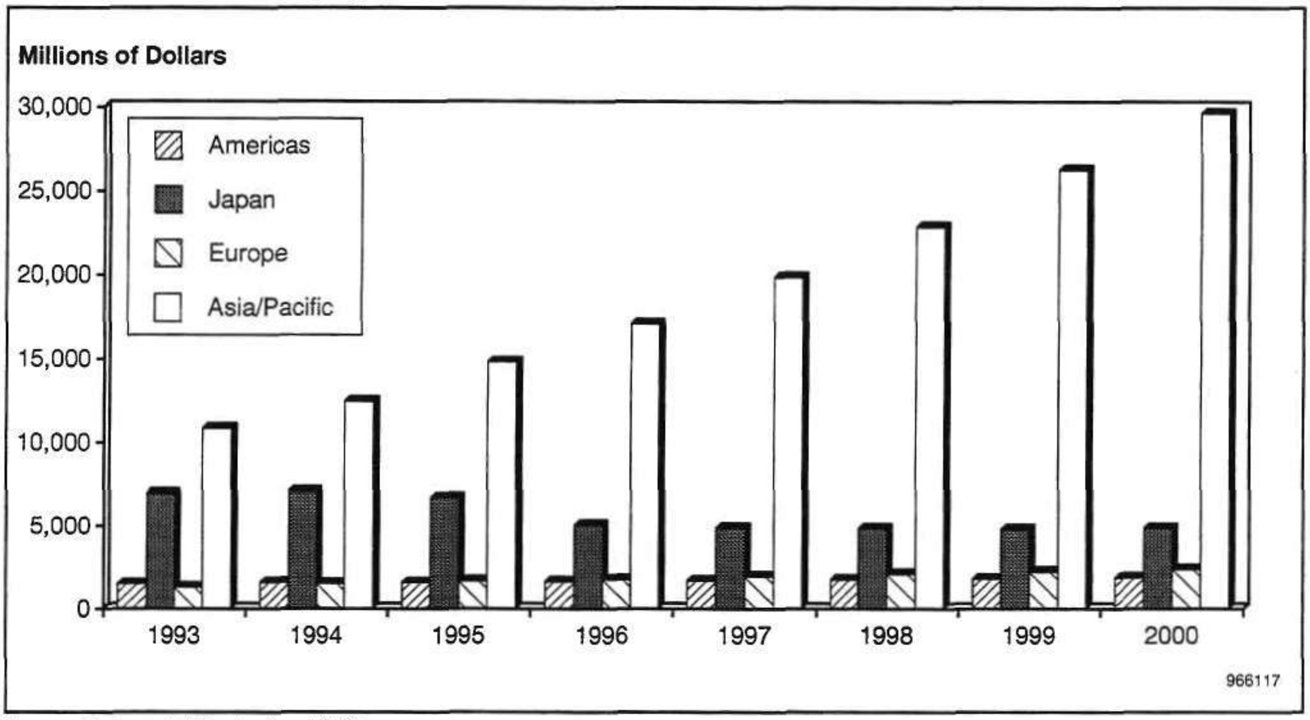
Figures 3-1 and 3-2 illustrate the commanding role that the Asia/Pacific region will play in audio products, with more than 76 percent of production taking place there by 2000. Table 3-1 shows Americas production of audio products. Major audio electronics manufacturers with U.S. facilities include Emerson Radio Corporation, Pioneer Electronic Corporation, Sanyo, Tandy Corporation, and Toshiba Corporation. As the various brand share tables in this chapter show, Sony Corporation plays a commanding role in every segment of the audio electronics equipment market.

This chapter will present a worldwide production forecast for personal portable stereos and a discussion on various major products. Brand share information is also presented for other major audio products.

Personal/Portable Stereos (Boom Boxes and Headsets)

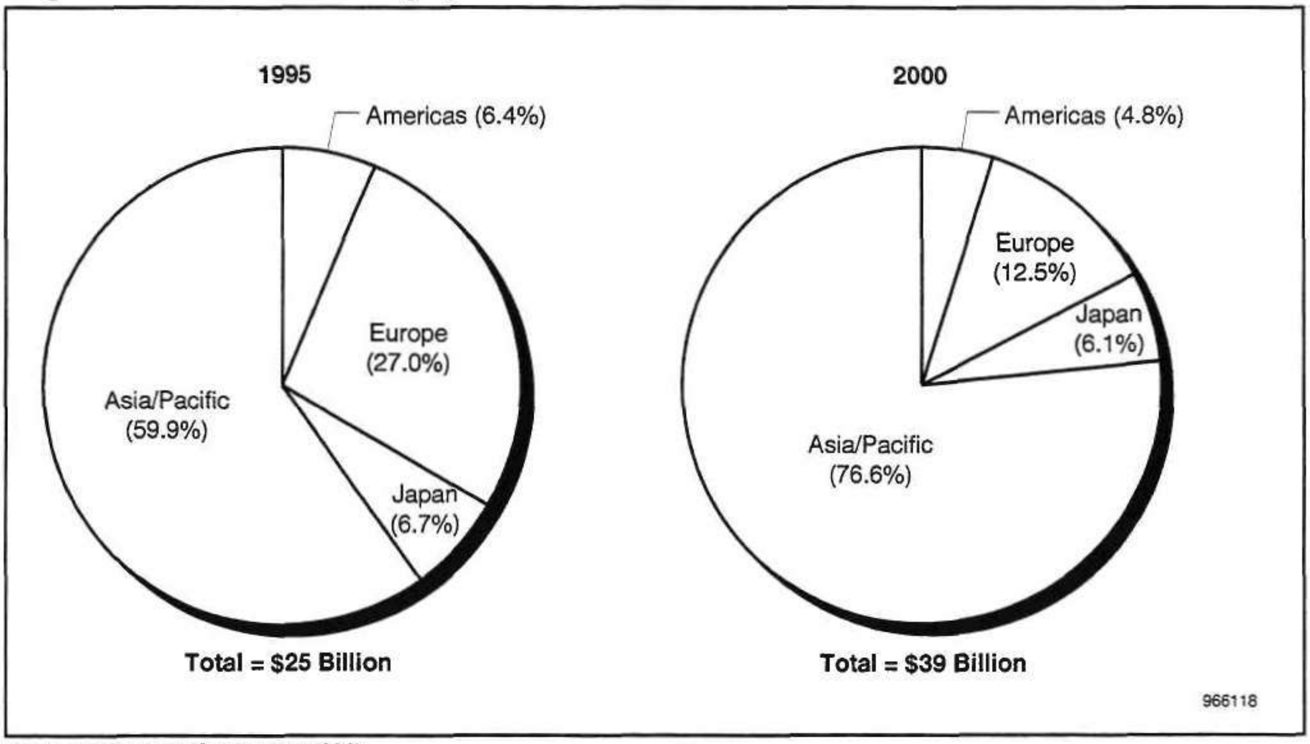
Digitization is also affecting the personal portable audio market. Three hundred radio stations have joined the Radio Data System (RDS) campaign sponsored by the Consumer Electronics Manufacturers Association (CEMA). Onkyo Corporation, Bang & Olufsen, and Denon are making RDS home radios, and Grundig AG is making RDS portable radios. RDS works by sending an inaudible data stream. This data appears as text and enables a variety of listener-convenience and community-service features.

Figure 3-1
Worldwide Audio Equipment Production Revenue Forecast



Source: Dataquest (September 1996)

Figure 3-2
Regional Share of Audio Equipment Production Revenue



Source: Dataquest (September 1996)

Table 3-1
Americas Audio Equipment Production Revenue Forecast (Millions of Dollars)

Segment	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Compact Disc Players	55	59	61	64	67	70	74	77	4.8
Radios	840	880	850	865	889	916	942	971	2.7
Personal/Portable Stereos	87	92	95	102	110	119	127	137	7.5
Stereo Components	237	248	255	263	272	281	291	301	3.3
Musical Instruments	223	226	230	236	241	248	255	261	2.5
Tape Recorders	56	71	84	92	99	102	103	109	5.4
Total	1,498	1,575	1,575	1,622	1,677	1,737	1,792	1,855	3.3

Source: Dataquest (September 1996)

For example, listeners can select the desired station by its call letters or program format, which appear in text form on the face of the RDS radio.

Another example is the announcement by SGS-Thomson in June 1996 of the signing of a contract with WorldSpace Inc. for the development and production of chipsets that will bring CD-quality sound to personal radios. The set will comprise one advanced bipolar chip and two CMOS chips. It will use Motion Picture Experts Group (MPEG) compression/decompression technology and produce a signal length up to 128 Kbps (CD stereo quality). The channel decoder and source decoder chips will be integrated in the future.

Figure 3-3 and Table 3-2 show the worldwide production forecast for personal/portable stereos. Although these systems represent a high-volume opportunity, the growth in revenue will remain very low. Figure 3-4 provides a regional breakout of personal/portable stereo production. The dominance of the Asia/Pacific region in the production of personal/portable stereos will increase through 2000, reaching 78.4 percent of worldwide production. Table 3-3 lists the Americas production forecast for personal/portable stereos. Sony commanded more than 30 percent of the U.S. market in 1995 for boom boxes (see Tables 3-4 and 3-5).

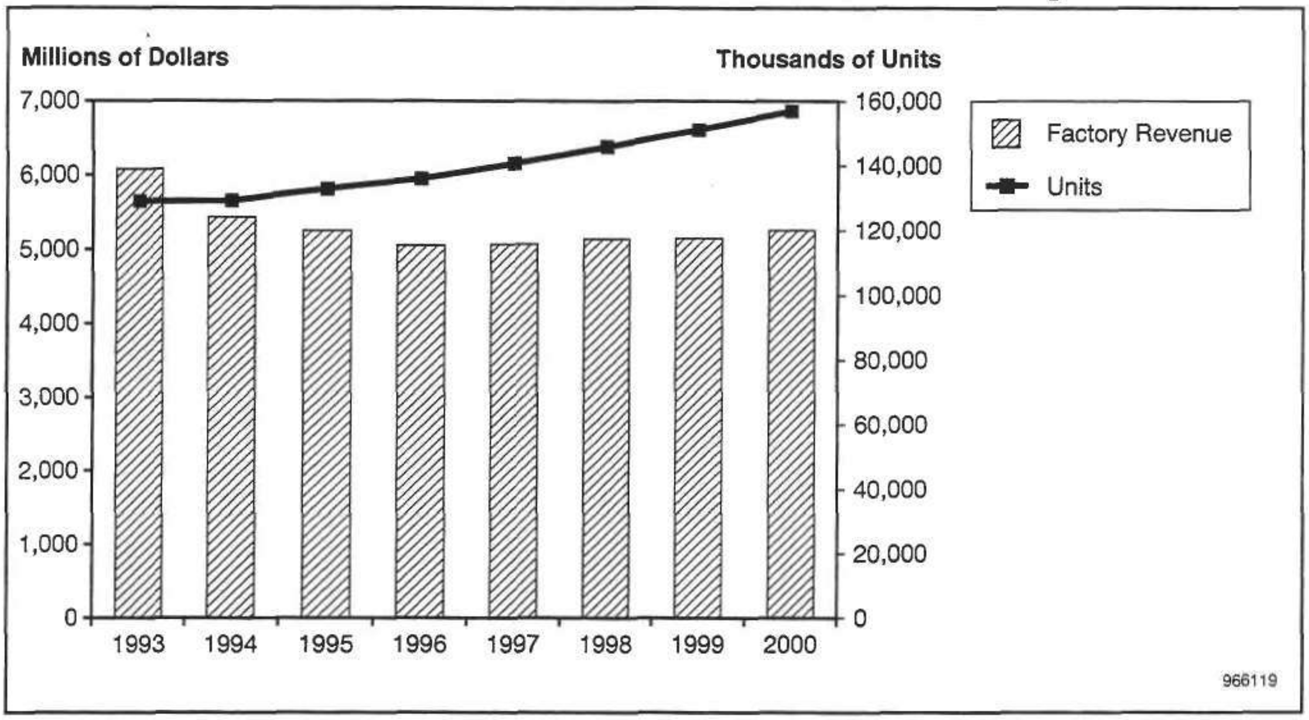
CD Players

Beyond personal CD players, much of the growth in the CD player market is driven by upgrades to CD changer players that accommodate multiple CDs. Tables 3-6 and 3-7 show brand share leaders for CD players in the United States.

Personal CD Players

Tables 3-8 and 3-9 list U.S. brand share leaders in personal CD players.

Figure 3-3
Worldwide Personal/Portable Stereo Production Revenue and Unit Shipment Forecast



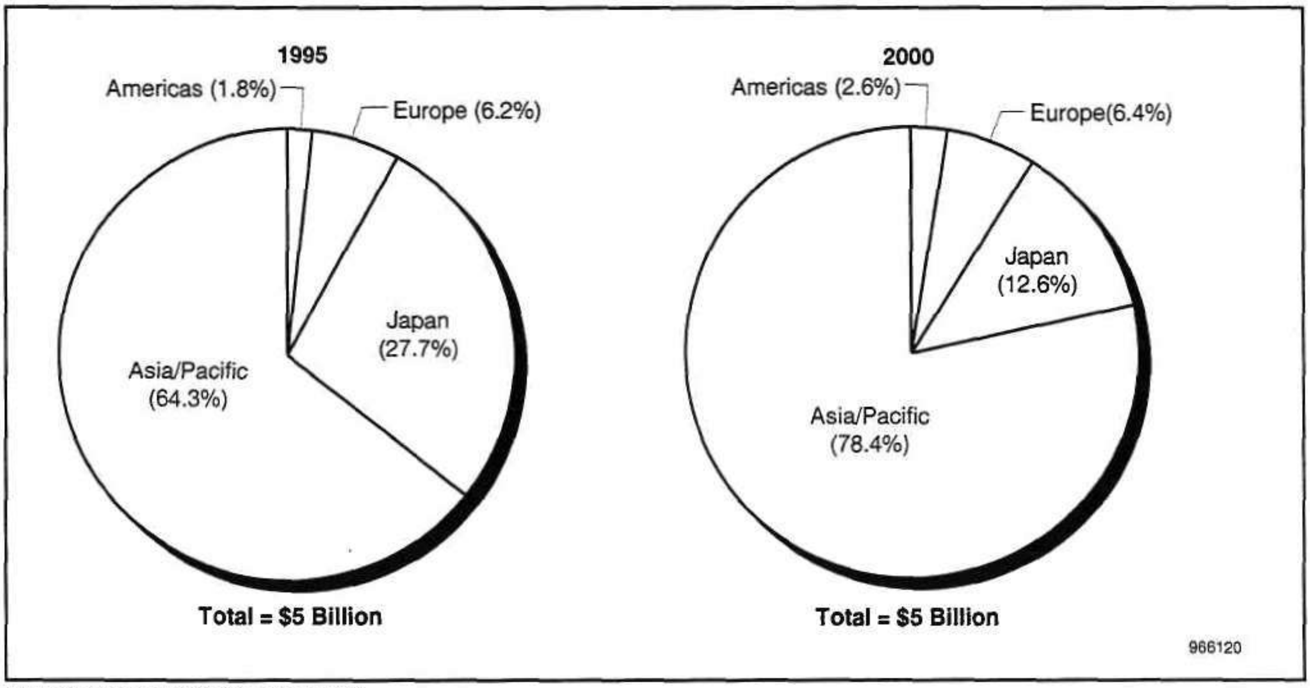
Source: Dataquest (September 1996)

Table 3-2
Worldwide Personal/Portable Stereo Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	129,044	129,237	132,861	135,945	140,594	145,801	151,042	156,911	3.4
Factory ASP ($)	47	42	40	37	36	35	34	33	-3.8
Factory Revenue ($M)	6,077	5,434	5,251	5,053	5,067	5,138	5,145	5,249	0
Semiconductor Content ($)	10	9	9	8	8	8	8	7	-4.9
Semiconductor TAM ($M)	1,251	1,185	1,161	1,133	1,149	1,168	1,151	1,171	0.2
Regional Production Trends (Percentage of World by Unit Production)									
Americas	1	1	1	1	1	1	1	1	
Europe	12	12	12	11	11	11	11	10	
Japan	13	9	8	6	5	5	4	4	
Asia/Pacific	74	78	79	81	82	83	84	84	

Source: Dataquest (September 1996)

Figure 3-4
Regional Share of Personal/Portable Stereo Production Forecast



Source: Dataquest (September 1996)

Table 3-3
Americas Personal/Portable Stereo Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	1,479	1,552	1,638	1,754	1,900	2,059	2,183	2,314	7.2
Factory ASP ($)	59	59	58	58	58	58	58	59	0.3
Factory Revenue ($M)	87	92	95	102	110	119	127	137	7.5
Semiconductor Content ($)	12	12	12	12	12	12	12	12	0.9
Semiconductor TAM ($M)	17	18	19	20	22	24	26	28	8.1

Source: Dataquest (September 1996)

Table 3-4
U.S. Boom Box Brand Share Leaders, First Quarter 1995 through Fourth Quarter 1995 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sony	31.8	33.0
RCA	8.8	8.7
Magnavox	8.4	8.1
Sanyo	5.6	5.1
Panasonic	4.6	5.3
Emerson	3.6	2.8
Sharp	3.6	3.8
Craig	3.4	2.4
GPX	3.3	2.6
GE	2.9	2.4
Others	24.0	25.8
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-5
U.S. Boom Box Brand Share Leaders, Second Quarter 1995 through First Quarter 1996 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sony	31.6	32.9
Magnavox	9.3	9.4
RCA	8.2	8.0
Sanyo	5.4	5.0
Panasonic	4.7	5.2
GPX	3.7	2.8
GE	3.5	3.7
Sharp	3.1	2.2
Emerson	3.0	2.3
JVC	2.8	2.1
Others	24.7	26.4
Total	100.00	100.00

Source: The Scout Report®/The Polk Company

Table 3-6
U.S. CD Player Brand Share Leaders, First Quarter 1995 through Fourth Quarter 1995 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sony	28.4	28.4
Pioneer	13.9	15.3
JVC	6.8	6.0
Technics	7.7	6.8
Panasonic	5.2	4.0
Kenwood	5.3	4.5
RCA	5.3	4.6
Magnavox	3.5	2.3
TEAC	2.9	1.7
Fisher	1.9	2.2
Others	19.1	24.2
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-7
U.S. CD Player Brand Share Leaders, Second Quarter 1995 through First Quarter 1996 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sony	27.8	27.7
Pioneer	11.9	13.6
JVC	8.4	8.3
Technics	7.9	7.0
Panasonic	5.8	4.8
Kenwood	5.7	5.0
RCA	4.4	4.0
Magnavox	4.1	2.7
TEAC	2.7	1.6
Fisher	2.4	2.9
Others	18.9	22.4
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-8
U.S. Personal CD Player Brand Share Leaders, First Quarter 1995 through Fourth Quarter 1995 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sony	42.8	41.6
Panasonic	13.9	14.0
RCA	12.1	11.3
Magnavox	5.4	5.1
Koss	3.5	3.1
Aiwa	2.7	3.3
Fisher	3.0	5.0
Sanyo	2.8	2.6
Kenwood	1.9	2.1
Radio Shack Brands	1.4	1.4
Others	10.5	10.5
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-9
U.S. Personal CD Player Brand Share Leaders, Second Quarter 1995 through First Quarter 1996 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sony	42.3	42.1
Panasonic	14.1	14.3
RCA	12.3	11.7
Magnavox	5.8	5.5
Koss	3.9	3.4
Aiwa	3.1	3.6
Fisher	2.5	3.8
Sanyo	2.4	2.3
Kenwood	2.2	2.4
Radio Shack Brands	1.4	1.4
Others	10.0	9.5
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

MiniDisc Players

MiniDisc (MD) is similar to a standard CD player in looks and features but offers much improved portability and the ability to record at slightly less than CD quality. Sony concedes that the product is not intended to replace today's CD but to be its portable counterpart. MD is vying to replace the analog cassette. MD uses a compression technique known as Adaptive Transform Acoustic Coding (ATRAC) to fit 74 minutes of near CD-quality music on a 2.5-inch optical disc. ATRAC is designed to remove the frequencies the human ear is less sensitive to and therefore the least likely to notice missing. Shockproofing is achieved by incorporating a RAM buffer. If the laser does mistrack during play, the music will continue to flow for up to 10 seconds, which is good for mobile applications.

While MDs represent a growing market in Japan, they are still unpopular in Europe and the United States. MD players demand in Japan should more than double in 1996 to reach 3 million units, while overseas markets may consume over 500,000 units. Sony still believes the global market has the potential to reach 30 million units by the year 2000. However, low demand has limited the entry of new companies to the market and the introduction of new models by existing players. But vendors are not giving up. Anticipating accelerating growth, Sony has recently reintroduced the MD in the United States for the third time. Sharp and Aiwa are also introducing new products. To date, all audio makers have acquired MD manufacturing licenses from Sony, including Sharp, Kenwood, Sansui, Clarion, Aiwa, RCA, and Sanyo. In September 1995, Matsushita began selling a MiniDisc portable audio player. Matsushita's entry is significant because it was one of the original developers of the rival audio format called digital compact cassettes (DCC) or digital audio tape (DAT). At its first introduction in 1992, the MD was targeted at people in their early 30s. This time, companies will focus on high-school and college students who have become the main users in Japan. Growing sales in Japan helped lower cost for all products. By developing low-cost models, MD player makers will attempt to offer prices and features acceptable to the market. However, today, MD players are still expensive items for mainstream consumers. In Japan, prices revolve around the equivalent of $500, and in the United States they are closer to $600.

Today, the removable storage industry is scrambling for a replacement for the floppy disk, and there is some talk about using MDs to that end. Technically speaking, MDs are suitable for multimedia use because they can record data and images as well as music. At 140MB, MDs offer a recording capacity equivalent to about 100 floppy disks. However, two factors are essential to the adoption of MDs as data storage devices:

- Price: MD players need to break the $200 barrier. Consumers have indicated that they are willing to pay no more than $200 for a storage drive. Dataquest believes that this price barrier will be very difficult to break for MDs.
- IEEE 1394: Adoption of IEEE 1394 as a universal bus interface. IEEE 1394 will enable easy setup of MD players to stereo systems as well as computers.

Cassette Tape Decks

Tables 3-10 and 3-11 list the brand share leaders for cassette tape decks in the United States.

Table 3-10
U.S. Cassette Tape Deck Brand Share Leaders, First Quarter 1995 through Fourth Quarter 1995 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sony	22.3	27.2
Pioneer	14.1	13.7
JVC	9.0	9.3
Kenwood	6.0	6.6
Radio Shack Brands	5.0	3.8
Technics	5.4	5.8
Fisher	3.3	2.1
GE	4.9	NA
TEAC	4.5	2.8
GPX	2.4	1.8
Others	23.1	26.9
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-11
U.S. Cassette Tape Deck Brand Share Leaders, Second Quarter 1995 through First Quarter 1996 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sony	20.2	23.7
Pioneer	13.8	12.8
Kenwood	13.4	13.7
JVC	6.5	6.7
TEAC	4.8	3.6
GE	4.4	4.6
Technics	3.6	2.6
Radio Shack Brands	3.5	NA
Panasonic	3.3	2.0
Onkyo	2.6	1.2
Others	23.9	29.1
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Personal Tape Players

Tables 3-12 and 3-13 list the brand share leaders in the United States.

Table 3-12
U.S. Personal Tape Player Brand Share Leaders, First Quarter 1995 through Fourth Quarter 1995 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sony	41.4	46.0
GE	9.4	6.9
Panasonic	6.5	8.4
Aiwa	5.6	7.5
GPX	4.9	4.5
RCA	3.6	3.4
Radio Shack Brands	4.0	4.5
Lenoxx Sound	2.5	1.4
Philco	2.0	1.1
Emerson	2.0	1.3
Others	18.1	15.0
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-13
U.S. Personal Tape Player Brand Share Leaders, Second Quarter 1995 through First Quarter 1996 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sony	41.2	46.0
GE	9.0	7.0
Panasonic	6.9	9.0
Aiwa	5.1	6.5
GPX	4.9	3.9
RCA	4.0	3.9
Radio Shack Brands	3.8	4.0
Lenoxx Sound	2.4	1.3
Philco	2.2	1.2
Emerson	2.0	1.2
Others	18.5	16.0
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Stereo Rack Systems

Tables 3-14 and 3-15 list the brand share leaders for stereo rack systems in the United States.

Table 3-14
U.S. Stereo Rack System Brand Share Leaders, First Quarter 1995 through Fourth Quarter 1995 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sony	18.0	19.9
Pioneer	9.5	13.4
Aiwa	9.4	8.1
Sharp	6.8	5.1
Fisher	6.8	9.2
Kenwood	6.7	9.6
Soundesign	5.4	3.8
Technics	5.0	8.3
JVC	3.8	5.5
Panasonic	3.2	3.2
Others	25.4	13.9
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-15
U.S. Stereo Rack System Brand Share Leaders, Second Quarter 1995 through First Quarter 1996 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sony	17.8	17.8
Pioneer	11.3	16.0
Aiwa	8.7	7.4
Sharp	8.3	7.0
Fisher	7.5	11.1
Kenwood	6.0	8.7
Soundesign	4.7	2.7
Technics	4.4	7.1
JVC	3.7	5.5
Panasonic	2.6	2.8
Others	25.0	13.9
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Stereo Receivers

Tables 3-16 and 3-17 list the brand share leaders for stereo receivers in the United States. Tables 3-18 and 3-19 list the brand share leaders for compact stereo systems in the United States.

Table 3-16
U.S. Stereo Receiver Brand Share Leaders, First Quarter 1995 through Fourth Quarter 1995 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sony	27.2	27.3
Pioneer	17.0	17.6
Kenwood	8.5	7.6
Technics	9.7	9.1
JVC	8.7	7.2
Onkyo	4.4	6.9
Yamaha	3.0	4.4
Radio Shack Brands	2.4	1.4
Denon	2.5	4.1
TEAC	1.6	1.2
Others	15.0	13.2
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-17
U.S. Stereo Receiver Brand Share Leaders, Second Quarter 1995 through First Quarter 1996 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sony	23.2	22.1
Pioneer	16.1	16.0
Kenwood	10.8	11.3
Technics	9.5	8.3
JVC	9.4	8.0
Onkyo	5.1	7.1
Yamaha	4.0	5.7
Radio Shack Brands	3.2	2.1
Denon	2.1	2.7
TEAC	1.5	1.2
Others	15.1	15.5
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-18
U.S. Compact Stereo System Brand Share Leaders, First Quarter 1995 through Fourth Quarter 1995 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Aiwa	13.7	22.0
Sony	16.4	18.6
RCA	9.2	6.3
Sharp	7.5	6.3
Magnavox	8.3	7.1
Soundesign	6.1	3.6
GPX	3.9	1.7
GE	4.2	2.1
JVC	3.1	4.3
Emerson	2.5	1.3
Others	25.1	26.7
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-19
U.S. Compact Stereo System Brand Share Leaders, Second Quarter 1995 through First Quarter 1996 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Aiwa	15.5	24.9
Sony	15.4	17.0
RCA	9.2	6.1
Sharp	7.4	5.9
Magnavox	7.0	5.9
Soundesign	5.9	3.3
GPX	3.8	2.0
GE	3.7	1.7
JVC	3.5	4.8
Emerson	2.9	1.5
Others	25.7	26.8
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Stereo Speakers

The main driving forces behind the growth of the stereo speaker industry are audio-for-video and new designs for speaker-specific applications. The home theater concept, where consumers want speakers to faithfully reproduce movie sound tracks, is mutating from being a high-end feature to a more mainstream technology. The Dolby Surround AC-3 specification, which enables home theater acoustics, requires the use of additional surround speakers and, optionally, the use of subwoofers. Speaker designs are taking into account the differing demands for movie sound track reproduction and music reproduction. Some systems incorporate a switch that allows the user to select the desired music or sound track mode.

Chapter 4
Video Equipment

Video equipment is positioned in the consumer market as entertainment equipment and, together with audio equipment, has been serving as a market and technology driver for the electronics equipment and semiconductor industries. In particular, it has spurred the development and commercialization of numerous production technologies and systems, which have also promoted the growth of industries that supply necessary components and materials.

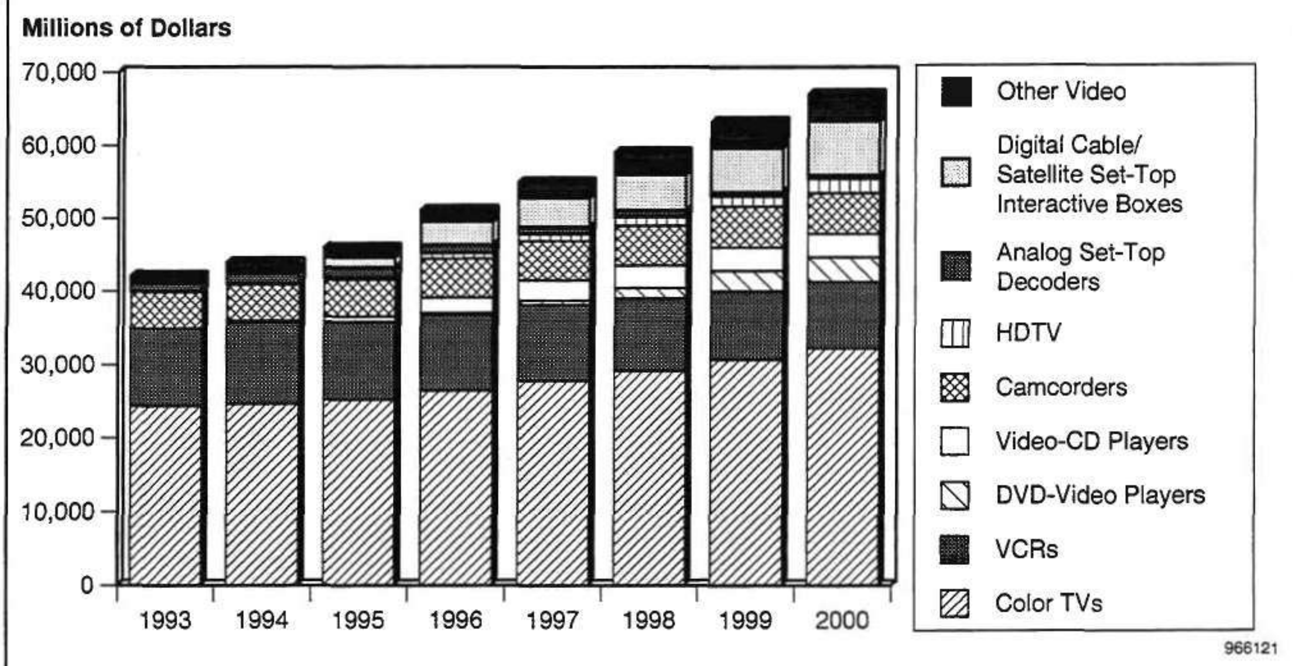
Home use of entertainment equipment assures wide market penetration because it is less affected or impeded by social and cultural barriers. Video equipment demand potentially covers the entire world and grows with the economic development in each country. At the same time, establishment of video equipment production bases in the areas offering low-cost labor has helped expand regional economies, which in turn has created the economic base that stimulates video equipment demand.

Figure 4-1 and Table 4-1 show the anticipated worldwide growth forecast of video equipment production. The CAGR for the next five years in video equipment is expected to be 7.8 percent. Particularly strong growth is anticipated in digital set-top boxes, with almost a 40 percent CAGR forecast. Japan will continue to shift video equipment production locations to the Asia/Pacific region: 42.7 percent of video equipment production will take place in the Asia/Pacific region by 2000 (see Figure 4-2). The forecast for Americas video equipment production is given in Figure 4-3 and Table 4-2. Although color televisions represent the dominant slice of revenue production in the Americas, new technology developments are pushing production rates of VCRs and set-top boxes to much higher levels. The "other video" equipment category includes items such as LCD TV, black-and-white TV, video accessories, and various emerging products. Table 4-3 lists major North American video research and design and manufacturing locations.

Major announcements related to video R&D and manufacturing investments in the Americas include the following:

- JVC completed production of its new Americas color TV manufacturing facility in Tijuana, Mexico, and closed its older facility in New Jersey. The new factory plans to produce 600,000 color sets in 1996 and then boost production to 1 million sets in 1997. JVC will also start to assemble 4:3 aspect ratio projection TVs in 1997 at the facility.
- Mitsubishi Corporation established a new television R&D center in Orange County, California.
- Philips Consumer Electronics added complete new production lines at its facility in Ottawa, Ohio, to give it the capacity to turn out 500,000 32-inch tubes and 300,000 35-inch tubes annually. The 32-inch production began in summer 1996. Production of 35-inch sets will start in 1997. Philips also announced that it would raise its prices by 6 percent to 8 percent for the picture tubes it sells to other TV and monitor manufacturers. It noted that the increase was necessary because of a number of factors, including increasing glass prices and the need to develop higher-quality displays suited to digital television.

Figure 4-1
Worldwide Video Equipment Production Revenue Forecast



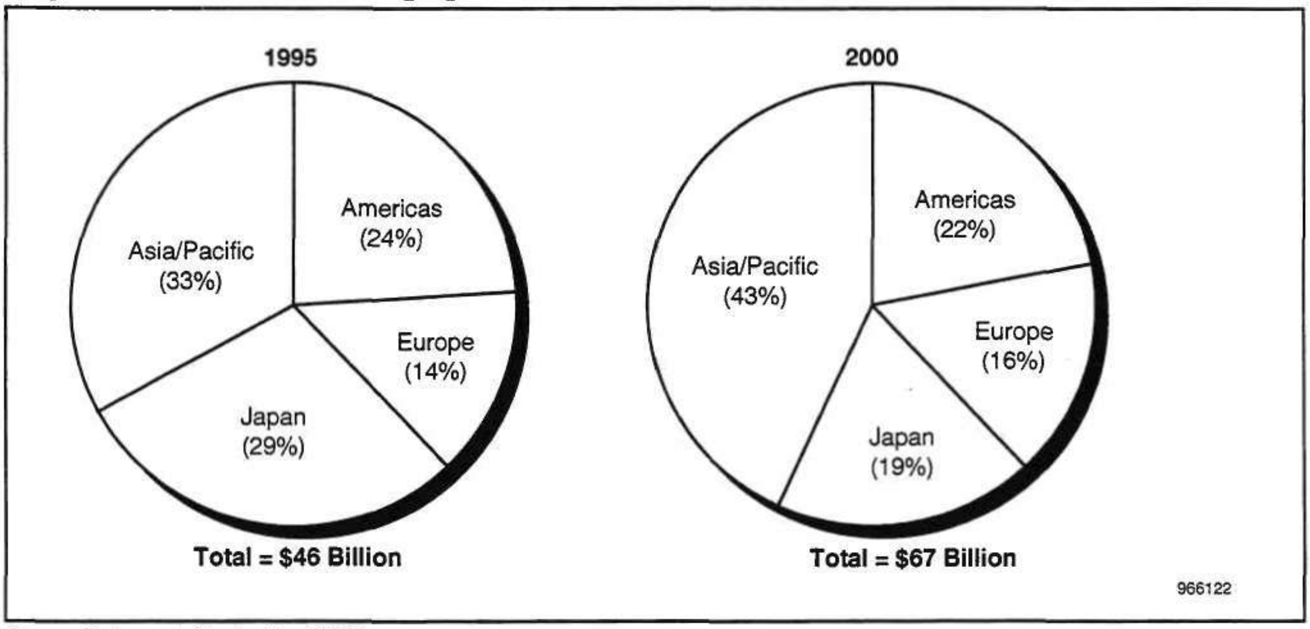
Source: Dataquest (September 1996)

Table 4-1
Worldwide Video Equipment Production Revenue Forecast (Millions of Dollars)

Segment	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Color TVs	24,372	24,687	25,252	26,493	27,871	29,212	30,714	32,251	5.0
VCRs	10,521	11,035	10,569	10,395	10,294	9,838	9,374	9,049	-3.1
DVD-Video Players	0	0	0	154	589	1,443	2,772	3,406	NM
Video-CD Players	17	242	735	2,115	2,768	3,078	3,240	3,238	34.5
Camcorders	4,984	4,942	5,037	5,350	5,444	5,485	5,601	5,590	2.1
HDTVs	96	138	352	735	942	1,198	1,378	1,890	40.0
Analog Set-Top Decoders	1,107	1,388	1,309	1,131	970	846	564	485	-18.0
Digital Cable/ Satellite Set-Top Interactive Boxes	8	420	1,390	3,159	3,932	4,867	5,981	7,398	39.7
Other Video	910	1,020	1,250	1,523	2,062	3,023	3,544	3,606	23.6
Total	42,015	43,872	45,894	51,055	54,872	58,991	63,168	66,912	7.8

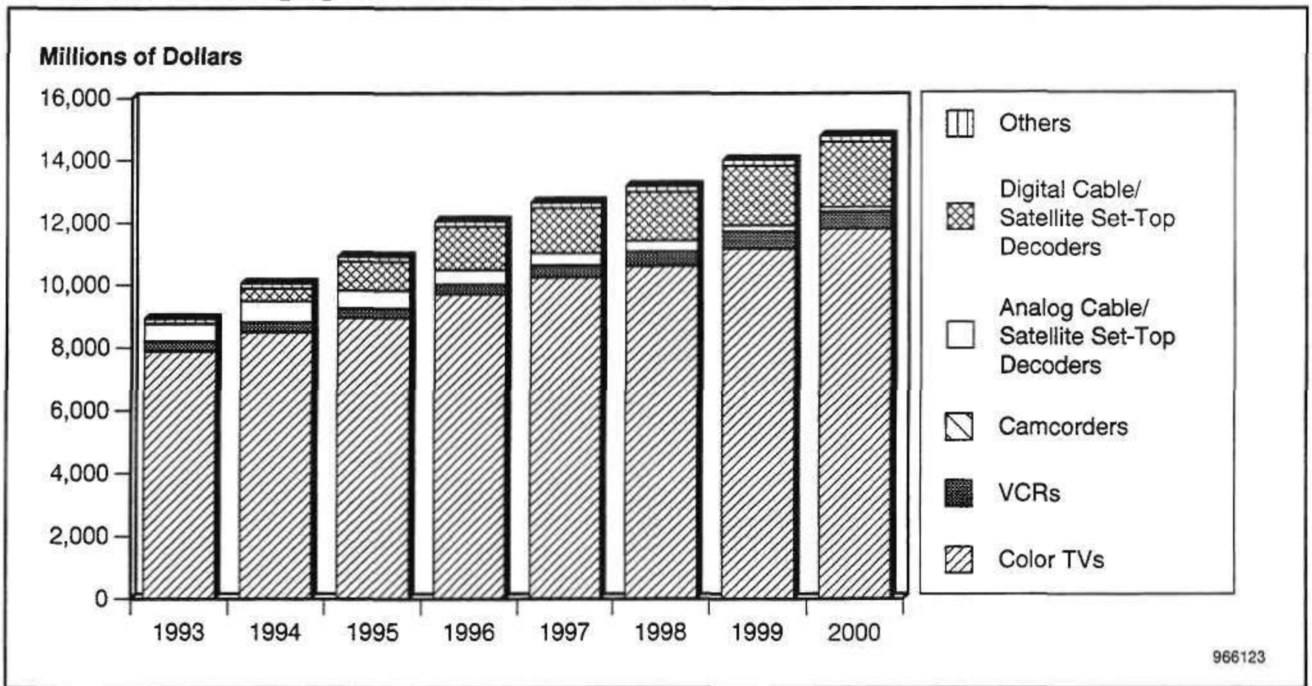
NM = Not meaningful
Source: Dataquest (September 1996)

Figure 4-2
Regional Share of Video Equipment Production Revenue



Source: Dataquest (September 1996)

Figure 4-3
Americas Video Equipment Production Revenue Forecast



Source: Dataquest (September 1996)

Table 4-2
Americas Video Equipment Production Revenue Forecast (Millions of Dollars)

Segment	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Color TVs	7,894	8,507	8,963	9,734	10,271	10,619	11,192	11,818	5.7
VCRs	292	305	313	307	385	476	552	561	12.4
Camcorders	31	8	0	0	0	0	0	0	NM
Analog Cable/ Satellite Set-Top Decoders	556	689	570	465	401	353	189	150	-23.4
Digital Cable/ Satellite Set-Top Decoders	6	400	930	1,392	1,433	1,557	1,906	2,074	17.4
Others	140	145	148	155	164	170	176	185	4.6
Total	8,919	10,054	10,923	12,054	12,653	13,175	14,015	14,788	6.2

NM = Not meaningful
Source: Dataquest (September 1996)

Table 4-3
North American Video R&D and Manufacturing

Company	R&D Center	Manufacturing Sites
Daewoo (Orion Electric)		San Luis Rio Colorado, Mexico;
Mexicali, Mexico		
Emerson	North Bergen, New Jersey	North Bergen, New Jersey
Hitachi		Tijuana, Mexico
JVC (Matsushita)		Tijuana, Mexico
LG Electronics		Mexico
Matsushita		Franklin Park, Illinois;
Vancouver, Washington		
Mitsubishi	Brazelton, Georgia	Brazelton, Georgia
	Santa Ana, California	Santa Ana, California
	Orange County, California	
Philips	Knoxville, Tennessee	Greenville, Tennessee; Ottawa, Ohio; Mexico
Thomson Consumer	Indianapolis, Indiana	Bloomington, Indiana; Marion, Indiana; Mexico
Samsung		Tijuana, Mexico
Sanyo		Tijuana, Mexico
Sony	San Jose, California	San Diego, California; Tijuana, Mexico
		Mount Pleasant, Pennsylvania
Zenith	Glenview, Illinois	Melrose Park, Illinois; Mexico

Source: Dataquest (September 1996)

- Sanyo Video Components completed a $25 million expansion with the opening of its second plant in Tijuana, Mexico. The expansion tripled Sanyo's local production capacity for audio and video parts. The new facility can produce 3 million flyback transformers and 2.5 million tuners annually. The first plant, which opened in 1993, produces about 6 million deflection yokes a year. Following the kidnapping of a Sanyo executive in Mexico during 1996, concerns were raised that Sanyo and other Japanese manufacturers could pull back investment in Mexico if security became a significant concern.
- Thomson Consumer Electronics has begun expansion of its color TV and picture tube operations in North America. It plans to spend $52 million to expand capacity at its picture tube plant in Marion, Indiana. The company recently boosted production of 25-inch color tubes. The new expansion will increase production of 31-inch and 35-inch tubes by 20 percent and allow for start-up of production of 32-inch tubes. The plant currently produces 4 million of Thomson's total U.S. output of 6.5 million tubes. Thomson will also invest $2 million to double the production capacity of projection TVs at its main color TV manufacturing site in Bloomington, Indiana.
- LG Electronics, formerly known as Goldstar, acquired a 57.5 percent interest in Zenith in 1995. Part of the LG Electronics investment will enable Zenith to make improvements such as upgrading its Melrose Park, Illinois, and Mexico picture tube plants. Zenith broke ground for the first phase of a $150 million expansion of its Melrose Park facility in spring 1996. The first investment of $80 million will allow the plant to increase production capacity by 10 percent. The second phase of investment is expected to give the plant the capability to produce larger-size picture tubes. It is equipped to manufacture 19-inch, 20-inch, 25-inch, and 27-inch tubes. Zenith uses tubes produced at this plant in its own TV sets and also sells them to other TV manufacturers.
- Daewoo subsidiary Orion Electric is investing $180 million in a color tube plant in Mexicali, Mexico. The investment will boost production capacity at the site to 4 million tubes annually. Daewoo also expanded its San Luis Rio Colorado plant to produce 1.5 million VCRs each year.
- Sony plans to become the second Americas region manufacturer of VCRs and will invest $9.3 million in a plant to be located in Tijuana, where it already manufactures color TVs. The new plant should be operational by spring 1997 and will ramp to produce 1 million units annually to supply markets in the United States, Canada, and Latin America. Output from this plant will replace VCRs now imported by Sony from Malaysia. The switch will result in cost savings by lowering inventory requirements. Sony has also indicated that the plant could be expanded to produce other products, such as the Sony PlayStation video game console.
- JVC has entered into a joint venture with Gradiente of Sao Paulo, Brazil, for marketing Brazilian-made VCRs, camcorders, and TVs. The venture will use parts and components that JVC supplies to its partner for manufacturing. Brazil is the largest audio/video market in Central and South America.

- Between 1996 and 2005, LG Electronics plans to invest $1 billion in a large electronics complex near Taubate, Brazil. The complex will produce color TV monitors, CRTs, electronic home appliances, and other parts. The first step will be to build an $86 million plant that can make 3 million color TV monitors annually. Within four years, LG Electronics plans to be the leading producer of color TV monitors in Brazil.

Market Trends

Today, worldwide video equipment demand is stratified by the following distinguishable levels:

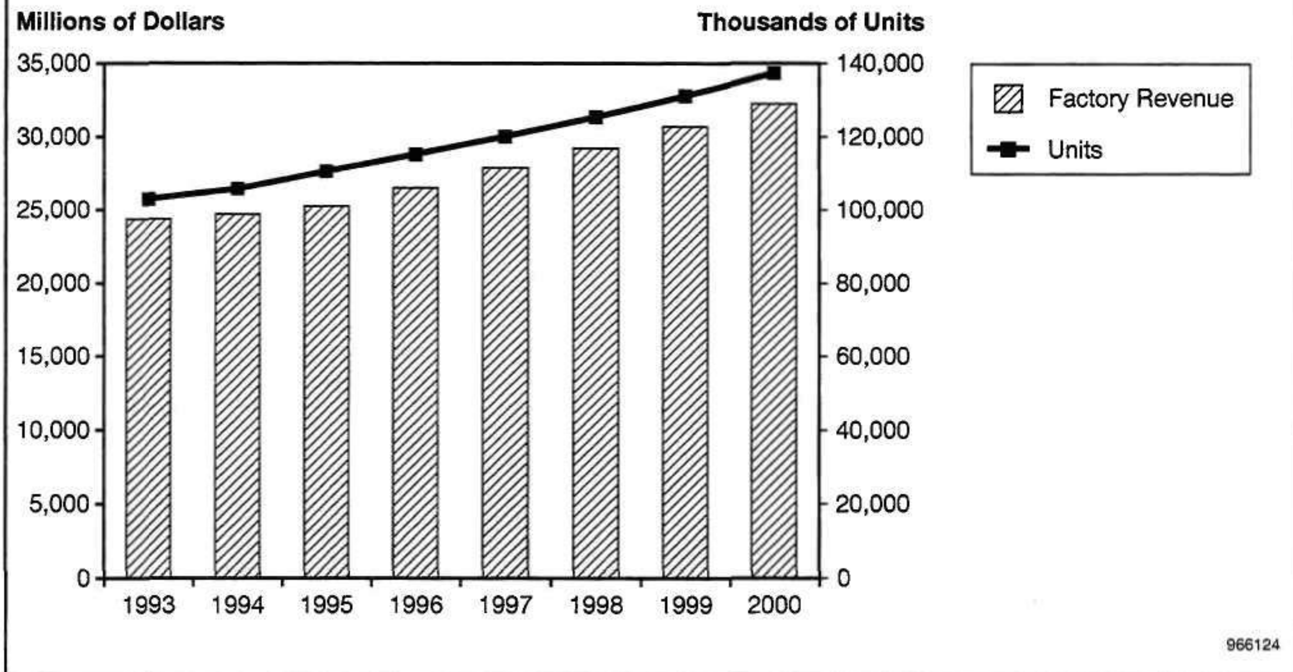
- Replacement and additional purchase demand in industrialized countries where the first-time buyer market is nearing a saturation point
- First-time purchase for low end and low cost
- Demand for hybrid products such as TV/VCR combinations
- Demand for next-generation video equipment, including wide-screen TV, HDTV, DVD, and Video-CD players

As shown in Figure 2-7, color TVs and VCRs are now found in almost all U.S. homes. The majority of homes in the United States and Canada have more than one TV, and many families have more than one VCR. Most purchases in these categories are for replacement or upgrade of existing products. Lower interest rates and strong new home sales stimulated consumer durable spending beginning in the early part of 1994, which led to robust sales of video equipment in the United States. However, in spite of higher consumer confidence in 1995, video electronics sales growth slowed. Newer video technologies such as direct broadcast satellite (DBS) receivers and DVD Video players present major growth opportunities. The following sections provide more detailed discussion of the high-volume video equipment—color TVs, VCRs, and camcorders. Emerging opportunities in HDTV, Video-CD, and DVD also are discussed at the end of this chapter. Detailed information on analog and digital set-top boxes is presented in Chapter 5, where interactive products are discussed.

Color Television

Figure 4-4 and Table 4-4 present the worldwide color television production forecast. The actions of most major color television producers indicate that production of color TVs will take place closer to the region where they are consumed. By virtue of the high growth of the Asia/Pacific markets, production of color TVs in that region will grow to 36 percent of the worldwide total in the year 2000. Production plans in China are so aggressive that government leaders fear they will not be able to find export markets for all their TV sets. Chinese officials now have instructions to enter only into new production ventures that are considered strategically important in the development of next-generation products. Tables 4-5 and 4-6 show the Americas color TV market and production forecast, respectively. Figure 4-5 shows the regional distribution of color TV production. Figures 4-6 and 4-7 show the sales mix of color TVs sold in the United States. RCA was the leading brand in the United States during 1994 and 1995. Tables 4-7 and 4-8 list leading color television brands.

Figure 4-4
Worldwide Color Television Production Revenue and Unit Shipment Forecast



Source: Dataquest (September 1996)

Table 4-4
Worldwide Color Television Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	102,861	105,748	110,527	115,171	120,085	125,443	131,172	137,408	4.5
Factory ASP ($)	237	233	228	230	232	233	234	235	0.5
Factory Revenue ($M)	24,372	24,687	25,252	26,493	27,871	29,212	30,714	32,251	5.0
Semiconductor Content ($)	33	32	31	31	32	33	34	35	2.2
Semiconductor Market ($M)	3,346	3,379	3,424	3,592	3,824	4,197	4,482	4,757	6.8
Regional Production Trends (Percentage of World by Unit Production)									
Americas	23	24	24	25	25	24	24	24	
Europe	19	19	18	17	17	17	16	16	
Japan	10	9	7	7	7	7	7	6	
Asia/Pacific	48	49	51	51	51	52	53	54	

Source: Dataquest (September 1996)

Table 4-5
Americas Color Television Market Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Color TV Only									
Units (K)	33,817	36,331	35,086	36,082	37,512	39,017	40,567	42,450	3.9
Factory ASP $	318	292	294	294	294	294	294	294	0
Factory Revenue ($M)	10,754	10,609	10,315	10,608	11,028	11,471	11,927	12,480	3.9
TV/VCR Combination									
Units (K)	1,884	2,333	2,532	2,804	3,043	3,298	3,569	3,872	8.9
Factory ASP $	368	350	344	337	333	331	330	330	-0.8
Factory Revenue ($M)	693	817	871	945	1,013	1,092	1,178	1,278	8.0

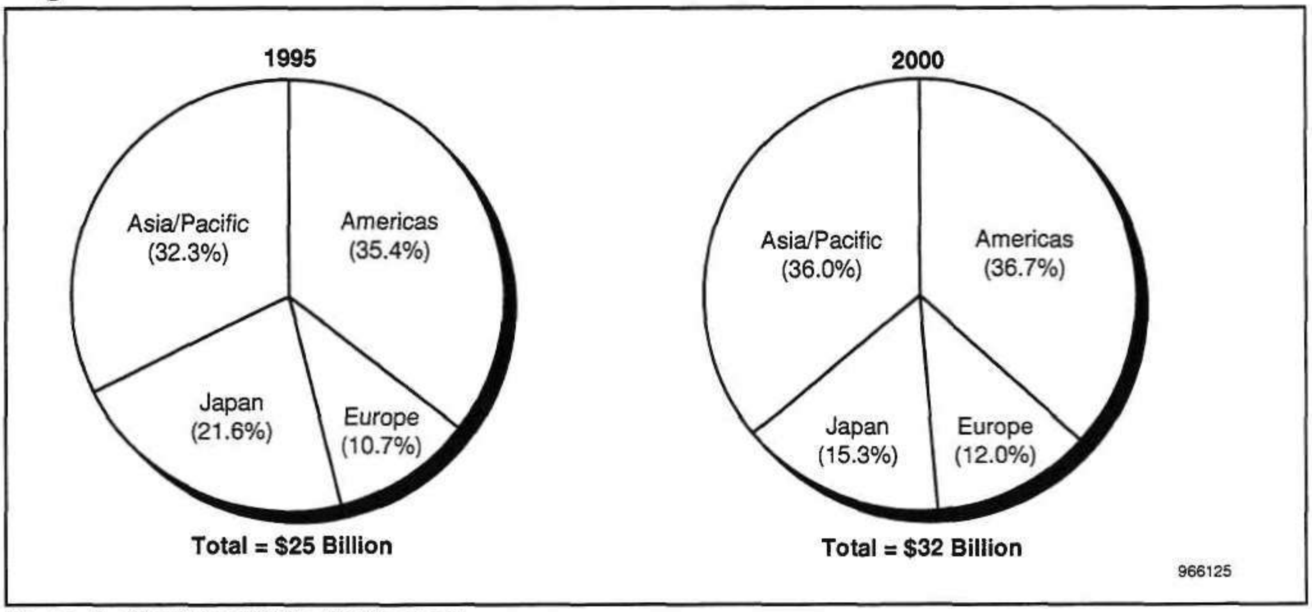
Note: Includes direct view stereo and nonstereo TV, does not include monochrome TV, color LCD TV, or projection TV.
Source: Dataquest (September 1996)

Table 4-6
Americas Color Television Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	23,408	24,976	26,850	28,461	29,600	30,340	31,705	33,290	4.4
Factory ASP ($)	337	341	334	342	347	350	353	355	1.2
Factory Revenue ($M)	7,894	8,507	8,963	9,734	10,271	10,619	11,192	11,818	5.7
Semiconductor Content ($)	29	29	29	29	30	31	31	31	1.5
Semiconductor Market ($M)	677	731	772	823	900	931	978	1,032	6

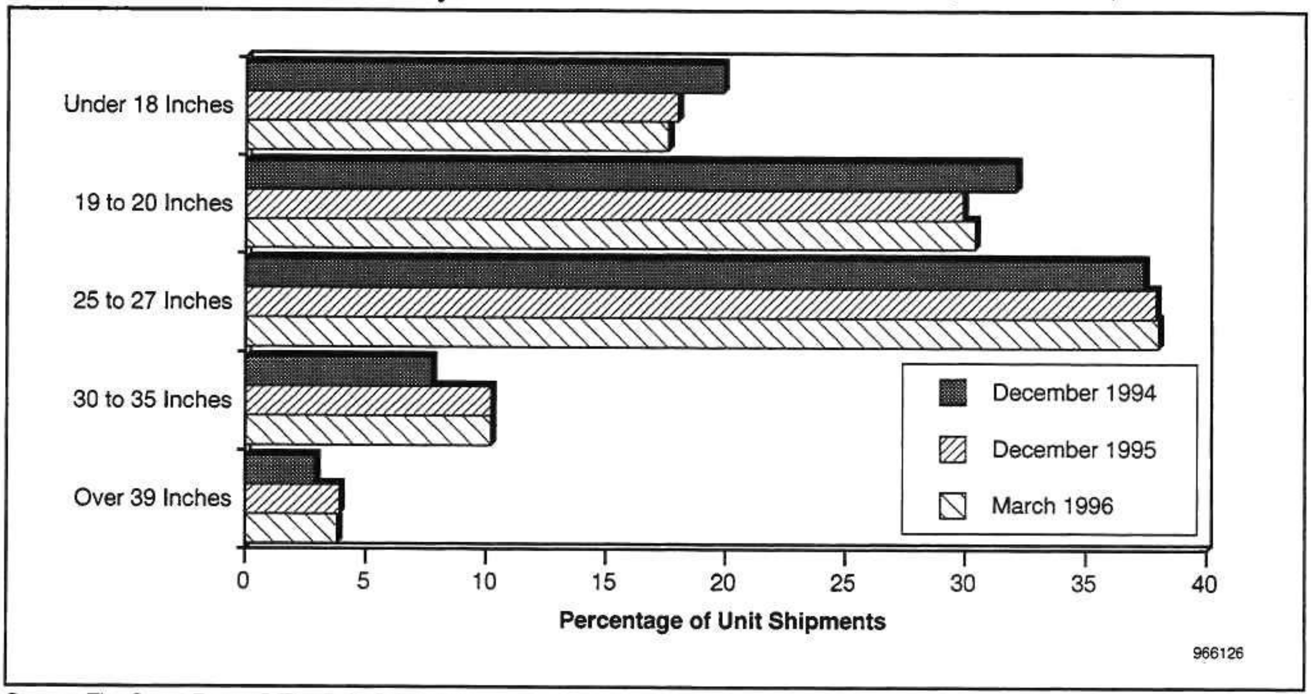
Source: Dataquest (September 1996)

Figure 4-5
Regional Share of Color Television Production Revenue



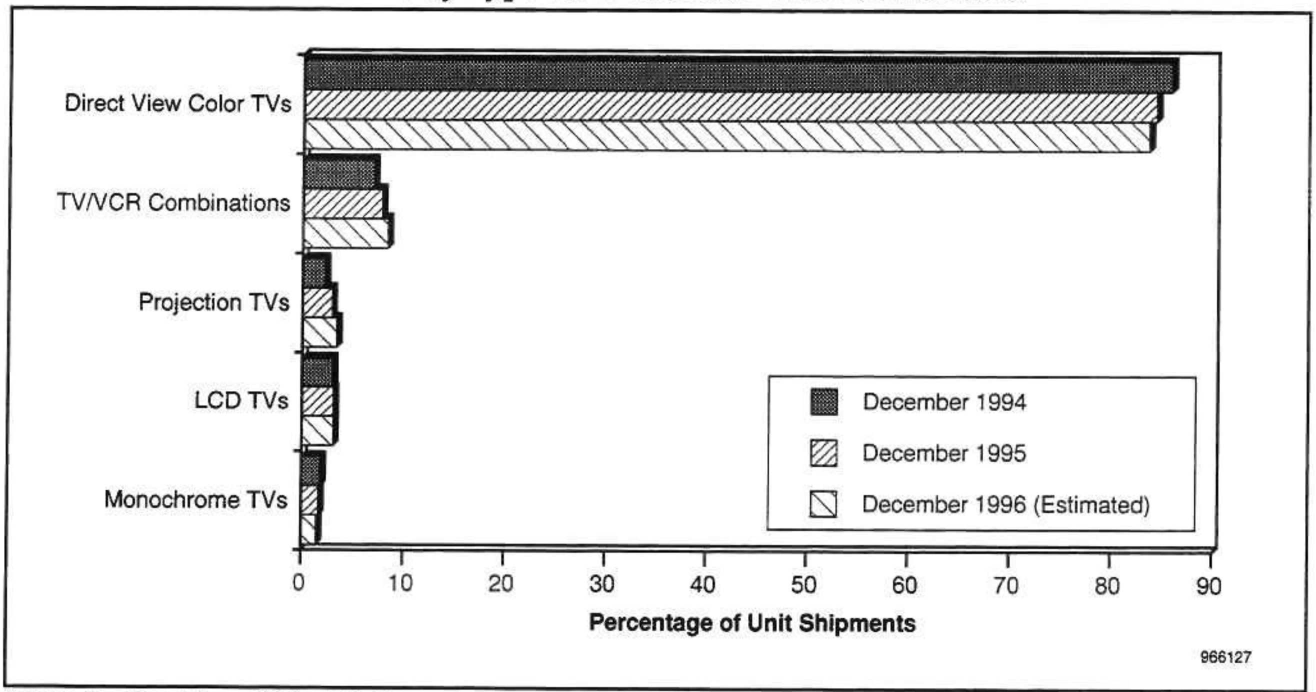
Source: The Scout Report®/The Polk Company

Figure 4-6
U.S. Color Television Sales by Screen Size for 12-Month Period (Unit Basis)



Source: The Scout Report®/The Polk Company

Figure 4-7
U.S. Color Television Sales by Type for 12-Month Period (Unit Basis)



Source: The Scout Report®/The Polk Company

Table 4-7
U.S. Color Television Brand Share Leaders, First Quarter 1995 through Fourth Quarter 1995 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
RCA	16.4	17.5
Magnavox	15.8	13.9
Zenith	12.6	11.9
Sony	7.9	10.6
GE	6.3	4.3
Sharp	5.4	3.3
Sanyo	5.3	3.2
Panasonic	3.9	4.2
Emerson	3.7	1.9
Toshiba	3.2	5.8
Others	19.5	23.4
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 4-8
U.S. Color Television Brand Share Leaders, Second Quarter 1995 through First Quarter 1996 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Magnavox	16.3	14.4
RCA	16.2	17.3
Zenith	12.4	11.8
Sony	7.5	9.7
GE	6.5	4.4
Sanyo	5.3	3.2
Sharp	5.2	3.3
Panasonic	4.0	4.2
Emerson	3.5	1.8
Toshiba	3.2	6.0
Others	19.9	23.9
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Key market trends and product developments affecting the color television market include the following:

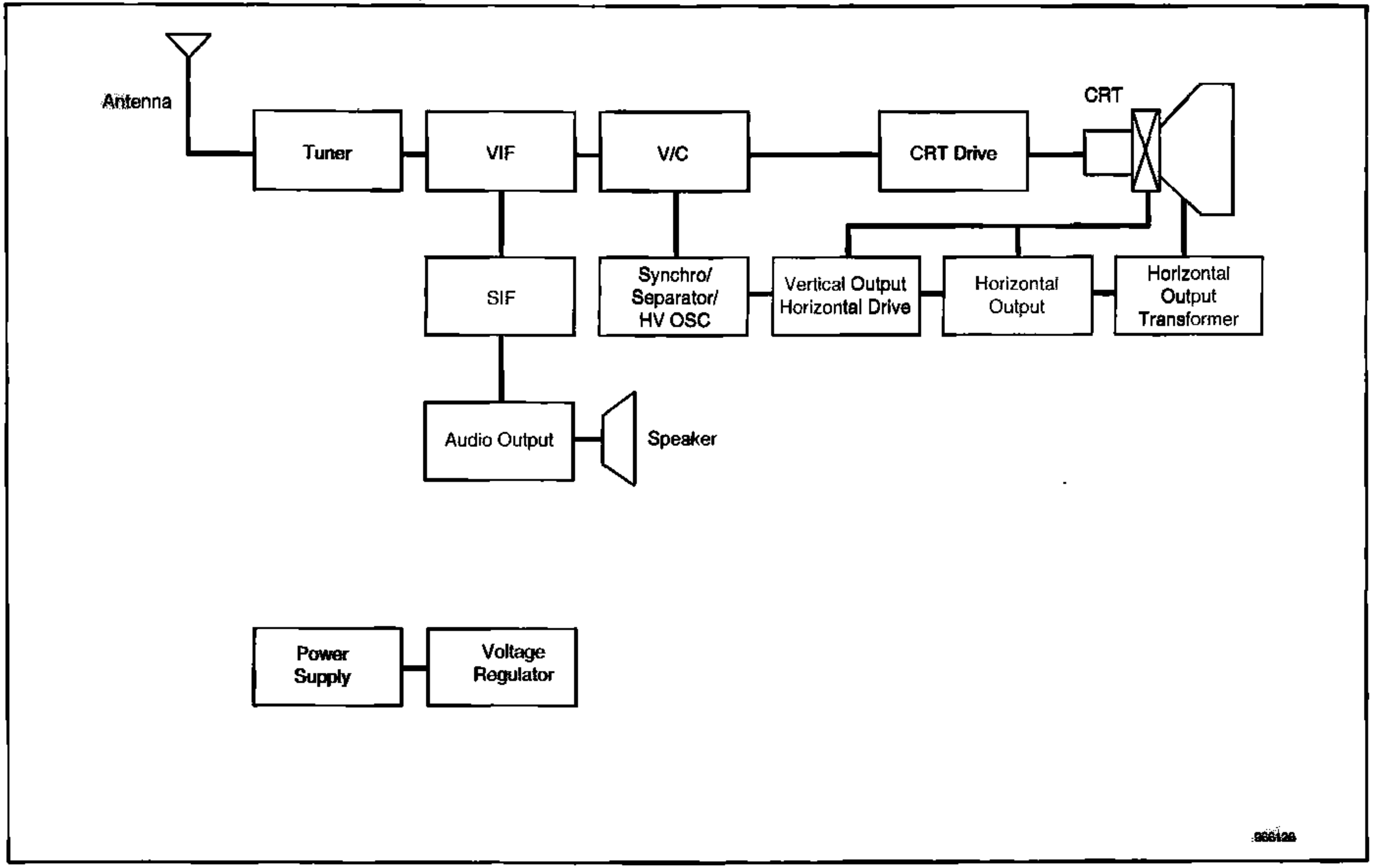
- TV/VCR combinations will continue to grow significantly as several manufacturers introduce new models. These are preferred by families as a unit for children because they save room and are easy to operate.
- Direct view screens of 20 inches and less are losing favor to screen sizes of 25 inches and more. A continued shift of the sales mix to larger screen sizes is expected. Screen sizes over 30 inches already 14 percent of the market in the United States for the 12 months ended March 1996.
- Stereo color TVs continue to expand their U.S. market presence. In June 1996, sales of stereo TVs set a new market share record with a 50.3 market share, 1.06 million TVs, during that month.
- Plasma displays made a big splash at the fall 1995 COMDEX show. These displays are about 4 inches thick and are expected to find their earliest application in "hang-on-the-wall" TVs. It appears that a market that was always "just 10 years away" is finally close to becoming a reality. Fujitsu and Panasonic were exhibiting the most impressive large flat panel designs based on their color plasma technology. Sony also demonstrated its Plasmatron display, which employs plasma-addressed liquid crystal (Palc) technology. Mitsubishi has also announced plans to introduce a flat panel TV display using plasma technology. Fujitsu looks like it is probably about a year ahead of other plasma panel competitors. Its 42-inch color plasma display featuring 300-candela-per-square-meter brightness, a wide aspect ratio of 16:9, 24-bit color, 852 x 480 resolution, a 160-degree viewing cone, and a 70:1 contrast ratio outclassed virtually everything else in sight and captured constant media attention at the show. Major investments in research and production capacity have been announced by leading Japanese television manufacturers. Market introductions of plasma displays are scheduled to begin in the second quarter of 1996. However, pricing on these displays will create a barrier to early market acceptance. Fujitsu is targeting a price of $5,000 during mass production in 1996. This means that complete consumer systems should be available for less than $10,000.
- New technology developments are paving the way for introduction of three-dimensional televisions (3-D TVs) that allow viewers to see 3-D images without wearing special glasses. Sanyo has already exhibited a 3-D video projection system and announced that it intends to begin shipping systems outside Japan in late 1996. Shipments for use in commercial applications, arcade games, and medical equipment began in 1994. Sanyo's 40-inch 3-D LCD system employs twin LCD projectors that cast the images onto a double lenticular lens screen. This screen then separates the signals into right side and left side images, resulting in the illusion of 3-D images without the use of special glasses. Also, a company called HinesLab Inc. announced in September 1995 that it had patented a display system that achieves true stereo 3-D images. The company claims that its system uses conventional optics and is built into a single display panel that affords users a greater degree of freedom, allowing anyone to sit in front of a monitor and experience

realistic moving images. Finally, engineers from the University of Alabama have demonstrated a prototype that pumps moving holographic stereogram images through an active matrix LCD. The prototype, called ICVision, is constructed using a 1-inch diagonal active matrix LCD from Kopin Corporation and a diffractive optical element for directing light through a series of slits, which form the left and right halves of the stereo image.

- Digital micromirror display (DMD) technology continues to be advanced by Texas Instruments. Texas Instruments has been working on DMD technology for decades. It has now developed a DMD device that measures 2 centimeters squared and holds between 300,000 and 480,000 movable aluminum mirrors, each about 16 square microns. By controlling the mirrors' movement, the device projects a brighter image than today's LCD-based video projectors. Employing processing techniques the company calls Digital Light Processing (DLP), TI now supplying evaluation kits for purchase by selected applicants. These subsystems, called DLP Digital Video, support a 640 x 480 display and are being shipped in the thousands of units at prices between $6,850 and $5,200. TI has also opened a center to showcase its digital imaging technology. The DMD device is now poised to make a direct assault on TFT LCDs in at least one application area, projection systems. If the micromirror begins to capture market share, it will be one of the few technologies developed since the commercial introduction of TFT LCDs to establish itself—by matching performance at about an equivalent price—in a specific application now dominated by the TFT LCD.
- The "V-Chip" (the V stands for violence) that identifies programs by content and allows consumers to block out objectionable shows was introduced in 1994. Although the major TV networks have voiced opposition to this scheme, legislation has been passed in the U.S. that mandates the use of V-chip technology in new TV sets. The V-chip will find its way into set-top boxes, VCRs, and TVs. Zilog Inc. has already announced that its Z89300 TV control and on-screen display chip family have the recommended TV program rating decoding and control capability. In volume production, this chip will be priced in the $4-to-$6 range. Europe has now launched its own debate over V-Chip technology. Adoption of the technology in Europe faces high hurdles because of opposition to a single standard for rating content. With 15 different countries and even more cultures, a common standard for moral decency will be hard to establish.

Functionally, color TVs have reached near-maturity, and the focus is being placed on improvement of productivity in the manufacturing process through digitization. Integration of peripherals devices into semiconductor chips allows reduction of components, and thus reduction of inspection/adjustment points. Also, an increasing use of microcomputers enables signal processing control by computer bus, leading to standardization of chassis design. Figure 4-8 shows a block diagram of a currently available multifunction, high-performance color TV.

Figure 4-8
Block Diagram of Multifunction, High-Performance Color TV



Source: Dataquest (September 1996)

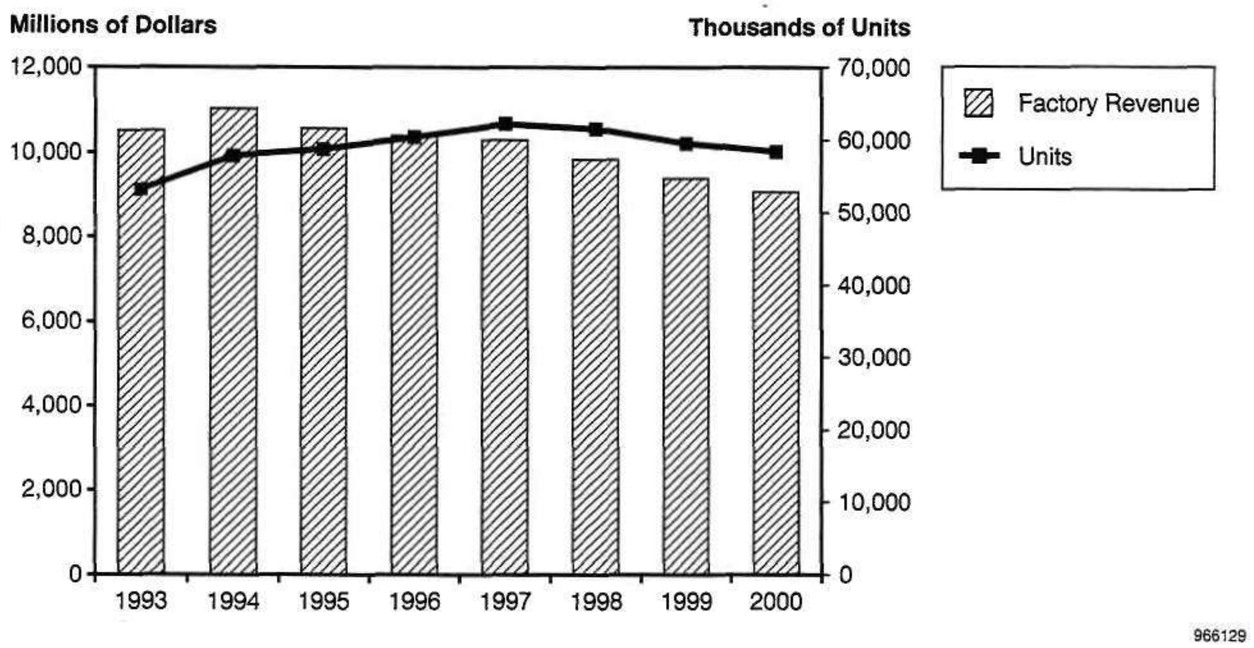
Major technological trends in electronic circuits for video equipment are classified as follows:

- Digital processing of image, voice, and mechanical control signals. Digital processing of video and voice signals for low-end products has been incorporated into ICs, except for CRT video and horizontal output circuits, which are configured by discrete devices.
- Ghost cancellation technology. Since the adoption of the Ghost Cancellation Reference (GCR) by the U.S. Federal Communications Commission (FCC) in May 1993, awareness of its technology has increased. Many more stations are including the reference in their transmission. Ghost cancellation technology is also being introduced to the public through a consumer standalone unit. With time, ghost cancellation will become more widely accepted, and the technology will become a commonly integrated feature of the television receiver or VCR.
- Interframe signal processing using TBC technology and semiconductor memory. Improved-definition TV (IDTV) and enhanced definition TV (EDTV) use digital memories to scan 525 lines at a frequency twice that used in the National Television Standards Committee (NTSC) standard. The use of digital memory also allows currently available color TVs to adopt technologies to improve picture quality by eliminating or reducing cross-color and jitter.
- Closed-captioning decoders. Closed-captioning decoders for the hearing impaired are now mandatory on U.S. market TVs.
- Use of the bus system for interactive control of ICs. In particular, the I2 bus technology patented by Philips is beginning to be adopted by color TVs.
- Incorporation of new features. Digitization of signal processing has promoted incorporation of new features, such as picture in picture, digital still, and on-screen display.

VCRs

Figure 4-9 and Table 4-9 show the forecast for worldwide VCR production. With high household penetration rates in the United States and popular alternative products such as Video-CD players in Japan and Asia/Pacific countries, Dataquest expects unit shipments and revenue for the next five years to remain essentially flat through 1997. Sales are now sustained by replacement, upgrades, and households adding a VCR. As new DVD Video players assert themselves in the market, they will cause the market for VCRs to start to decline, beginning in 1998. With the introduction of rewritable DVD players, the decline of the VCR market will accelerate, starting in the year 2000. Asia/Pacific is now the dominant region for VCR production. Figure 4-10 shows the distribution of VCR production by

Figure 4-9
Worldwide VCR Production Revenue and Unit Shipment Forecast



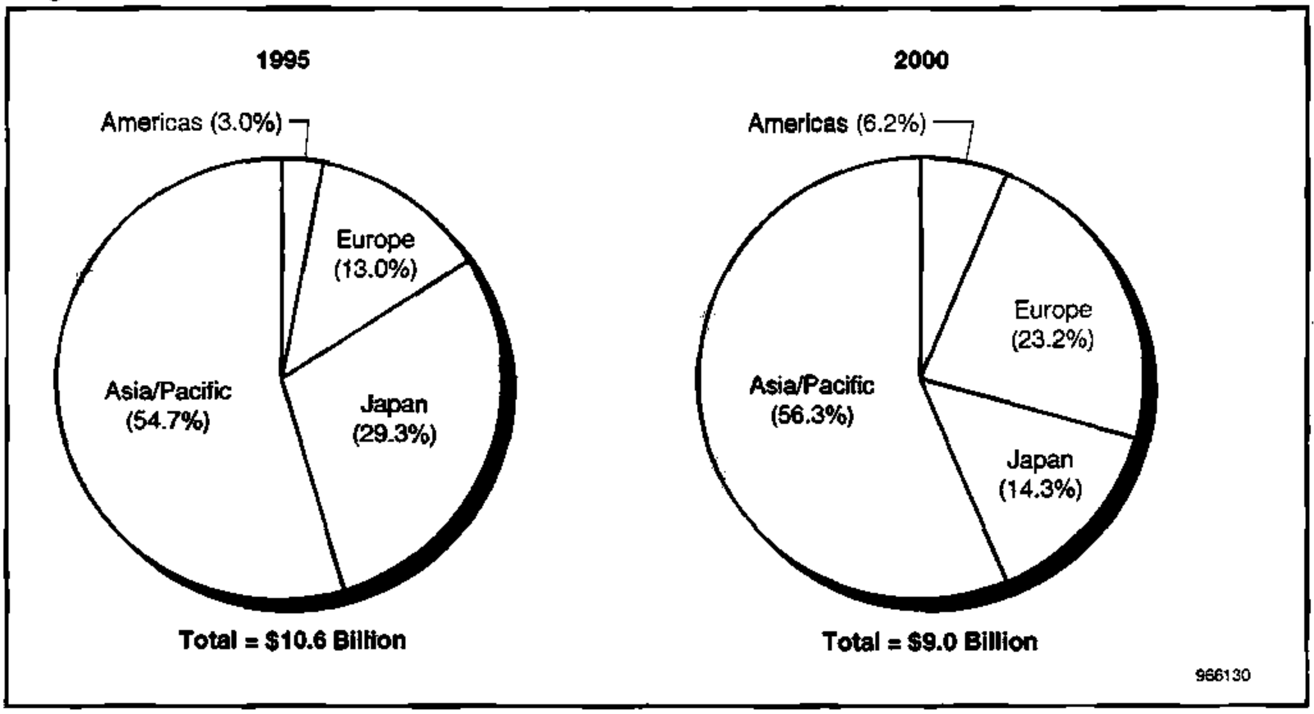
Source: Dataquest (September 1996)

Table 4-9
Worldwide VCR Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	53,133	57,930	58,821	60,456	62,276	61,613	59,583	58,465	-0.1
Factory ASP ($)	198	190	180	172	165	160	157	155	-2.9
Factory Revenue ($M)	10,521	11,035	10,569	10,395	10,294	9,838	9,374	9,049	-3.1
Semiconductor Content ($)	43	44	43	42	42	41	41	41	-1.0
Semiconductor Market ($M)	2,297	2,569	2,516	2,512	2,620	2,501	2,426	2,383	-1.1
Regional Production Trends (Percentage of World by Unit Production)									
Americas	2	2	2	2	3	3	4	4	
Europe	12	13	15	16	17	18	21	23	
Japan	30	27	22	20	18	15	13	12	
Asia/Pacific	55	58	62	62	62	64	62	61	

Source: Dataquest (September 1996)

Figure 4-10
Regional Share of VCR Production Revenue



Source: Dataquest (September 1996)

region. Tables 4-10 and 4-11 show the Americas VCR market and production forecast, respectively. Tables 4-12 and 4-13 list the leading VCR brands. Key trends to note among VCRs are as follows:

- The most popular upgrade feature is stereo audio. The 1996 market for home VCR will be heavily stereo-oriented. There will probably be a decline in the sale of mono models in the United States. Other advanced features include special effects with four heads and the S format, which offers more effective scan lines.
- The VCR Plus programming standard for simplified program recording is nearly a standard feature on step-up VCRs, and advanced features such as the Video Guide System are penetrating the VCR.

Table 4-10
Americas VCR Market Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	15,249	16,751	17,816	18,427	19,038	19,303	19,369	18,843	1.1
Factory ASP ($)	229	218	206	195	192	195	197	200	-0.6
Factory Revenue ($M)	3,492	3,652	3,670	3,593	3,655	3,764	3,816	3,769	0.5

Note: Does not include TV/VCR combinations or camcorders
Source: Dataquest (September 1996)

Table 4-11
Americas VCR Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	1,238	1,313	1,365	1,378	1,756	2,127	2,442	2,450	12.4
Factory ASP ($)	236	232	229	223	219	224	226	229	0
Factory Revenue ($M)	292	305	313	307	385	476	552	561	12.4
Semiconductor Content ($)	31	31	31	33	34	34	34	34	1.8
Semiconductor Market ($M)	39	41	43	45	59	72	84	84	14.4

Source: Dataquest (September 1996)

Table 4-12
U.S. VCR Brand Share Leaders, First Quarter 1995 through Fourth Quarter 1995 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
RCA	13.5	14.5
Magnavox	12.6	12.2
Panasonic	8.0	8.7
Emerson	7.5	5.4
Zenith	5.9	6.2
Sony	5.5	7.5
JVC	5.1	6.1
Sharp	5.0	4.5
GE	4.8	4.2
Sanyo	3.4	2.7
Others	28.7	28.0
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 4-13
U.S. VCR Brand Share Leaders, Second Quarter 1995 through First Quarter 1996 (Percent)

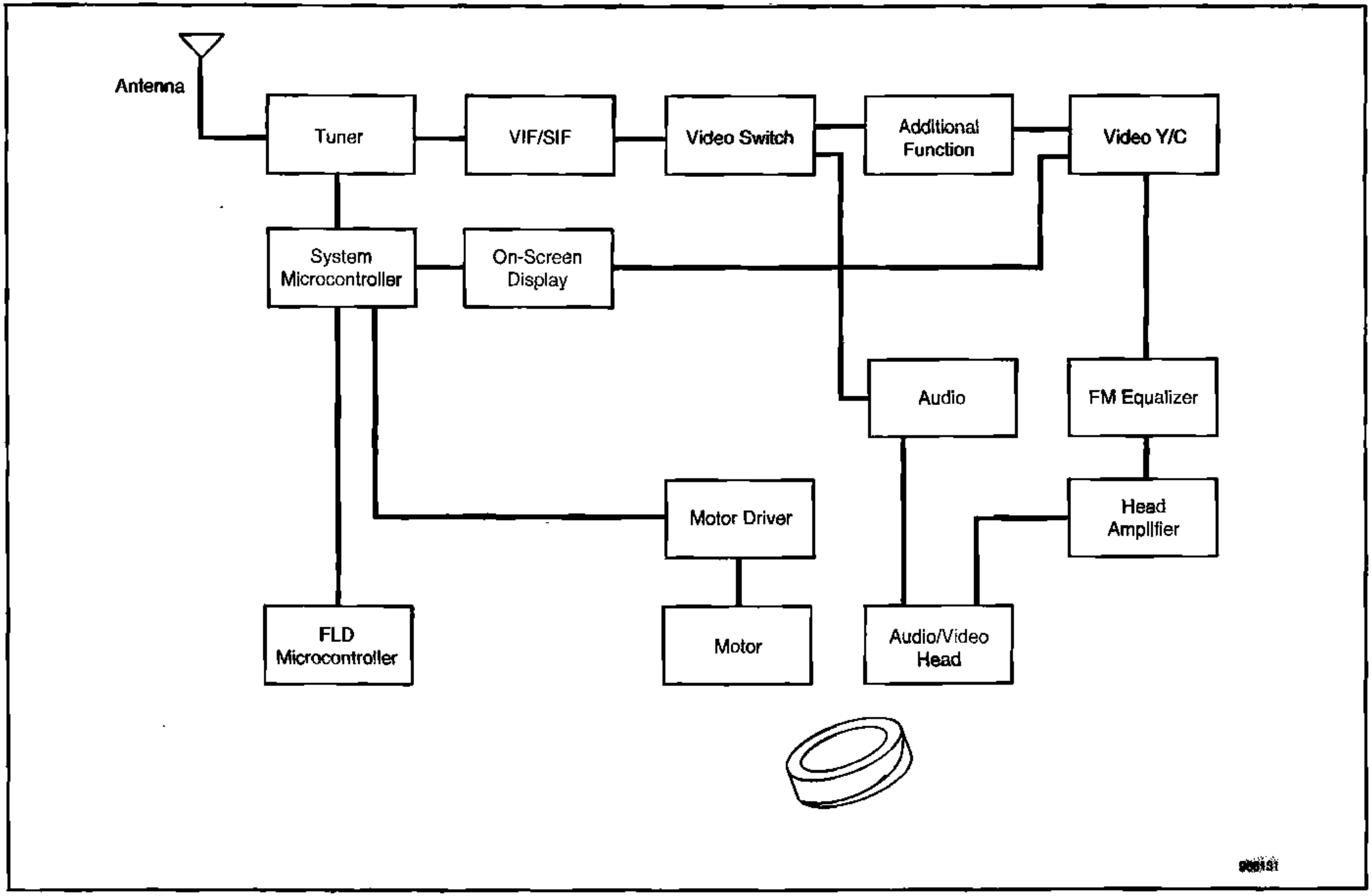
Brand	Unit Market Share (%)	Revenue Market Share (%)
Magnavox	13.7	12.9
RCA	13.1	14.0
Panasonic	7.9	8.6
Emerson	7.0	5.0
Sony	5.8	7.7
Zenith	5.8	5.8
JVC	5.5	6.6
Sharp	5.1	4.6
GE	4.7	4.1
Sanyo	3.4	2.7
Others	28.0	28.0
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

In terms of basic features and functions, VCRs have reached a stage of near perfection. Basic signal processing circuits are increasingly digitized by using analog-to-digital converters (ADCs) and digital-to-analog converters (DACs) and are eventually integrated into semiconductor chips incorporating digital signal processors (DSPs). New developments are expected in restoration of original signals, in addition to accurate replay, as well as the ability to provide output according to diverse consumer demand. Digitization has boosted the number of ICs capable of handling NTSC, PAL (European), and SECAM (French) formats. Also, the use of on-screen display ICs and filter-equipped ICs is reducing the number of components and adjustment points at the factory. Copy-protection circuitry from Macrovision is becoming more popular as both Philips and Texas Instruments are producing copy-protection chips. Figure 4-11 shows a block diagram of a typical VCR.

A new standard called Data-VHS (D-VHS) is being developed by VCR manufacturers, led by JVC. The new D-VHS system will be backward-compatible with the VHS format and would also add a bitstream recording capability to allow recording of compressed digital data. The standard would use existing Super VHS media and would be capable of offering 49 hours of recording per cassette. D-VHS will also record analog broadcasts such as NTSC and PAL. This feature would open new applications for VCRs in uses such as data storage and multimedia systems. JVC has consulted with Hitachi, Matsushita, and Philips Electronics in developing this new standard. Also, the following companies have expressed support for the D-VHS format: LG Electronics, Mitsubishi Electric, Samsung Electronics, Sanyo Electric, Sharp, Sony, Thomson Consumer Electronics, and Toshiba. Thomson is looking at D-VHS as an extension of its RCA Digital Satellite System (DSS) equipment line. D-VHS could record the actual digital direct-to-home satellite feeds of DirecTV and U.S. Satellite Broadcasting (USSB) programming.

Figure 4-11
Block Diagram of a Typical VCR



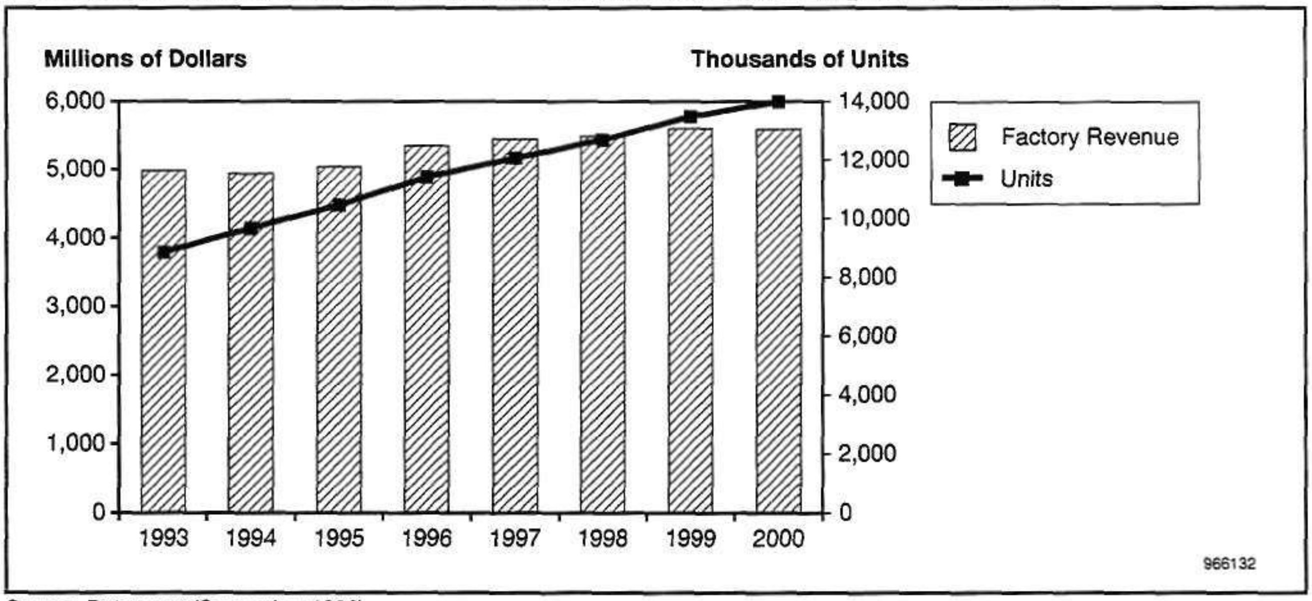
Source: Dataquest (September 1996)

The inclusion of digital recording capability will add $300 to $400 to the retail price of a VHS VCR. The first D-VHS VCRs hit the market in mid-1996. The higher price will present a significant barrier to market acceptance. A survey conducted by the Electronic Industries Association explored U.S. consumer interest in a digital VCR. When digital VCR was described to them, 29 percent of the VCR owners said they would be interested in purchasing it and 22 percent were unsure. However, when asked about the price they would be willing to pay, 25 percent of respondents said they would pay $400, 11 percent would pay $600, 3 percent would pay $800, and 5 percent would pay $1,000.

Camcorders

Figure 4-12 and Table 4-14 present Dataquest's forecast for worldwide camcorder production. Growth in revenue and shipments will be healthy during the next five years. Tables 4-15 and 4-16 present the Americas market and production forecast, respectively. Figure 4-13 shows the production distribution by region. Japan is the primary location for production of camcorders. In spite of some shifting of production to Europe, Japan will still produce the large majority of camcorders through 2000. Tables 4-17 through 4-18 show the leading camcorder brands in the United States.

Figure 4-12
Worldwide Camcorder Production Revenue and Unit Shipment Forecast



Source: Dataquest (September 1996)

Table 4-14
Worldwide Camcorder Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	8,833	9,659	10,457	11,410	12,071	12,683	13,474	13,994	6.0
Factory ASP ($)	564	512	482	469	451	432	416	399	-3.7
Factory Revenue ($M)	4,984	4,942	5,037	5,350	5,444	5,485	5,601	5,590	2.1
Semiconductor Content ($)	144	133	125	117	114	112	111	108	-2.9
Semiconductor Market ($M)	1,276	1,288	1,306	1,330	1,372	1,418	1,489	1,512	3.0
Regional Production Trends (Percentage of World by Unit Production)									
Americas	1	0	0	0	0	0	0	0	
Europe	10	14	15	17	18	19	20	20	
Japan	88	81	81	79	78	77	77	76	
Asia/Pacific	1	4	4	4	4	4	4	4	

Source: Dataquest (September 1996)

Table 4-15
Americas Camcorder Market Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	3,428	3,594	3,836	4,012	4,201	4,400	4,612	4,834	4.7
Factory ASP ($)	630	621	596	586	581	578	577	577	-0.6
Factory Revenue ($M)	2,159	2,232	2,286	2,351	2,441	2,543	2,661	2,789	4.1

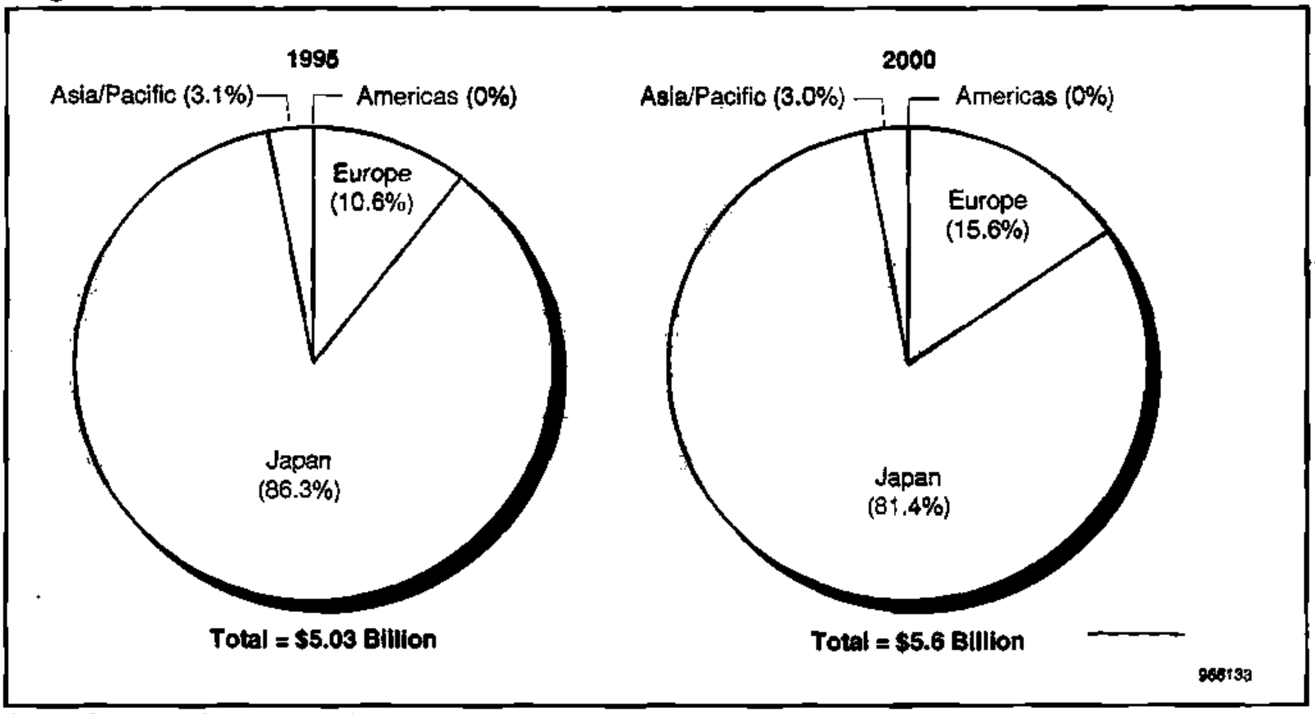
Source: Dataquest (September 1996)

Table 4-16
Americas Camcorder Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	50	15	0	0	0	0	0	0	NM
Factory ASP ($)	611	555	0	0	0	0	0	0	NM
Factory Revenue ($M)	31	8	0	0	0	0	0	0	NM
Semiconductor Content ($)	92	87	0	0	0	0	0	0	NM
Semiconductor Market ($M)	5	1	0	0	0	0	0	0	NM

NM = Not meaningful
Source: Dataquest (September 1996)

Figure 4-13
Regional Share of Camcorder Production Revenue



Source: Dataquest (September 1996)

Table 4-17
U.S. Camcorder Brand Share Leaders, First Quarter 1995 through Fourth Quarter 1995 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sony	22.8	26.1
RCA	18.7	18.3
Panasonic	15.6	15.7
JVC	12.6	11.9
Sharp	8.6	9.4
GE	4.3	3.2
Hitachi	4.2	4.8
Magnavox	3.5	2.6
Samsung	1.9	1.2
Canon	1.8	1.9
Others	6.0	4.9
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 4-18
U.S. Camcorder Brand Share Leaders, Second Quarter 1995 through First Quarter 1996

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sony	22.5	25.6
RCA	19.1	18.6
Panasonic	16.3	16.5
JVC	12.3	11.7
Sharp	8.5	9.3
GE	4.5	3.3
Hitachi	3.3	3.9
Magnavox	3.0	2.4
Canon	2.3	2.5
Samsung	2.2	1.5
Others	6.0	4.7
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Key trends to note among camcorders are as follows:

- More than 23 percent of U.S. homes have camcorders, although it is primarily homes with children that are buying camcorders. Aggressive pricing by some companies has pushed entry-level pricing well below $400. The hottest price points remain in the $700 to $800 range.
- The strong movement to compact versions is helping fuel new sales. S versions are beginning to win over resolution-conscious movie makers.
- Viewfinders that rely on LCDs rather than on traditional optical techniques are contributing to the impressive market surge for camcorders. The percentage of camcorders equipped with LCD monitors is more than doubling annually in Japan and abroad, according to statistics from Sharp, a leader in LCD technology implementation in camcorders. Sharp predicts that camcorders with built-in LCD monitors will represent 25 percent of all U.S. camcorder sales in 1996. Matsushita claims the number will be closer to 16 percent. Hitachi, JVC, Matsushita, Minolta, Sharp, and Sony all introduced new LCD-based products in 1996.
- The VHS-C format appears to be capturing a greater share of the U.S. market at the expense of the full-size VHS camcorders. According to the Photo Marketing Association, in 1991, the full-size VHS standard represented 42 percent of the U.S. camcorder market, with 8mm accounting for 37 percent and VHS-C for 22 percent. By 1994, the mix had shifted to: VHS, 26 percent; VHS-C, 38 percent; and 8mm, 36 percent. In 1995, it appeared that VHS-C and 8mm were neck and neck at 41 percent, and VHS was declining to 18 percent of the market. (JVC claims that VHS-C captured 44 percent of the market, compared with 37 percent for 8mm in 1995.) JVC is now forecasting that, by the end of 1996, VHS-C will grow to 46 percent of the market while VHS sinks to 15 percent and 8mm holds steady at 37 percent.

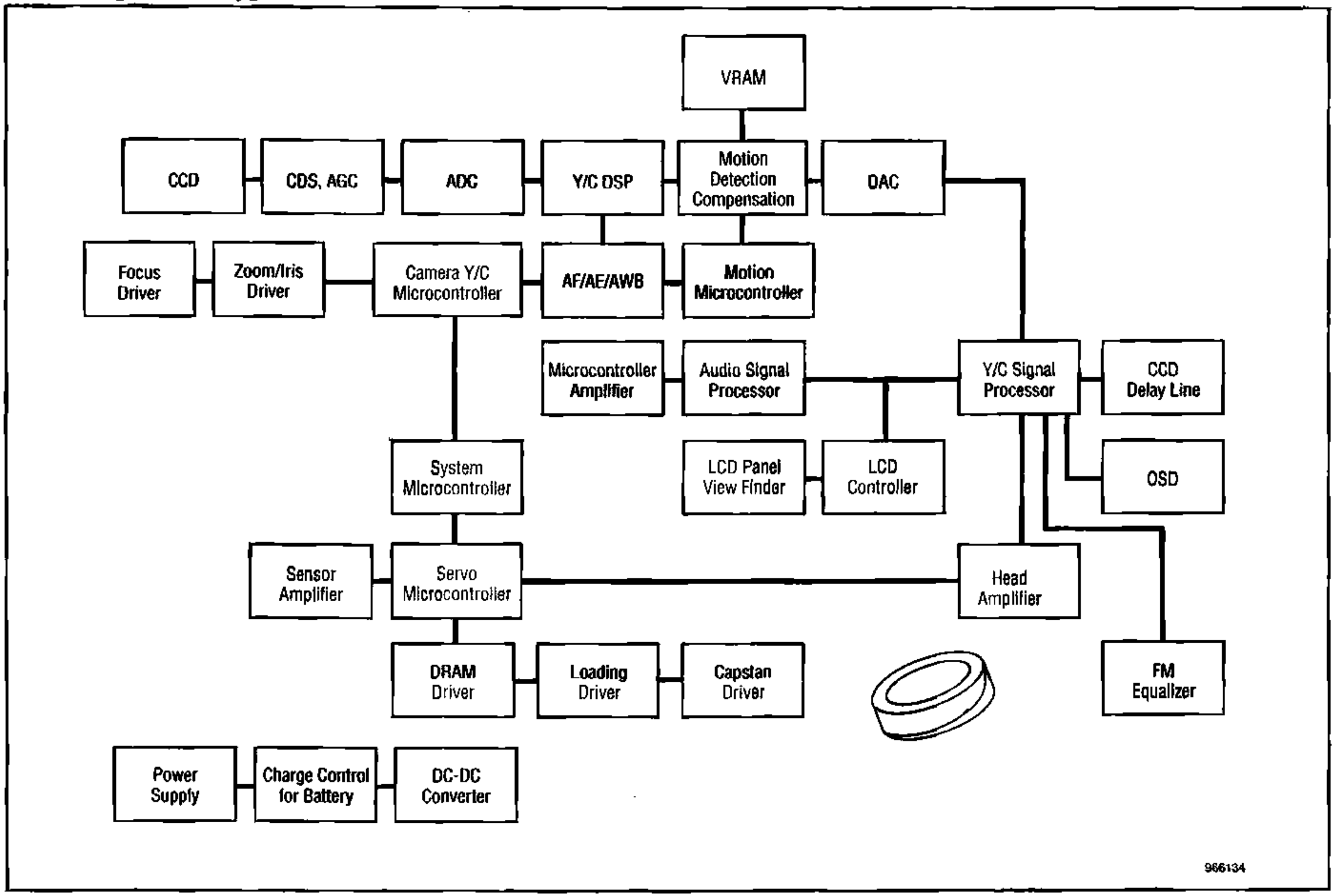
Figure 4-14 shows a block diagram of a typical camcorder. Some technology features and trends with implications for semiconductor opportunities are:

- Charge-coupled device (CCD) makers are increasing their share in the camcorder market. CCDs are becoming smaller and are accommodating more picture elements.
- CCD output signals, which have been conventionally analog processed, are converted to digital signals through a 10-bit DAC and, after luminance and chrominance (Y/C) signal processing by the DSP, are sent to the processing stage for functions such as blur correction and electronic zooming. Auto focus/auto iris/auto white balance (AF/AE/AWB) detection has been integrated into digital circuits on a single chip. Peripherals circuits related to blur correction consist of fuzzy logic circuits for motion detectors, blur-correction control, and memory control, which are incorporated into standard cells (DSPs).
- Mechanism control is handled by an 8-bit microcomputer (servo microcomputer). With the increasing emphasis on portability, development efforts are being shifted from low power consumption to lower operation voltage to 3.3V (3V). Further demand for high-performance camcorders will encourage digital processing, incorporation of a battery charge circuit into a single chip, and development of a single/hybrid chip.
- In the video equipment market, advanced technology developed for industrial use (broadcast equipment) is finding its way to consumer applications that demand much lower levels of picture quality. Various technologies unique to consumer products, such as blur correction, have been commercialized. At the same time, because color TVs, VCRs, and camcorders share common features, new technology developed for any of them is diffused to others.
- Vibration or shake compensation has become a key feature in camcorders, equal in importance to compact, lightweight design and strong-magnification zooms. There are two approaches to shake compensation, one electronic and the other optical. Recently, almost all but the low-end camcorders have adopted some version of electronic shake compensation.
- With the adoption of digital camera circuits, many camcorders feature digital zooms allowing greater magnification. For example, combining a 12X optical zoom lens with a 2X digital zoom function makes it possible to record images at 24X magnification.

Digital Camcorders

The first digital camcorders were introduced in 1995. These camcorders are based on the Digital Video (DV) format specification for home-use digital camcorders that was agreed to by 55 manufacturers as part of the HD Digital VCR Conference. Matsushita and Sony were the first manufacturers to offer digital camcorders, followed by JVC and Sharp. Hitachi is expected to introduce its digital camcorder. The Hitachi camcorder will record on a floppy disk that can be inserted into a PC instead of on a tape. As with most of the new digital video products, the steep pricing of these new camcorders will limit the potential market to semiprofessionals and the top 1 percent to 2 percent of the consumer camcorder market. Pricing on these early models ranges from $2,200 to $4,700.

Figure 4-14
Block Diagram of a Typical Camcorder



Source: Dataquest (September 1996)

To record image signals, camcorders using the DV format adopt the digital component system, recording luminance and chrominance signals separately. This format provides a resolution of 500 horizontal lines. Instead of the standard 0.3-MHz color signal bandwidth, the DV format works with a 1.4-MHz bandwidth. The format also calls for a built-in time base correction (TBC) function to diminish jitter. Audio recording involves the use of pulse code modulation (PCM) stereo. There are two possible audio modes. For audio quality equal to that of compact discs and digital audio tapes (DAT), a 16-bit sound system using two channels and 48-KHz sampling frequencies can be used. The specification also defines a 12-bit audio system with four channels and 32-KHz sampling frequencies. The interface format for connecting to personal computers is still being finalized, but it appears that it will be based on the IEEE-1394 standard.

As mentioned previously, Matsushita was one of the first manufacturers to bring a digital camcorder to market. This first model integrated 2.5 million transistors into five main video chips on a 0.5-micron process. Two of the chips, error correction and digital modulation devices, are produced by LSI Logic. A PCM device is made by Mitsubishi Electric. Mitsubishi can use the PCM chip for its camcorder with Matsushita's agreement.

HDTV

HDTV is high-definition television, a technology that provides a quantum leap in video quality over conventional NTSC sets. Higher-quality television is everyone's desire, from the consumers who would like a better picture, to the broadcasters who would like to deliver nicer-looking content, to the equipment vendors, who would love to sell new, high-priced products. However, other technologies have emerged—both analog and digital—that can deliver higher-quality television at a much lower price. That, combined with the seemingly endless political hurdles HDTV must jump before it becomes a reality, makes it questionable if it is really worth all the trouble.

The Challenges of U.S. HDTV

- Political: The FCC must approve the system and then allocate space in the frequency spectrum to transmit the signals.
- Broadcasters: Head-end gear for HDTV currently is very expensive compared with NTSC gear.
- Receivers: HDTV sets intended for consumers require very expensive components and may never achieve enough volume to reduce costs significantly.

Political

For nine years, HDTV has been on an arduous journey through the U.S. political process. The end to that journey appeared to be in sight in May, when the U.S. Federal Communications Commission (FCC) endorsed a standard for HDTV that had been proposed by a Grand Alliance of seven industry and research organizations. In July, the four FCC commissioners advanced for public comment two separate proposals based on the Grand Alliance system.

Both proposals license to current TV broadcasters two channels, one to transmit their signals in an analog format and another for digital television. Under the terms of the proposals, the FCC would take back the licenses for the analog stations after about 15 years, forcing broadcasters to go fully digital. This transition period is intended to give consumers the chance either to upgrade to new digital TVs or to purchase digital converter boxes. The only difference between the two proposals comes in the total number of channels allocated for digital TV broadcasts. One of the proposals would reserve all television channels for digital broadcasting. The other proposal would allocate channels 60 to 69 to other services, such as mobile communications.

The House of Representatives in June solidly defeated a proposal requiring broadcasters to pay for their new digital spectrum. Thus, neither of the proposals forwarded for public comment by the FCC calls for frequency allocation auctions. The elimination of the possibility of frequency auctions is a major victory for broadcasters, as it removes a potentially major disincentive for them to offer HDTV programming.

However, although the actions of the FCC and the House of Representatives remove one hurdle in the way of HDTV, two major roadblocks remain.

The first problem facing the new proposals is a coalition of entertainment and computing leaders who oppose the Grand Alliance system. The coalition, called Americans for Better TV, contends the Grand Alliance proposal represents inferior technology that will favor foreign suppliers at the expense of American-based computer makers. At the heart of their objection to the Grand Alliance system is its inclusion of interlaced video, as opposed to progressive scanning. Interlaced video, the traditional scanning format for broadcast television, offers lower-quality pictures and is not suited for computer display, they contend. Led by high-profile spokespersons, including Microsoft's Bill Gates and film director Steven Spielberg, Americans for Better TV is asking the FCC to dump the Grand Alliance proposals and adopt a less stringent approach to HDTV standardization.

A second obstacle in the path of the FCC approval process is that the government and industry disagree over which proposals should be approved by the FCC. There is strong support in Congress and the White House for the proposal that would hold out channels 60 to 69 to auction off for other services. The government believes these channels can be auctioned off to generate cash, in light of the fact that more than $15 billion was garnered from wireless spectrum auctions. However, broadcasters claim that holding out these channels would crowd digital transmissions and cause serious signal interference in some situations. Broadcasters are supporting the proposal that would allocate all the channels for digital TV transmissions. After giving broadcasters and other industries a chance to comment, the FCC is scheduled to adopt final rules on the allocation of digital spectrum by the end of 1996.

There are even five lobbying organizations that promote HDTV in Washington, D.C. HDTV eventually will be approved by the FCC, but the FCC is now also supporting standard-definition (digital) television (SDTV).

Following are descriptions of the two key U.S. government bodies involved with HDTV:

- Federal Communications Commission: New spectrum is being allocated for digital broadcast TV. If digital broadcasting succeeds, under the two proposals for HDTV that have been forwarded, the FCC in 15 years will regain possession of the spectrum now used for analog TV channels and auction it off for up to $23 billion. Currently, 400 MHz of spectrum is allocated for broadcast TV; however, only about 120 MHz is used even in the biggest cities. The FCC chairman is Reed Hundt. Mark Corbitt is director of technical policy at the Office of Planning and Policy.
- Advisory Committee on Advanced Television Services (ACATS): A 50-member committee was established by the FCC in September 1987 to evaluate and recommend an HDTV standard for the United States. Former FCC Chairman Richard E. Wiley has been the chairman of ACATS since its inception. David Kettler is executive director of science and technology for BellSouth Corporation and cochairman of ACATS' Systems Analysis Working Party. CBS executive Joseph Flaherty is cochairman of the ACATS Technical Subgroup. Robert Hopkins is chairman of the ACATS Expert Group on Scanning Formats and Compression. Jules Cohen is chairman of the ACATS Field-Testing Task Force.

Broadcasters

Although the discouraging prospect of digital frequency auctions has been removed, broadcasters are unlikely to invest heavily in HDTV, because of the high cost of equipment. Instead, terrestrial broadcasters can always invest in more translators and more power for their transmitters. In October 1995, *Television Broadcast* magazine conducted a survey of TV station general managers. Of those surveyed, 88 percent of broadcasters expect to switch from tape to digital storage by the year 2000. Substantial costs will be incurred in the next five years to accomplish this. Also, 28 percent of broadcast general managers wish advanced television would just go away.

Receivers

The biggest challenge facing the acceptance of HDTV is the price of the receivers. If that price is too high, consumers will not buy them. If consumers do not buy the receivers, there will be no audience. If there is no audience, broadcasters will not be able to sell air time to advertisers. If advertisers do not buy air time, broadcasters will be unwilling to invest in expensive HDTV gear. Members of the Grand Alliance, the U.S. consortium of HDTV hopefuls, admitted in November 1995 that HDTV will not be available in the United States until 1998 at the earliest. Grand Alliance members remain confident that consumers will pay $3,500 for an HDTV receiver. Dataquest is much less optimistic that consumers will accept equipment at that price.

Problems with Wide-Screen TVs and HDTV Receivers

Beyond price, there are a number of other problems facing HDTV receivers. The following are problems presented by wide-screen TVs and HDTV receivers:

- Will not fit on standard TV production and assembly lines, therefore more labor and cost is required to transport the work-in-progress from one station to the next
- Too wide to fit through a standard-size doorway
- Too wide to fit in standard wall unit furniture
- Electron gun must be quite far from the screen so it can scan its full width at a reasonable speed
- As screen gets wider, glass must be thicker (and heavier) for structural strength. Difficult to mold a flat screen
- Proposed viewing distance for HDTV is half that for standard NTSC TVs. Therefore, the number of viewers within the optimal distance will be more than halved.
- Very heavy—about 200kg

Displays

There are a number of technologies that are being developed for HDTV displays, including plasma display panels (PDP), LED displays, flat thin cathode ray tubes, vacuum fluorescent displays (VFD), electroluminescent (EL) panels, and field emission displays (FED). One of the major hurdles in developing all these products is moving from a successful prototype to full-scale production.

PDP is a new flat panel display technology that has the potential to reduce the cost of HDTV receivers. Several Japanese suppliers are planning to enter the PDP market. Fujitsu in October is expected to begin production at a rate of 10,000 units per month of a 42-inch model that will be priced at ¥500,000 each (about $5,000 for the display alone). Hitachi Ltd. expects to enter the market for plasma displays in 1997. NEC in April 1998 is scheduled to begin full operation of a ¥25 billion ($226.6 million) PDP plant that will produce 40- and 33-inch displays.

The LED display is perhaps the biggest wild card of all the technologies being advanced for HDTV. If a blue LED and a green LED with good reliability and performance are successfully developed at the right price, this could enable a major displacement of the LCD panels that currently dominate the mobile PC market, paving the way for a new consumer display market.

Another technology slated for HDTV applications is the digital micromirror display (DMD) developed by Texas Instruments with its digital light processing (DLP) technology. TI has shown that it can create 400,000 micromirrors on a chip that is 17 microns square.

There also are Laser CRT and Direct Laser products under development. The United States continues to flirt with investment in the display arena to help the development of a U.S. display industry. This industrial investment debate revolves around whether the creation of a display industry in the United States is critical to its competitive stature or whether it would be better to leverage the R&D and production that is taking place in Japan and the Asia/Pacific region.

Standards and Organizations

Standards and organizations include:

- **Grand Alliance**: Digital HDTV Grand Alliance (United States). The alliance of the seven organizations that proposed four all-digital HDTV systems to ACATS in 1993. Formed on May 24, 1993, the seven member organizations are AT&T Microelectronics (now part of Lucent Technologies), Zenith Electronics Corporation, General Instrument Corporation, Massachusetts Institute of Technology, Philips Consumer Electronics, Thomson Consumer Electronics, and the David Sarnoff Research Center. AT&T and GI jointly built the video encoder, Philips constructed the decoder, Sarnoff and Thomson cooperated in building the transport subsystem, and Zenith built the modulation subsystem.
- **SDTV**: Standard-definition (digital) TV. FCC-approved standard for digital TV using standard-resolution NTSC displays within an HDTV broadcast system. Hitachi is the leading developer of down-conversion systems for turning HDTV signals into SDTV for display on standard TV sets.
- **MUSE HDTV**: Multiple Sub-Nyquist Sampling Encoding (also known as Hi-Vision). Japanese standard for analog HDTV developed in 1968 by NHK. MUSE uses a display with interlaced scanning with 1,125 horizontal scanning lines at 60 fields per second. Since 1990, between nine and 11 hours of Hi-Vision has been transmitted every day by satellite in Japan. Around the time of the Olympics, Japan Public Broadcasting Corp. (NHK) increased daily broadcast time to 14 hours. The commercial service launch for Hi-Vision is scheduled for late 1997. As of July 31, 1995, Hi-Vision TV sets were priced at about $5,618. Narrow MUSE is a slimmed-down version occupying only 6 MHz of bandwidth. The system uses digital signal processing, but the frequency modulation is analog. Developed primarily by Sony.
- **MPT**: Japan's Ministry of Posts and Telecommunications. In July of 1995, the MPT announced that Japan, too, would have a digital TV specification. The specification is similar to Europe's DVB. However, there has been strong resistance from manufacturers of Hi-Vision HDTV sets to a shift from analog to digital HDTV technology. Dataquest does not expect to see a major move to a digital HDTV product in Japan any time soon. Full-scale broadcasting of Hi-Vision HDTV is still planned to start in 1997. MPT's Digital Broadcasting Systems Division director is Tomofumi Yasunari.
- **DVB**: Digital Video Broadcasting Group, formed in September 1983. HDTV is no longer a priority in Europe, and HDTV efforts have been replaced by the pan-European DVB standard for digital TV. DVB is headquartered in Geneva, operating under the auspices of the European Broadcast Union and the German Ministry of Telecommunications. Four standards exist: DVB-S for satellite using quadrature phase shift

key (QPSK), DVB-C for cable using 64-quadrature amplitude modulation (64-QAM), DVB-T, for terrestrial broadcasting using coded orthogonal frequency division multiplexing (COFDM), and DVB-MS, a digital multipoint video distribution system (MVDS). The compression technology is MPEG-2 main level, main profile.

- DAVIC: Digital Audio Visual Interoperability Council. Standard-setting organization for digital TV, formed in January 1994, headquartered in Europe, following the DVB project. The chairman is Dr. Leonardo Chiariglione. The original DAVIC 1.0 specification was completed in June 1995. DAVIC 1.1, which was introduced at a June meeting in New York, adds specifications for Internet access and cable modems, among other enhancements. DAVIC 1.2, planned for December, adds items such as a communications application program interface (API) for Internet access and Asymmetrical Digital Subscriber Loop (ADSL) Asynchronous Transfer Mode (ATM) mapping.

Current Specifications

Tables 4-19 through 4-21 present major HDTV technical specifications.

Receiver Production and Market

- Dataquest's forecast for worldwide production of HDTV receivers is shown in Table 4-22 and Figure 4-15. The North American market and production forecasts are presented in Tables 4-23 and 4-24, respectively. Table 4-25 shows sizes and prices for current HDTV models on the market.

Table 4-19
Grand Alliance Specification

	Specification
Resolutions and Frame Rates	1280 x 720; progressive 24-, 30-, 60 frames per second
	1920 x 1080; progressive 24-, 30 frames per second
	1920 x 1080; interlaced 60-frames per second
Video Compression	MPEG-2 main level, high profile
Audio Compression	Dolby AC-3 digital audio (ACATS standard A/52)
Modulation	8-VSB
Data Rate	20 Mbps
Bandwidth	6-MHz bandwidth per channel (cable version can fit two HDTV signals within 6 MHz)
Others	188-byte MPEG-2 transport packets, packetized data transport structure with headers and descriptors; 4-byte header, 184-byte payload
	HDTV signal will be compressed by a factor of more than 60 to 1, from 1.2 billion bits per second to less than 20 million bits per second.

Source: Dataquest (September 1996)

Table 4-20
SDTV Specification

	Specification
Resolutions	640 x 480 (4:3 aspect ratio, VGA)
704 x 480 (16:9 aspect ratio, CCIR Rec. 601)	
Frame Rates	60 interlaced fields per second, 24-, 30-, and 60 frames per second (progressive)
Video Compression	MPEG-2 main level, main profile
Audio Compression	Dolby AC-3 digital audio
Modulation	8-VSB

Source: Dataquest (September 1996)

Table 4-21
DAVIC 1.1 Specification

	Specification
Resolution	640 x 480
Video Compression	MPEG-2 main level, main profile
Audio Compression	Musicam
Modulation	64-QAM for hard-wired networks (cable and telco)
Upstream Data Rates	1.544 Mbps and 256 Kbps

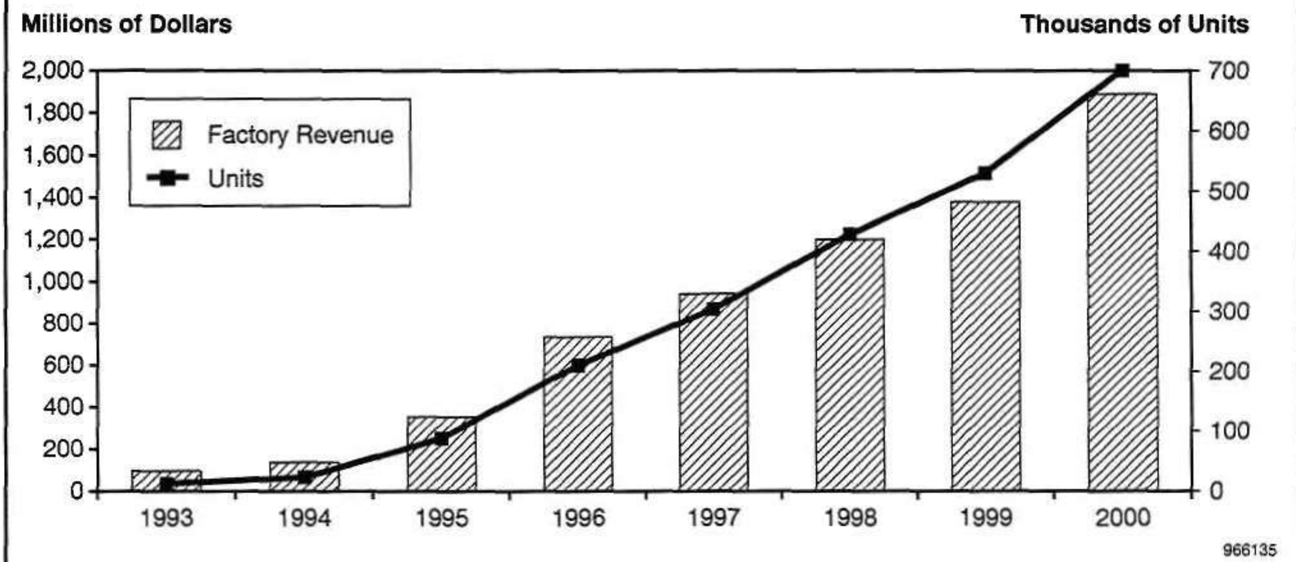
Source: Dataquest (September 1996)

Table 4-22
Worldwide HDTV Receiver Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	12	23	88	210	304	428	530	700	51.4
Factory ASP ($)	8,000	6,000	4,000	3,500	3,100	2,800	2,600	2,700	-7.6
Factory Revenue ($M)	96	138	352	735	942	1,198	1,378	1,890	40.0
Semiconductor Content ($)	700	540	450	400	363	340	315	300	-7.8
Semiconductor TAM ($M)	8.4	12.4	39.6	84	110.4	145.5	167	210	39.6

Source: Dataquest (September 1996)

Figure 4-15
Worldwide HDTV Receiver Production Forecast



Source: Dataquest (September 1996)

Table 4-23
Americas HDTV Receiver Market Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	0	0	0	0	1	9	16	37	NM
Factory ASP ($)	0	0	0	0	3,100	2,800	2,600	2,700	NM
Factory Revenue ($M)	0	0	0	0	3	25	42	100	NM

NA = Not meaningful
Source: Dataquest (September 1996)

Table 4-24
Americas HDTV Receiver Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	0	0	0	0	1	9	16	37	NM
Factory ASP ($)	0	0	0	0	3,100	2,800	2,600	2,700	NM
Factory Revenue ($M)	0	0	0	0	3	25	42	100	NM
Semiconductor Content ($)	0	0	0	0	363	340	315	300	NM
Semiconductor TAM ($M)	0	0	0	0	0.4	3.1	5	11.1	NM

NA = Not meaningful
Source: Dataquest (September 1996)

Table 4-25
Sizes and Prices of HDTV Sets (Fourth Quarter of 1995)

Size	Type	Price (Yen)
20 Inches	MUSE-to-NTSC only	-
24 Inches	MUSE-to-NTSC only	-
28 Inches	MUSE-to-NTSC only	200,000
32 Inches	MUSE-to-NTSC only	290,000
28 Inches	Hi-Vision HDTV	440,000
32 Inches	Hi-Vision HDTV	500,000
36 Inches	Hi-Vision HDTV	700,000
36 Inches	Rear projection	360,000
43 Inches	Rear projection	420,000
50 Inches	Rear projection	500,000
60 Inches	Rear projection	-
70 Inches	Rear projection	-
Up to 200 Inches	Front-screen projection	
(Mitsubishi and Sony are the leaders.)		

Source: Dataquest (September 1996)

Manufacturers of HDTV Sets

Manufacturers of HDTV receivers are as follows:

- Sony (also front- and rear-projection models)
- Toshiba
- Matsushita (Panasonic, JVC brands, also rear-projection models)
- Mitsubishi (also front- and rear-projection models)
- Sanyo
- Sharp (also front-projection models)
- Hitachi (also rear-projection models)
- Ikegami (also front-projection models)

Semiconductor Opportunities

HDTVs have a great deal of semiconductor content. Increasingly, intellectual property in DSP-based digital transmission, video manipulation, compression, and audio, to name a few areas, will be crucial for market participation. Key chip function opportunities include the following:

- Digital tuning (microcontroller, or MCU, controlled)
- Demodulation circuits for VSB
- MPEG-2 video decoder
- Digital video processing
- Forward error correction
- Transport depacketizer
- AC-2 (Dolby) six-channel CD audio decode

- Audio DAC and amplification
- 1MB to 2MB DRAM for decompression buffer
- Video RAMDAC (10 bits, 135 MHz)
- Infrared on-screen control display controls
- Closed captioning/ghost cancellation circuits
- Optionally: modem interfaces (for interactivity) and decryption

However, because of limited volumes, HDTV will not emerge as a major driver of semiconductor sales in this century. As was illustrated in Table 4-22, the worldwide semiconductor opportunity for HDTV sets will reach only $210 million in the year 2000.

DVD Video Players

In September 1995, Philips, Sony, and Toshiba announced an agreement to develop a single standard for the high-density digital video disc. DVD is the next generation of compact disc technology that is predicted to impact significantly consumer VCRs, as well as computer delivery of digital content, because of its several-gigabyte storage capabilities. The standard puts an end to a format war between two camps that was similar to the one that occurred in the early 1980s between the opposing consumer videotape camps, beta and VHS.

The agreement ended almost 10 months of format competition between the two primary camps: Multimedia CD (MMCD), led by Sony and Philips, and the Superdensity (SD) alliance, led by Toshiba, Matsushita, and Time Warner. The agreement between the two camps began lengthy negotiations to develop the final specification for DVD. From the perspective of the different manufacturers, perhaps the most important issue to be resolved is intellectual property rights. An immediate difficulty is the sheer number of companies involved in the DVD-format unification. At least nine companies have staked claims to become license holders: Sony, Philips Electronics, Thomson Multimedia, Hitachi, Matsushita, Toshiba, Mitsubishi, Pioneer, and JVC. Unable to reach an agreement in the DVD Consortium, Sony and Philips broke from the group negotiation as the end of 1996 was approaching and announced that they would license their patents independently. They invited other companies to join them in an attempt to bring DVD products to the market before the end of 1996.

In the announcement of the initial agreement, the parties stated their intent to release a final specification in December 1995. This was followed by promises to release the final specification almost every month during 1996. As of this writing, no final specification has been released. In the meantime, additional difficulties have been encountered because of disputes between Hollywood and the PC community over copy protection. Although the DVD manufacturers and the Hollywood community have reached agreement on an encryption scheme to protect content, the PC companies have not yet signed on to this agreement.

The end of 1996 is approaching, and DVD manufacturers are eager to ship products to the market before the end of the year. With major hurdles in the U.S. market still remaining, leading companies like Matsushita, Toshiba, Hitachi, and Pioneer have announced plans to ship DVD Video players in Japan beginning in October and November 1996.

Even though the near-term difficulties will not be solved easily, Dataquest is optimistic about the long-term prospects of the DVD market. A forecast for worldwide DVD production is presented in Table 4-26 and Figure 4-16. Figure 4-17 shows a representative block diagram of a DVD Video player. Some of the important elements of the DVD format that have been agreed to are as follows:

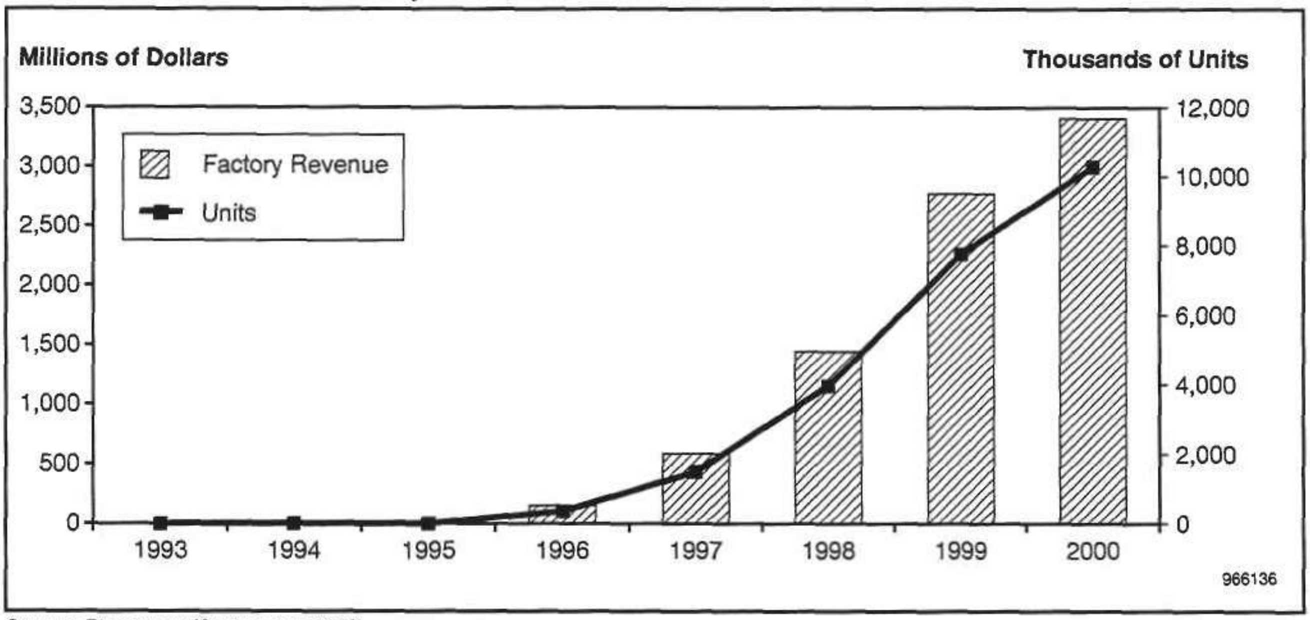
- 4.7GB storage in a single layer
- Dual-layer and double-sided discs
- Backward-compatibility with all current CDs
- MPEG-2 video compression
- AC-3, MPEG-2, and Linear PCM audio compression
- Compatibility between computer-based and consumer-based (television) products
- 0.6mm x 2 substrate thickness, bonded disc
- EFM Plus modulation/demodulation
- Reed-Solomon error-correction code

Table 4-26
Worldwide DVD Video Player Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	0	0	0	360	1,495	3,956	7,755	10,282	NM
Factory ASP ($)	0	0	0	428	394	365	357	331	NM
Factory Revenue ($M)	0	0	0	154	589	1,443	2,772	3,406	NM
Semiconductor Content ($)	0	0	0	146	133	122	116	108	NM
Semiconductor Market ($M)	0	0	0	53	199	481	903	1,112	NM
Regional Production Trends (Percentage of World by Unit Production)									
Americas				0	0	0	0	0	
Europe				1	0	0	0	0	
Japan				50	37	31	25	23	
Asia/Pacific				49	63	69	75	77	

NA = Not meaningful
Source: Dataquest (September 1996)

Figure 4-16
Worldwide DVD Video Player Production Forecast

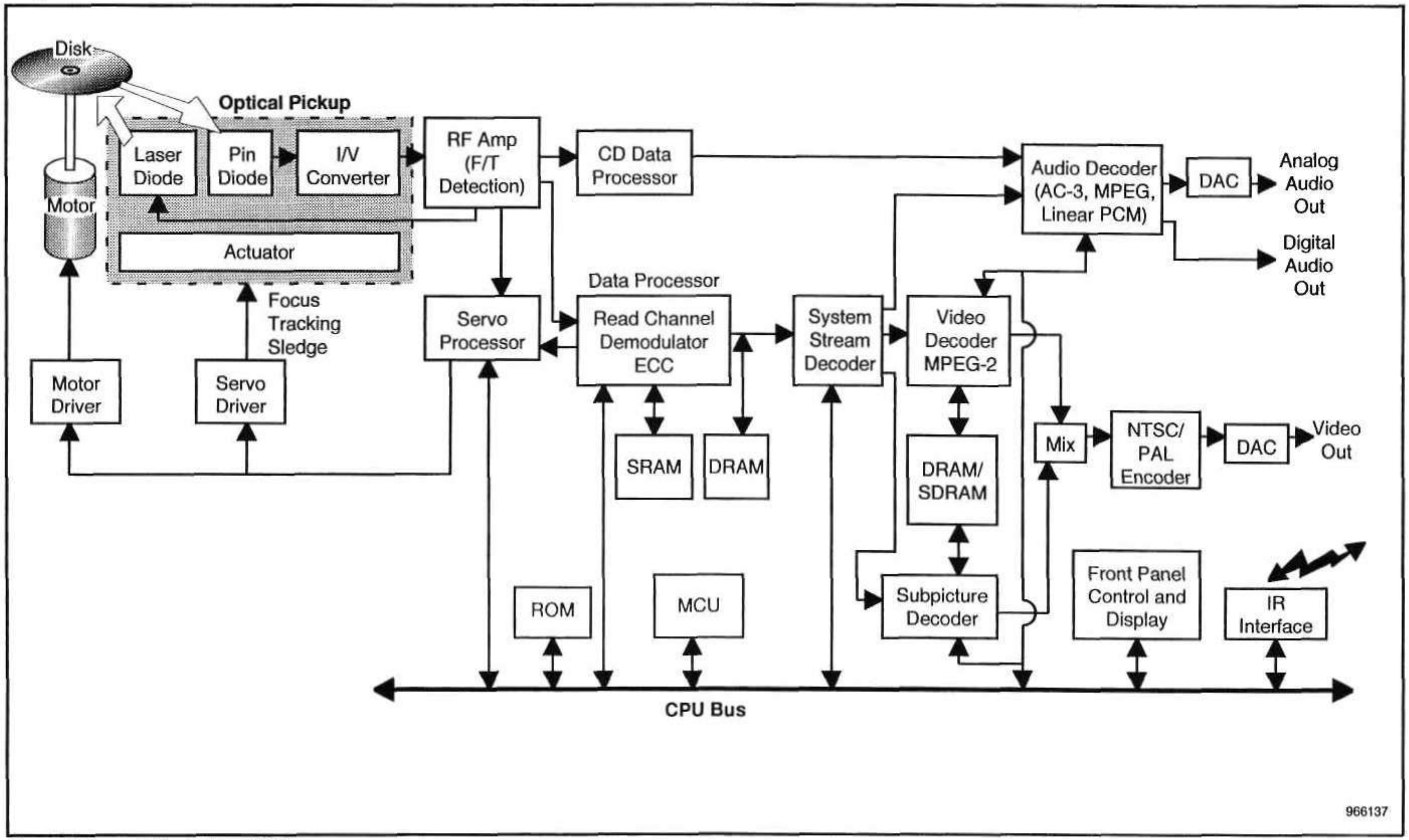


Source: Dataquest (September 1996)

Some of the important issues related to the rollout and development of DVD players are as follows:

- Initial pricing for DVD players was targeted at $500. It appears that the initial players will not hit that price. Instead, pricing in the United States will range between $600 and $700. Early prices for DVD Video players in Japan range between $750 and $900. Critical components such as the red laser diodes will drive higher initial costs; as they come down the price curve, it will be possible to lower system prices.
- There are concerns about the availability, supply, and pricing of 635/650nm red-laser diodes, which are a key element in DVD's high-density storage capacity. Although this is a concern for manufacturers eager to ramp production of DVD players quickly, it is not certain that market demand will materialize to meet the production plans of DVD manufacturers during 1996 and 1997. Pricing will be a hurdle in early market growth.
- Initially, players will be ROM only and eventually RAM and erasable. The draft format of a rewritable disc called the DVD-RAM was determined in late 1995. The rewritable DVD-RAM could use phase change (PD) technology (applying heat from the laser to change the recording layer from a polycrystalline structure to an amorphous state) or magneto-optic (MO) technology to store information. The draft specification calls for a capacity between 2.6GB and 3GB, with the wavelength of the laser diode in the range of 650nm to 680nm.

Figure 4-17
Representative DVD Video Player Block Diagram



Source: Dataquest (September 1996)

Video-CD Players

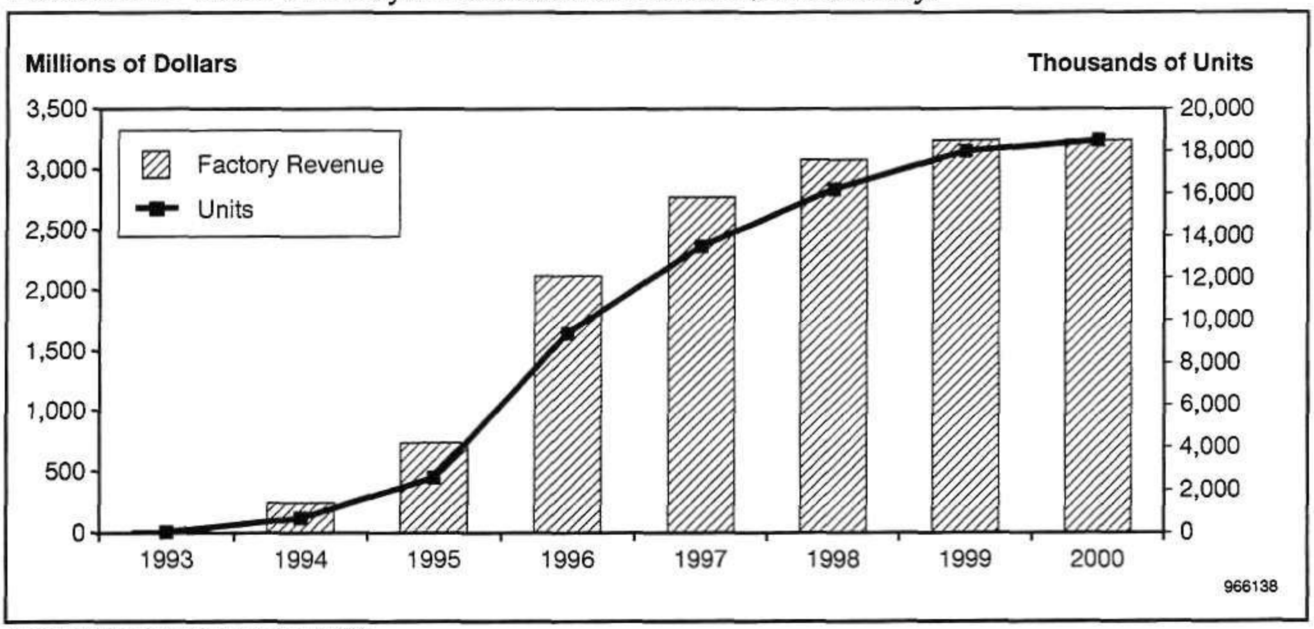
The market for early-generation video disc players, Video-CD, has grown much more quickly than called for by early predictions. Most industry observers expect market shipments to pass 8 million players in 1996, making this one of the most successful product introductions in the consumer electronics industry. Although Video-CD is virtually unknown in the Americas, it enjoys enormous popularity in Japan and the Asia/Pacific region. The most popular use of Video-CD is in karaoke applications. Video-CDs are also finding their way into PC applications. Manufacturers from Japan, Korea, Taiwan, and China are all competing in this market. As shown in Table 4-27 and Figure 4-18, Dataquest expects this market to continue its rapid expansion in the near term with growth tapering off approaching the year 2000.

Table 4-27
Worldwide Video-CD Player Production Forecast (Preliminary)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	38	685	2,580	9,400	13,500	16,200	18,000	18,500	48.3
Factory ASP ($)	460	354	285	225	205	190	180	175	-9.3
Factory Revenue ($M)	17	242	735	2,115	2,768	3,078	3,240	3,238	34.5
Semiconductor Content ($)	120	101	85	68	65	63	61	59	-7.2
Semiconductor Market ($M)	5	69	219	639	878	1,013	1,089	1,082	37.6

Source: Dataquest (September 1996)

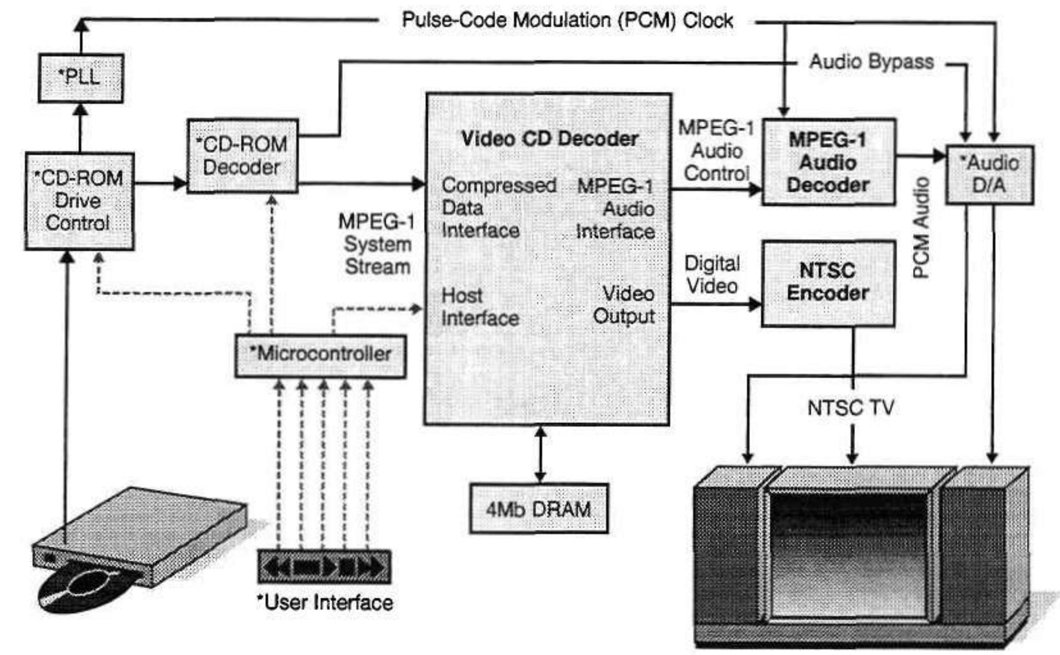
Figure 4-18
Worldwide Video-CD Player Production Forecast (Preliminary)



Source: Dataquest (September 1996)

These players use MPEG-1 technology and allow 74 minutes of storage for full-motion video. Figure 4-19 shows a block diagram for a Video-CD system. At 352 x 240/288 pixels, Video-CD's resolution is limited but has still found many applications in portable players and minicomponent systems, many of which use LCD displays.

Figure 4-19
Block Diagram of a Representative Video-CD System



*Components already included in CD player

Source: Dataquest (September 1996)

There are numerous Video-CD models, and it is estimated that there were over 7,000 Video-CD software titles available in 1996. Of this number, 3,000 were karaoke titles and 60 percent were targeted at non-Japanese markets. This number should expand dramatically as Video-CD players are introduced in India, with its prolific movie industry. One of the major issues surrounding Video-CD has been the large pirate movie industry associated with it. This has probably added to its success. Trade negotiations between China and the United States in 1996 focused on this issue, and a new agreement has been reached on intellectual property protection. Following this agreement, Warner Home Video and MGM/UA announced licensing agreements with one of China's largest manufacturers and distributors of Video-CD and laser disc (LD) hardware and software.

C-Cube Microsystems Inc. has been one of the major semiconductor winners in the Video-CD market, with design-wins for its MPEG-1 decompression chips in market leaders such as Sony and Sharp and a large majority of other Video-CD manufacturers. C-Cube has set an aggressive schedule to narrow the ultimate cost differential between audio CD and Video-CD systems to $30. Its initial MPEG-1 devices should allow manufacturers to produce Video-CD players for about $100 over the cost of audio CD products. The company hopes to halve that to $50 by 1997. Oak Technology Inc. is another chip company competing for the merchant market MPEG-1 chip business in Video-CD players.

Chapter 5
Interactive Products and Personal Electronics

Interactive consumer products include those that allow users real-time control of information presented on the TV screen. The primary examples covered here include interactive television and associated set-top decoder boxes and video games. Some visionaries are projecting that these technologies may merge, at least in part, in the coming decade with each other or with the standard TV set.

Interactive Television and Set-Top Box Definitions

"Set-top box" is a generic term that means different things to different industries. The seven product categories presented in Table 5-1 have all been referred to as "set-top boxes," based merely on their location in relation to the TV set.

This section will focus on the first category, pay-TV receivers. Within the combined pay-TV industries, the terminology used is "subscriber terminal." Figure 5-1 presents a diagram of an interactive system that shows how a subscriber terminal would be used in a cable, satellite, or telephone system. The following terms are also synonymous with pay-TV receivers:

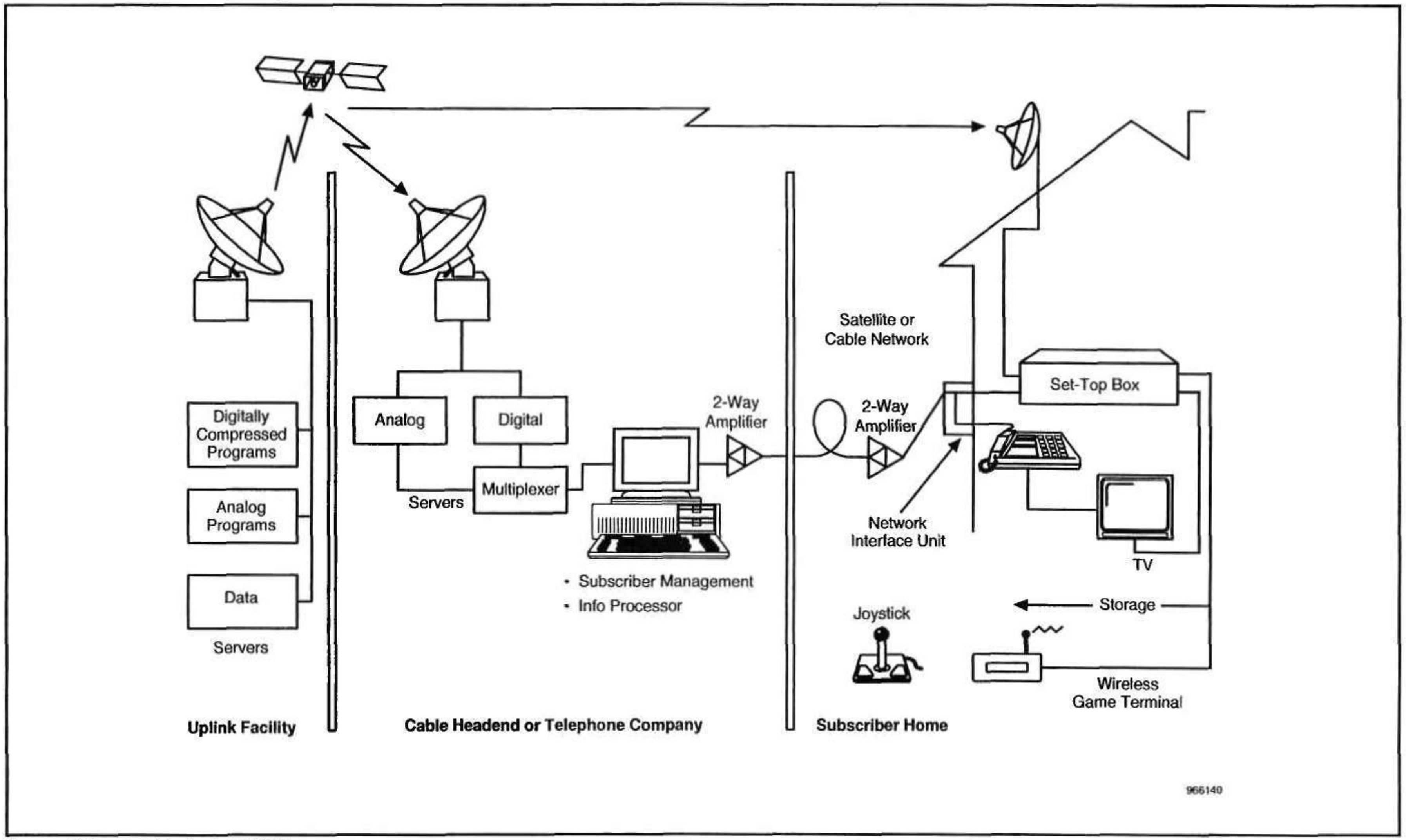
- Integrated receiver/decoder (IRD): satellite industry
- Customer-premises equipment (CPE): telco industry
- Subscriber terminal, cable converter: cable industry
- Compuverter, pay-TV receivers

Table 5-1
Descriptions of Various Products Referred to as "Set-Top Boxes"

Product	Description
Pay-TV Receivers	Includes cable, DBS, C-band satellite, MMDS, LMDS, and now telco
Dedicated Game Consoles	Examples: Sony PlayStation and Sega Saturn
Read-Only Multimedia Computers	Examples: 3DO and Philips CD-I. Formerly known at Dataquest as TV CD-ROM players. This category is being replaced by dedicated game consoles.
Backchannel Transmitters	Allow user to play along with networked sports and game shows—TV Answer, for example
Audio and Data Decoders	Used for nonvideo signals transmitted out-of-band in the vertical blanking interval, in-band video, or in-band audio. Include digital cable radio and closed captioning.
Navigational Systems	A special type of data decoder for electronic programming guides. Dedicated hardware systems exist, but most are being integrated into pay-TV receivers. Examples include StarSight, Prevue Network, and Interactive TV Guide
Data Storage Devices	Examples are VCR-Plus and Sega Channel Game Adapter

Source: Dataquest (September 1996)

Figure 5-1
Interactive Television Systems



Source: Dataquest (September 1996)

Subscriber terminals are further divided into the following four subcategories by technology:

- Nonaddressable analog
- Addressable analog
- Advanced analog (includes addressability and upstream communications)
- Digital

A digital set-top box includes a digital video decoder for receiving digitally encoded TV signals. The compression schemes are typically MPEG-2, but also include General Instrument's DigiCipher I and DigiCipher II. The difference between addressable analog boxes and advanced analog boxes is that advanced boxes also include an embedded modem for upstream communications. Embedded modems are the basic semiconductor components for receiving interactive services. Cable modems fall into a separate category, more closely related to PC modems than to set-top boxes. As subscriber terminals move from nonaddressable to addressable to advanced analog and finally to digital, almost every major component maker is eyeing this market as a major application area.

Markets for Subscriber Terminals

The following six network systems represent potential markets for subscriber terminals:

- Cable TV
- C-band satellite (also known as full-view satellite)
- Ku-band satellite (also known as DBS and DTH)
- Wireless cable (also known as MMDS)
- Cellular cable (also known as LMDS)
- Telco

Production and Market Forecast

Analog terminals will be buoyed temporarily by new sales in the wireless cable market. However, shipments of new digital terminals will overtake their analog predecessors by 1997. Now the cable industry is planning to introduce hybrid boxes capable of receiving both analog and digital signals. Because these boxes will include the expensive digital decoders and demodulators, we have included their projected sales in the digital terminals category.

Because of the controlled nature of the cable equipment business, competition in the set-top box market has been limited. With consumers given no choice of boxes to buy, analog set-top box pricing has been frozen, remaining at a selling price of about $105 for the last 10 years. As digital boxes become more prevalent, the average selling prices (ASPs) for analog boxes will finally begin to erode. There is a significant opportunity for system makers to reduce both the costs and the margins for DBS receivers over time. In fact, with the breakout of a DBS set-top box price war in the summer of 1996, system makers are being forced to cut the cost of their equipment just to stay competitive. The chief means of cost cutting is the use of cheaper, more highly integrated silicon.

Tables 5-2 through 5-4 show Dataquest's forecast for worldwide analog set-top box production, the Americas analog set-top box market, and the Americas analog set-top box production, respectively. Figures 5-2, 5-3, and 5-4 and Table 5-5 present the forecast for worldwide and regional digital set-top box production and average selling price forecast. Tables 5-6 and 5-7 show the Americas market and production forecast for digital set-top boxes. Figures 5-5 and 5-6 show worldwide and regional share of production by revenue for digital set-top boxes.

Table 5-2
Worldwide Analog Cable/Satellite Set-Top Box Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	10,719	12,233	11,505	11,388	11,115	10,890	7,583	6,790	-10.0
Factory ASP ($)	103	113	114	99	87	78	74	71	-8.9
Factory Revenue ($M)	1,107	1,388	1,309	1,131	970	846	564	485	-18.0
Semiconductor Content ($)	41	44	44	41	37	34	32	30	-7.0
Semiconductor TAM ($M)	441	535	501	462	413	372	239	206	-16.3
Regional Production Trends (Percentage of World by Unit Production)									
Americas	50	50	43	41	40	39	30	28	
Europe	40	41	44	43	38	26	20	14	
Japan	3	3	3	3	2	2	3	2	
Asia/Pacific	6	6	9	13	19	32	47	55	

Source: Dataquest (September 1996)

Table 5-3
Americas Analog Cable/Satellite Set-Top Box Market Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	4,860	5,490	4,500	4,230	4,050	3,870	2,070	1,710	-17.6
Factory ASP ($)	103	113	114	99	89	82	82	79	-7.1
Factory Revenue ($M)	501	620	513	419	360	317	170	135	-23.4

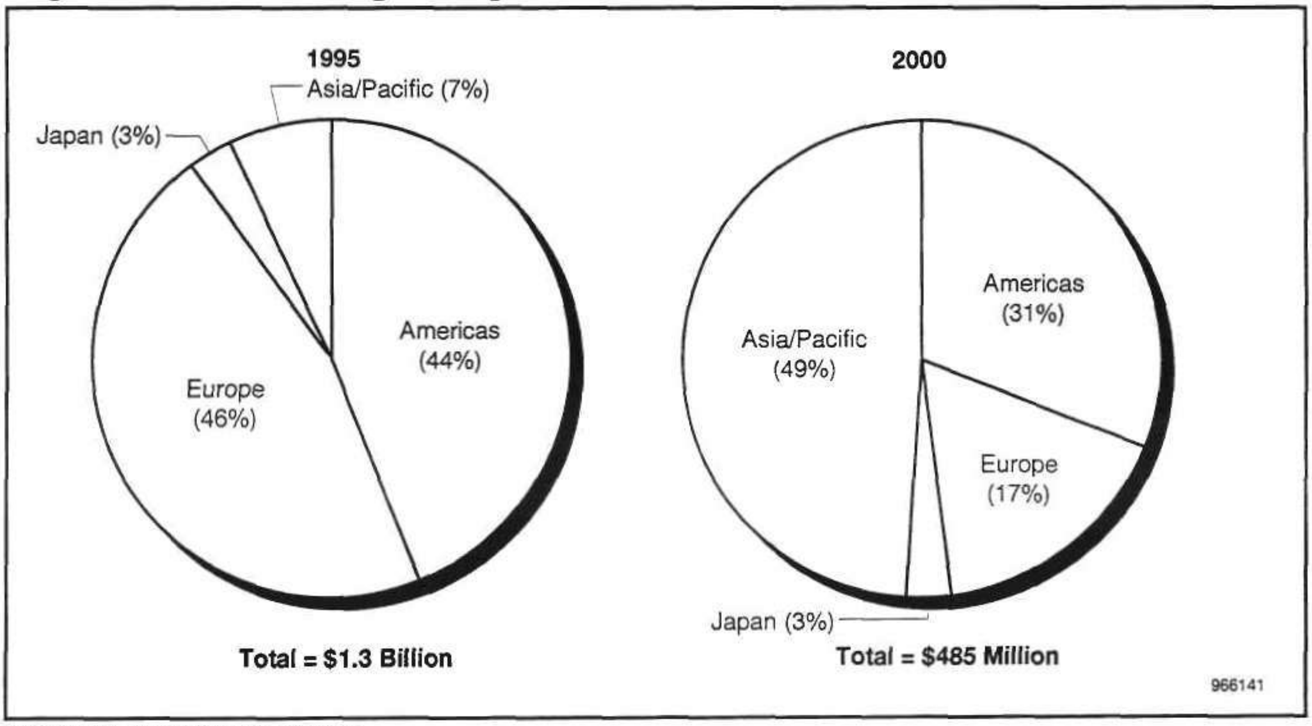
Source: Dataquest (September 1996)

Table 5-4
Americas Analog Cable/Satellite Set-Top Box Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	5,400	6,100	5,000	4,700	4,500	4,300	2,300	1,900	-17.6
Factory ASP ($)	103	113	114	99	89	82	82	79	-7.1
Factory Revenue ($M)	556	689	570	465	401	353	189	150	-23.4
Semiconductor Content ($)	42	46	47	43	38	35	32	31	-8.0
Semiconductor TAM ($M)	228	281	235	200	171	151	74	59	-24.2

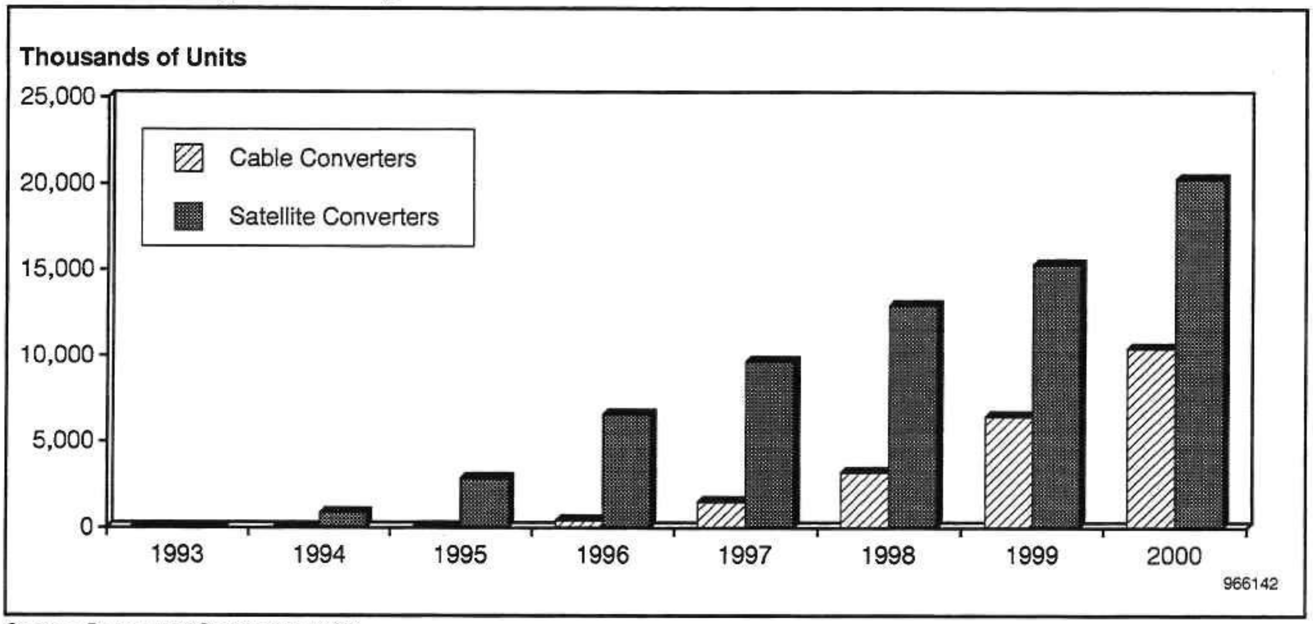
Source: Dataquest (September 1996)

Figure 5-2
Regional Share of Analog Set-Top Box Production Revenue



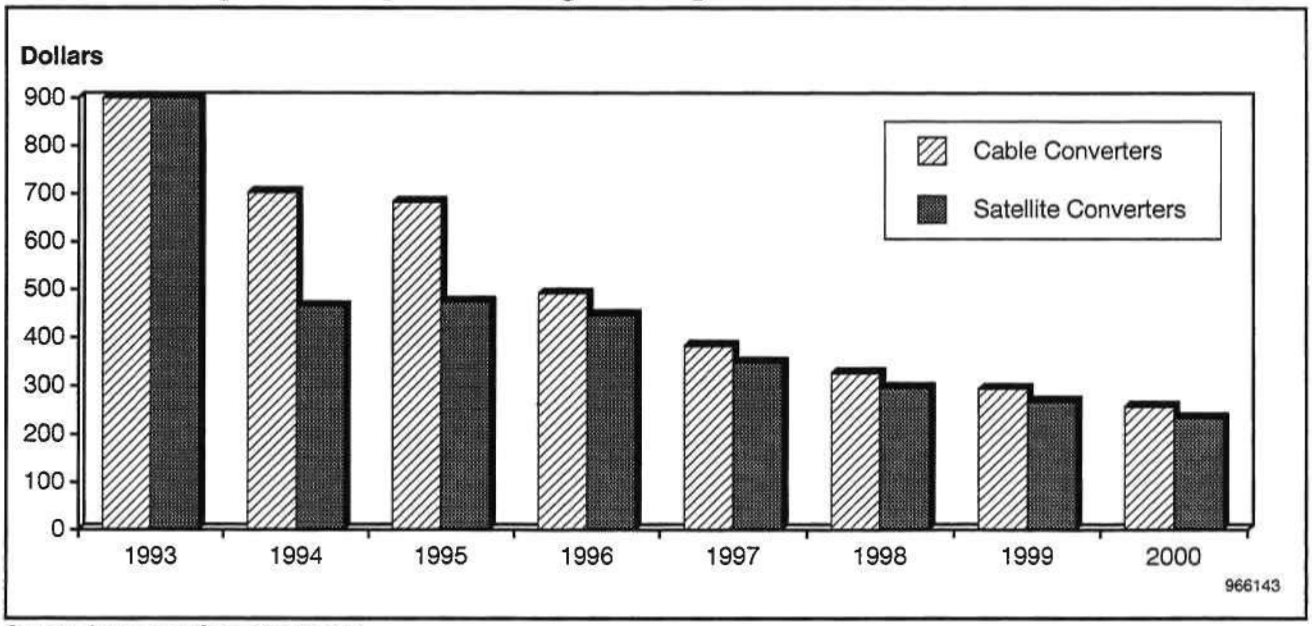
Source: Dataquest (September 1996)

Figure 5-3
Worldwide Digital Set-Top Box Production Forecast



Source: Dataquest (September 1996)

Figure 5-4
Worldwide Digital Set-Top Box Average Selling Price Forecast



Source: Dataquest (September 1996)

Table 5-5
Worldwide Digital Set-Top Box Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Cable Converters									
Units (K)	8	20	63	437	1,500	3,199	6,447	10,405	177.5
Factory ASP ($)	900	702	682	492	383	326	294	257	-17.8
Factory Revenue ($M)	7	14	43	215	574	1,043	1,895	2,671	128.2
Semiconductor Content ($)	474	272	208	190	174	138	132	124	-9.9
Semiconductor TAM ($M)	4	5	13	83	260	441	852	1,287	150.1
Satellite Converters									
Units (K)	1	874	2,841	6,579	9,655	12,903	15,295	20,255	48.1
Factory ASP ($)	900	465	474	447	348	296	267	233	-13.2
Factory Revenue ($M)	0	406	1,347	2,943	3,358	3,824	4,086	4,727	28.5
Semiconductor Content ($)	400	262	198	183	151	122	114	105	-11.9
Semiconductor TAM ($M)	0	229	562	1,204	1,458	1,572	1,744	2,127	30.5
Total Digital Converters									
Units (K)	9	894	2,904	7,016	11,155	16,102	21,742	30,660	60.2
Factory ASP ($)	900	470	479	450	352	302	275	241	-12.8
Factory Revenue ($M)	8	420	1,390	3,159	3,932	4,867	5,981	7,398	39.7
Semiconductor Content ($)	470	262	198	183	154	125	119	111	-10.9
Semiconductor TAM ($M)	4	234	575	1,287	1,718	2,013	2,596	3,414	42.8
Regional Production Trends (Percentage of World by Unit Production)									
Americas	93	98	73	49	40	33	33	28	
Europe	7	2	12	28	39	44	44	35	
Japan	0	0	5	6	4	3	3	4	
Asia/Pacific	0	0	11	17	18	20	20	33	

Source: Dataquest (September 1996)

Table 5-6
Americas Digital Cable and Satellite Decoder Market Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Cable Converters									
Units (K)	8	18	51	335	945	1,440	2,775	3,664	134.9
Factory ASP ($)	900	509	483	443	350	315	282	255	-12.0
Factory Revenue ($M)	7	9	25	148	331	453	781	935	106.7
Satellite Converters									
Units (K)	0	758	1,849	2,742	3,016	3,317	3,649	4,014	16.8
Factory ASP ($)	0	462	439	403	318	286	256	232	-12.0
Factory Revenue ($M)	0	350	812	1,105	959	949	934	931	2.8

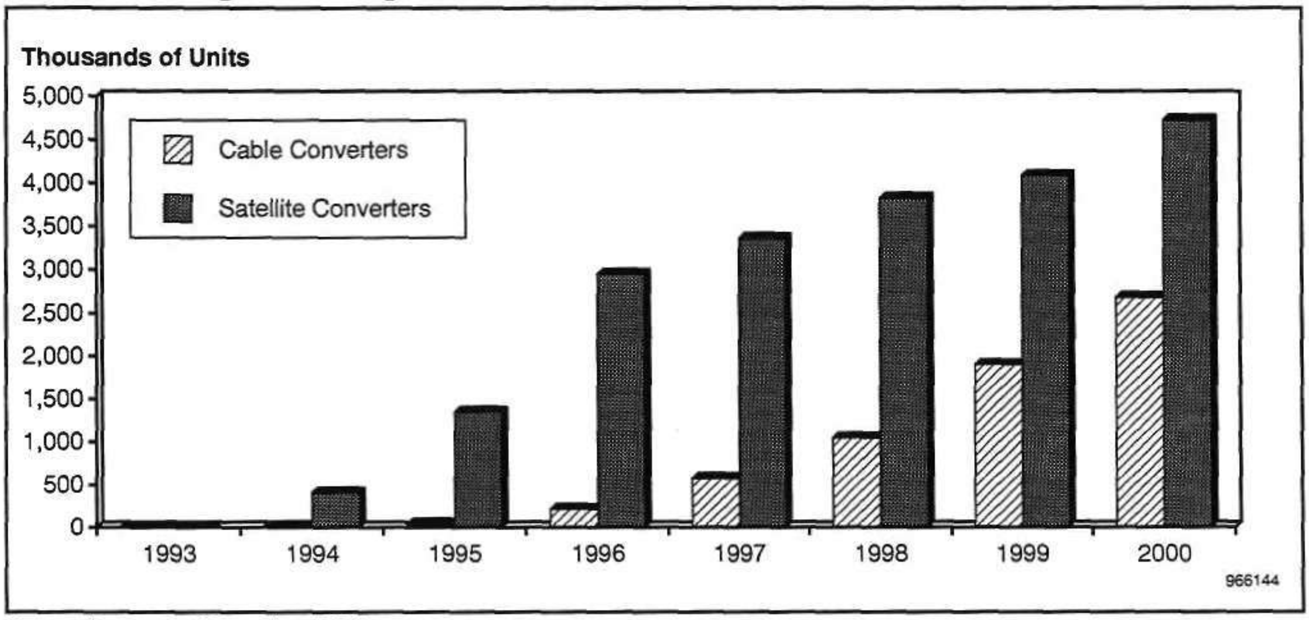
Source: Dataquest (September 1996)

Table 5-7
Americas Digital Cable and Satellite Decoder Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Cable Converters									
Units (K)	7	20	57	372	1,050	1,600	3,083	4,072	134.9
Factory ASP ($)	900	509	483	443	350	315	282	255	-12.0
Factory Revenue ($M)	6	10	28	165	367	503	868	1,039	106.7
Semiconductor Content ($)	479	287	204	197	172	141	138	133	-8.2
Semiconductor TAM ($M)	3	6	12	73	180	226	424	542	115.7
Satellite Converters									
Units (K)	0	842	2,054	3,046	3,351	3,686	4,054	4,460	16.8
Factory ASP ($)	0	462	439	403	318	286	256	232	-12.0
Factory Revenue ($M)	0	389	902	1,228	1,066	1,054	1,038	1,035	2.8
Semiconductor Content ($)	0	261	185	179	156	128	125	121	-8.2
Semiconductor TAM ($M)	0	219	381	544	523	473	507	540	7.2
Total Digital Converters									
Units (K)	7	862	2,111	3,418	4,401	5,285	7,138	8,531	32.2
Factory ASP ($)	900	463	440	407	326	295	267	243	-11.2
Factory Revenue ($M)	6	400	930	1,392	1,433	1,557	1,906	2,074	17.4
Semiconductor Content ($)	479	261	186	181	160	132	130	127	-7.4
Semiconductor TAM ($M)	3	225	392	617	704	698	931	1,082	22.5

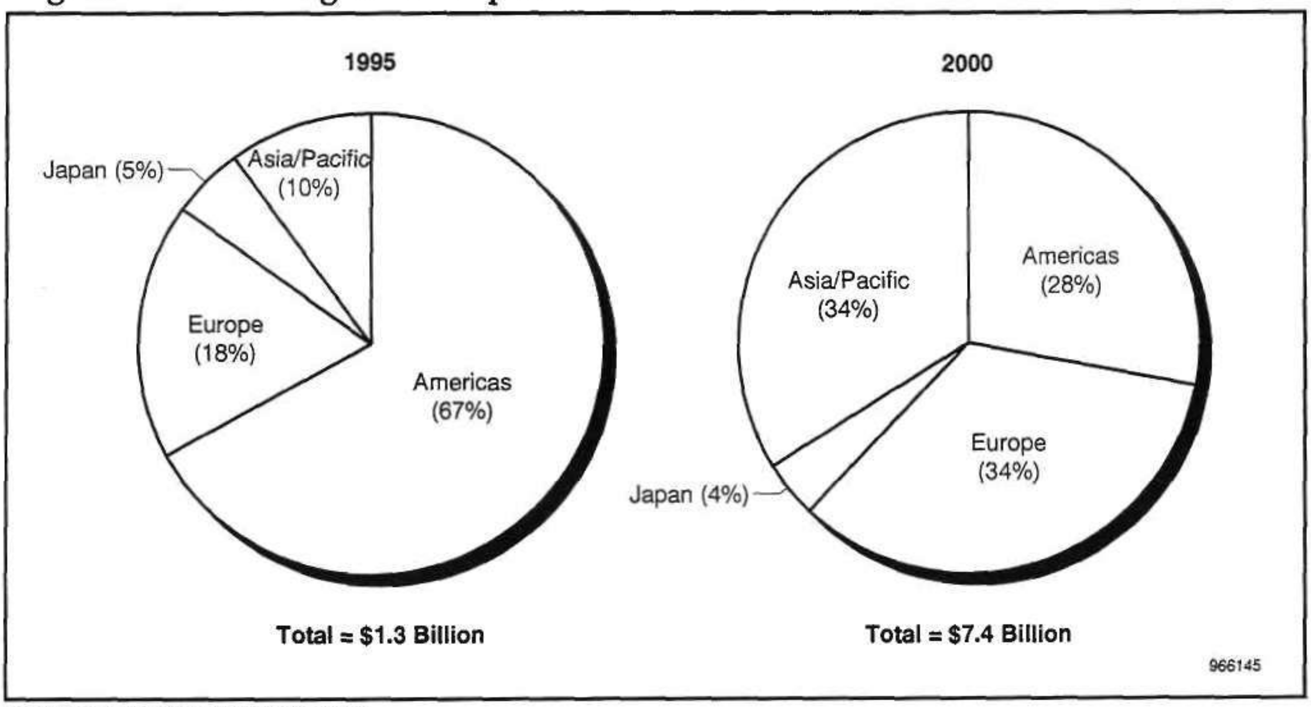
Source: Dataquest (September 1996)

Figure 5-5
Worldwide Digital Set-Top Box Revenue Forecast



Source: Dataquest (September 1996)

Figure 5-6
Regional Share of Digital Set-Top Box Production Revenue



Source: Dataquest (September 1996)

Technology Requirements

Figure 5-7 presents a generic block diagram of the type of technology required in interactive terminals. A generic set-top box will require a variety of technologies ranging from RF to CMOS (see Table 5-8). Likewise, the opportunities will range from standard products to ASICs as the box OEMs differentiate through design and cost structure. There are many layers of software involved, and companies like Microsoft are heavily involved in creating standard APIs to handle the various application programs managing the interactive services. The communication features are initially designed as modules that upgrade the basic terminal.

As shown in Table 5-9, the interactive terminal will require more features in the coming years, including embedded two-way capability, greater processing power, and support for higher bandwidth transmission links. The digital set-top box of 1996 is capable of digital reception, decompression, and audio/video processing. The video decompression standard primarily is MPEG-2, and audio decompression is Dolby AC-3 or MPEG. Line transmission opportunities include 8-level vestigial side band (8 VSB) or higher or 64-level QAM or higher. Error correction is needed to clean up the fast-moving bit stream, decryption for privacy, and a transport layer function for network overhead.

About 2MB of DRAM or tailored field memory is required for buffering. Many of the functions initially are ASIC-based, with the overall design controlled by the decoder box companies. Eventually, standard functions will dominate as cost reduction becomes paramount.

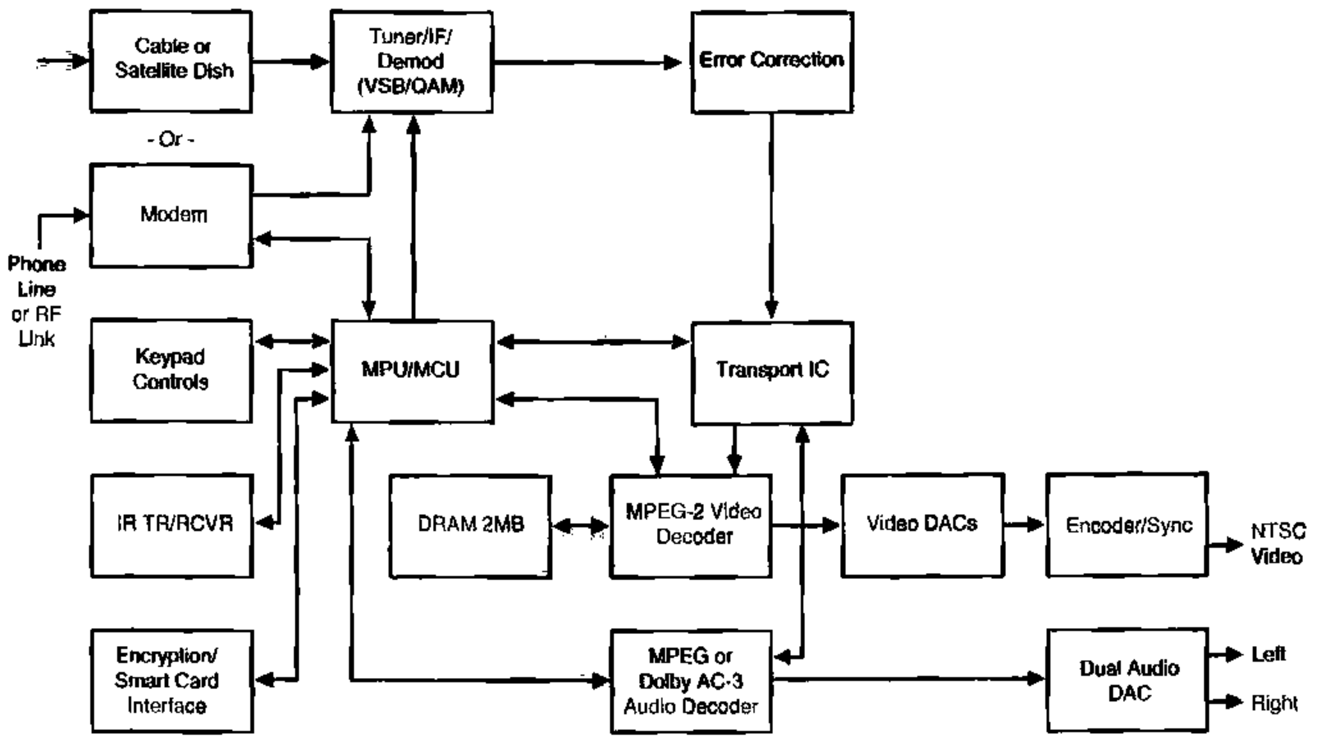
Manufacturers and Products

Thomson has emerged as the leading supplier of digital set-top boxes. Figure 5-8 presents a block diagram of Thomson's DirecTV Satellite decoder terminal. In 1995, Thomson Consumer Electronics (also known as Thomson Multimedia) shipped nearly 1.3 million DSS systems capable of receiving authorized programming from DirecTV or USSB. Table 5-10 shows the worldwide market share for leading manufacturers of digital cable and satellite decoder terminals in 1995.

General Instrument traditionally has been the leader in subscriber terminals, producing 3.9 million analog boxes for the cable industry in 1994. Scientific-Atlanta held the No. 2 spot with 1.7 million analog boxes in 1994. In Europe, Pace Micro Technology of West Yorkshire, England, claims to be the leading supplier of analog set-top boxes. Pace supplies boxes for the cable, satellite, and wireless cable markets.

We should note that changes occur in the cable equipment market very slowly. For instance, in 1982, GI shipped 2 million analog converter boxes. Eleven years later, in 1993, GI's shipments were up to 3 million units. The cable industry in the United States is slow to change because the nation is wired with a patchwork of 11,460 cable operators, each with a slightly different system.

Figure 5-7
Block Diagram of a Typical CATV/DBS Set-Top Box



Source: Dataquest (September 1996)

Table 5-8
Semiconductor Opportunities in Interactive TV

Semiconductor Function	Technology
Broadband Up/Down Conversion	Bipolar/GaAs
IF Processing	Bipolar
Modulation/Demodulation (VSB, QAM)	CMOS, bipolar
ATM/SONET Physical	Opto, bipolar, and BiCMOS
ATM/Network Protocol	CMOS
Transport Layer and Error Correction	CMOS
Video Standard Decode/Encode	Bipolar/CMOS
Video DAC	Bipolar
Video Conversion, Scaling	CMOS
Video Compression (MPEG-2, DigiCipher)	CMOS
Audio Conversion	Bipolar/CMOS
Audio Compression (AC-3, MPEG)	CMOS
DRAM	CMOS
VRAM/Field Memory	CMOS
Fast DRAM (SDRAM, FRAM)	CMOS
SRAM	CMOS
MPU (32/64-Bit RISC)	CMOS
Encryption (Decryption) Functions	CMOS
Modem (Up to V Fast)	CMOS
ASICs (for above Functions)	CMOS/bipolar

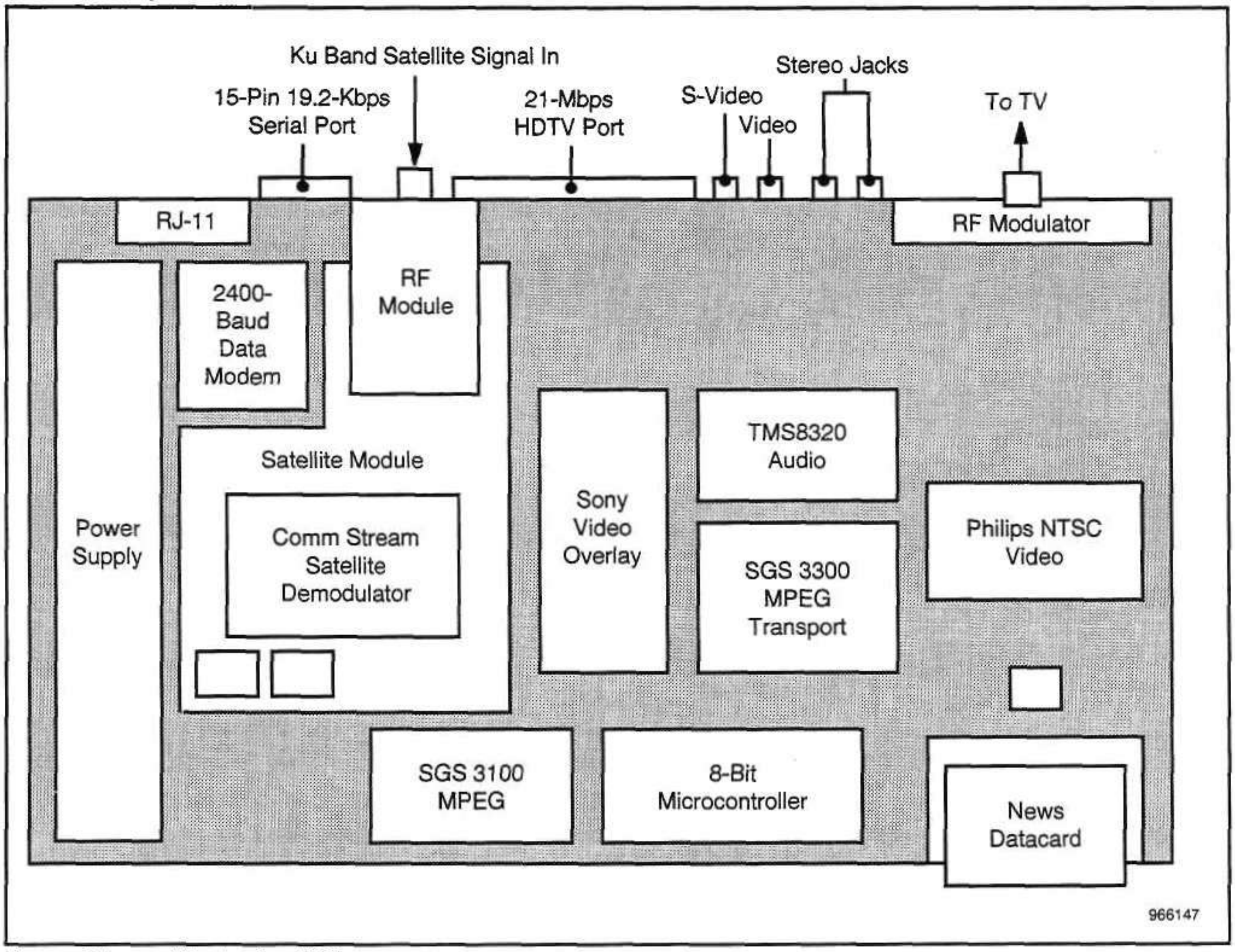
Source: Dataquest (September 1996)

Table 5-9
Interactive Television Technology Evolution

Category	1994	1996	1998
Transmission	Cable: analog; cable: digital test, 80 channels, FM subcarrier; fiber-optic/ADSL tests	Cable: analog/digital, 500 channels, IVDS, FM, VBI; Fiber-optic, ATM tests; QAM	Cable/DBS; digital/two-way, IVDS, FM, VBI; fiber-optic, ATM; QAM
Processing	Addressing, pay-per-view; DBS down conversion; bipolar/CMOS ASIC	Digital video, audio; MPEG decompression, error correction; bipolar/CMOS ASIC	Digital video, audio; MPEG decompression, error correction; bipolar/CMOS ASIC
Memory	2MB	2MB	2MB
Others	-	Modular design; security/decryption; digital radio	Modular design; security/decryption

Source: Dataquest (September 1996)

Figure 5-8
Block Diagram of Thomson's DirecTV Box



Source: Dataquest (September 1996)

Table 5-10
Worldwide Digital Cable and Satellite Decoder Revenue Market Share, 1995 (Percent)

Vendor	Unit Market Share (%)	Revenue Market Share (%)
Thomson	49.0	47.3
General Instrument	38.9	40.2
Sony	3.9	3.8
Others	8,2	8.9
Total	100.0	100.0

Source: Dataquest (September 1996)

However, with new network systems for delivering pay-TV signals (DBS, wireless, and telco), the market has opened up for suppliers from the computer, communications, and consumer electronics industries. Sony was the most significant new player to enter the market in 1995. Sony's RCA-DSS-compatible receivers succeeded in displacing Hewlett-Packard from the No. 3 spot it held in 1994. Besides Thomson Consumer Electronics and Sony, Toshiba America Consumer Products Inc., Uniden America Corp., Hughes Network Systems, Sanyo Electric Co. Ltd., Samsung Electronics Co. Ltd., Daewoo Electronics Co. Ltd., and Matsushita Consumer Electronics Co. have been licensed to manufacture DSS boxes and are expected to begin shipping in 1996. DirecTV Inc., a unit of Hughes Electronics Corporation, is the trademark holder of DSS. Table 5-11 lists advanced subscriber terminals and their manufacturers.

Table 5-11
Advanced Subscriber Terminal Manufacturers and Their Products (Digital Boxes Unless Otherwise Noted)

Manufacturer	Product
Adaptive Micro-Ware Inc.	DAVID (with Mitsubishi and Stellar One)
Apple Computer Inc.	M4120 (first generation) intend to OEM
AT&T Network Systems	Digital Home Terminal
Compression Labs Inc.	Media Access and Magnitude
Daewoo Electronics Co. Ltd.	DSS-compatible receiver
Divicom	Navigator 1000
EchoStar Communications	DISH DBS
General Instrument Corporation	CFT-2000 (analog), CFT-2200 DigiDock, CFT-2900 TCI, Primestar, DigiCipher I and II receivers
Hewlett-Packard Co.	Kayak
Hughes Network Systems Inc.	DirectPC, DSS-compatible receiver
IBM	Videoway Terminal (analog)
LG Electronics (Goldstar)	GIV-101
Matsushita Consumer Electronics Co.	DSS-compatible receiver
Mitsubishi Electronics America	STB-1000 (with Adaptive Micro-Ware and Stellar One)
Pace Micro Technology	DGT 400
Philips Consumer Electronics	Media Access, Consumer IRDs, and Magnavox for EchoStar
Pioneer North America	BA-9000, BAV-1000 Command Station, BA-6700 for Quantum (these are all analog, digital is Canal Plus DBS in France)
Samsung Electronics America	DSS-compatible receiver, AlphaStar receiver, and the PowerPC Digital Interactive Set-Top Box (ISTB)
Sanyo Electric Co. Ltd.	DSS-compatible receiver
Scientific-Atlanta Inc.	8600xD and 8600xDI (hybrid analog/digital boxes)
Sony Electronics Inc.	DSS SAS-BS1, SAS-BA1, and SAS-AD1
Stellar One Corporation	Stellar 1000 (with Adaptive Micro-Ware and Mitsubishi)
Tee-Comm Electronics Inc.	StarTrak Digital IRD
Thomson Consumer Electronics	RCA DSS-1 and DSS-2

(Continued)

Table 5-11 (Continued)
Advanced Subscriber Terminal Manufacturers and Their Products
(Digital Boxes Unless Otherwise Noted)

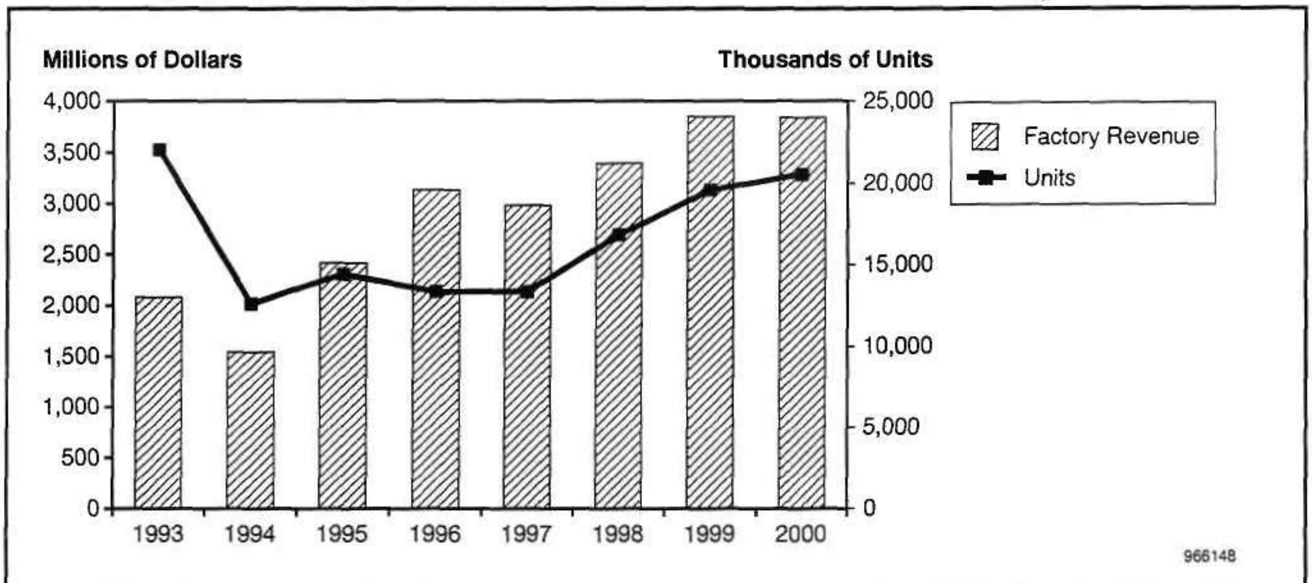
Manufacturer	Product
Toshiba America Corporation	DSS-compatible receiver
TV/COM International	AlphaStar DVB receiver
Uniden	UDS 200 DSS-compatible receiver
Zenith Electronics Corporation	Media Access

Source: Dataquest (September 1996)

Interactive Video Games

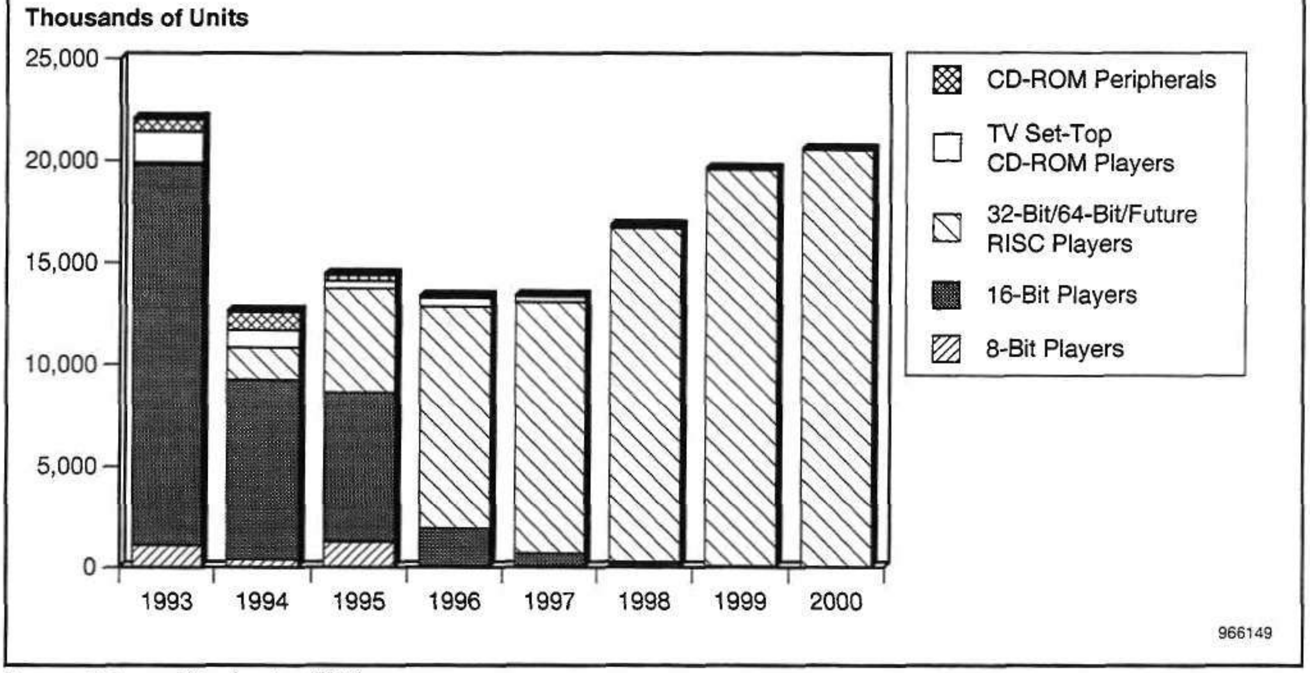
Figures 5-9 and 5-10 and Tables 5-12 through 5-14 present the production forecast for handheld and console video games. With the hardware costs being subsidized to an increasing level by software sales and royalties of the manufacturers, the market price and factory price charged to dealers for video game hardware is becoming disconnected from the true value of the hardware. The figures in Figure 5-9 and Table 5-12 represent estimated "factory value" rather than the actual price charged by the factory or factory ASP. This factory value would be analogous to internal transfer pricing. Figure 5-11 shows the regional share of production revenue for video game consoles. Figure 5-12 presents the market share for video game controllers.

Figure 5-9
Worldwide Video Game Controller Production Revenue and Unit Shipment Forecast



Source: Dataquest (September 1996)

Figure 5-10
Worldwide Video Game Controller Unit Shipment Forecast, by Type (Thousands of Units)



Source: Dataquest (September 1996)

Table 5-12
Worldwide Video Game Controller Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	22,045	12,590	14,411	13,328	13,343	16,797	19,583	20,536	7.3
Factory Value ($)	94	123	168	235	224	202	197	187	2.2
Factory Revenue ($M)	2,077	1,542	2,414	3,136	2,984	3,396	3,849	3,840	9.7
Semiconductor Content ($)	36	54	100	149	134	128	125	118	3.3
Semiconductor Market ($M)	788	682	1,444	1,987	1,786	2,147	2,441	2,423	10.9
Regional Production Trends (Percentage of World by Unit Production)									
Americas	0	0	0	0	0	0	0	0	
Europe	0	0	0	0	0	0	0	0	
Japan	64	51	31	23	16	16	16	17	
Asia/Pacific	36	48	68	77	84	84	84	83	

Note: Includes handheld
Source: Dataquest (September 1996)

Table 5-13
Worldwide Video Game Controller Unit Shipment Forecast, by Type (Thousands of Units)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
8-Bit Players	1,110	400	1,272	55	38	30	0	0	-100.0
16-Bit Players	18,710	8,860	7,349	1,874	649	235	62	0	-100.0
32/64-Bit/Future RISC Players	100	1,570	5,123	10,928	12,387	16,442	19,510	20,536	32.0
TV Set-Top CD-ROM Players	1,525	860	385	435	268	90	12	0	-100.0
CD-ROM Peripherals	600	900	281	37	0	0	0	0	-100.0
Total	22,045	12,590	14,411	13,328	13,343	16,797	19,583	20,536	7.3

Source: Dataquest (September 1996)

Table 5-14
Americas Video Game Controller Production Forecast

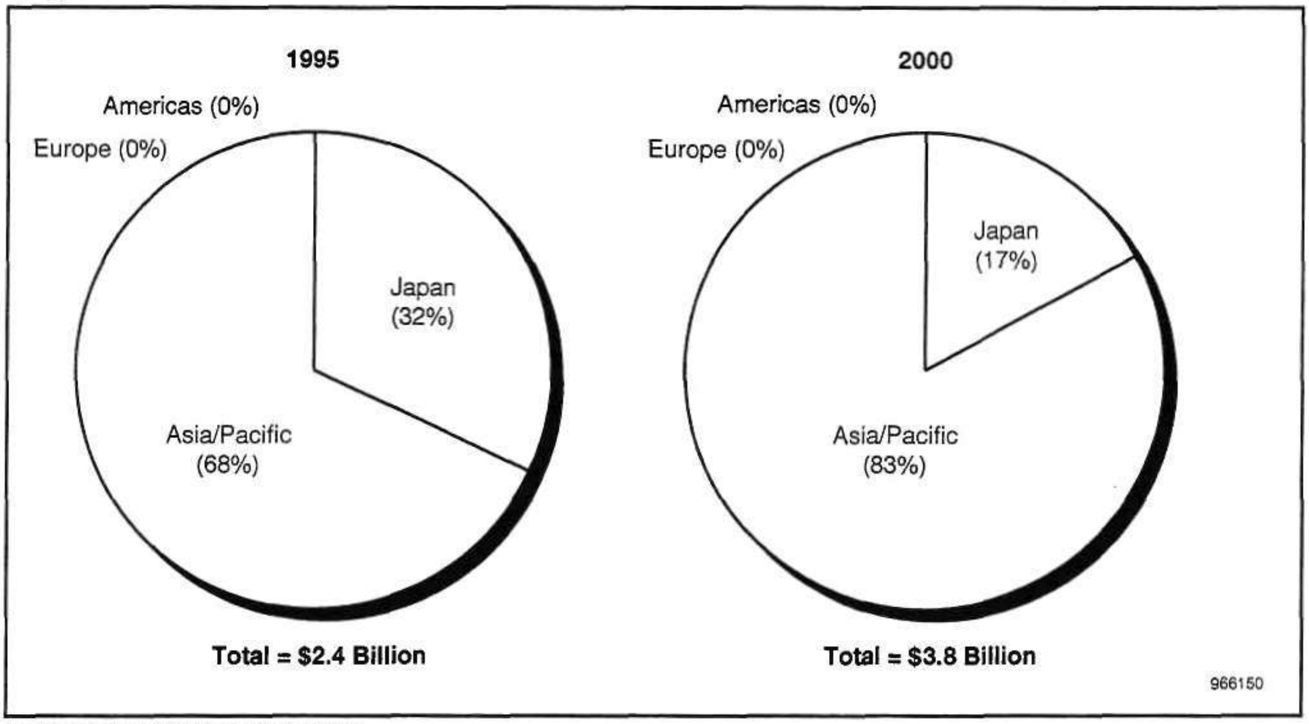
	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	65	71	77	0	0	0	0	0	NM
Factory ASP ($)	135	121	102	0	0	0	0	0	NM
Factory Revenue ($M)	9	8	8	0	0	0	0	0	NM
Semiconductor Content ($)	42	40	38	0	0	0	0	0	NM
Semiconductor Market ($M)	3	3	3	0	0	0	0	0	NM

Note: Includes handheld
Source: Dataquest (September 1996)

There were two major events in the video game market during 1996. The first event was the breakout of a major price war between Sony and Sega over their PlayStation and Saturn platforms. At the E3 show in Los Angeles, both companies dropped the price of their video game consoles to $199. The second important event was the introduction of the Nintendo 64 to the market. Shipments began in Japan first at the end of June and in the United States at the end of September. Although orders from retailers for the Nintendo 64 have been very strong, ultimately, the consumer will determine the success of the system. Nintendo maintained its price at $249 for introduction of the player in Japan but has dropped the price to $199 for the United States launch to reach price parity with Sega and Sony.

Dataquest predicts that worldwide shipments of these new video game controllers will climb to over 20 million by the year 2000. With the semiconductor content in this new generation of controllers leaping to over 66 percent of manufacturing cost, the semiconductor market driven by these new video game controllers will reach $2.4 billion by the year 2000.

Figure 5-11
Regional Share of Video Game Controller Production Revenue (Percent)

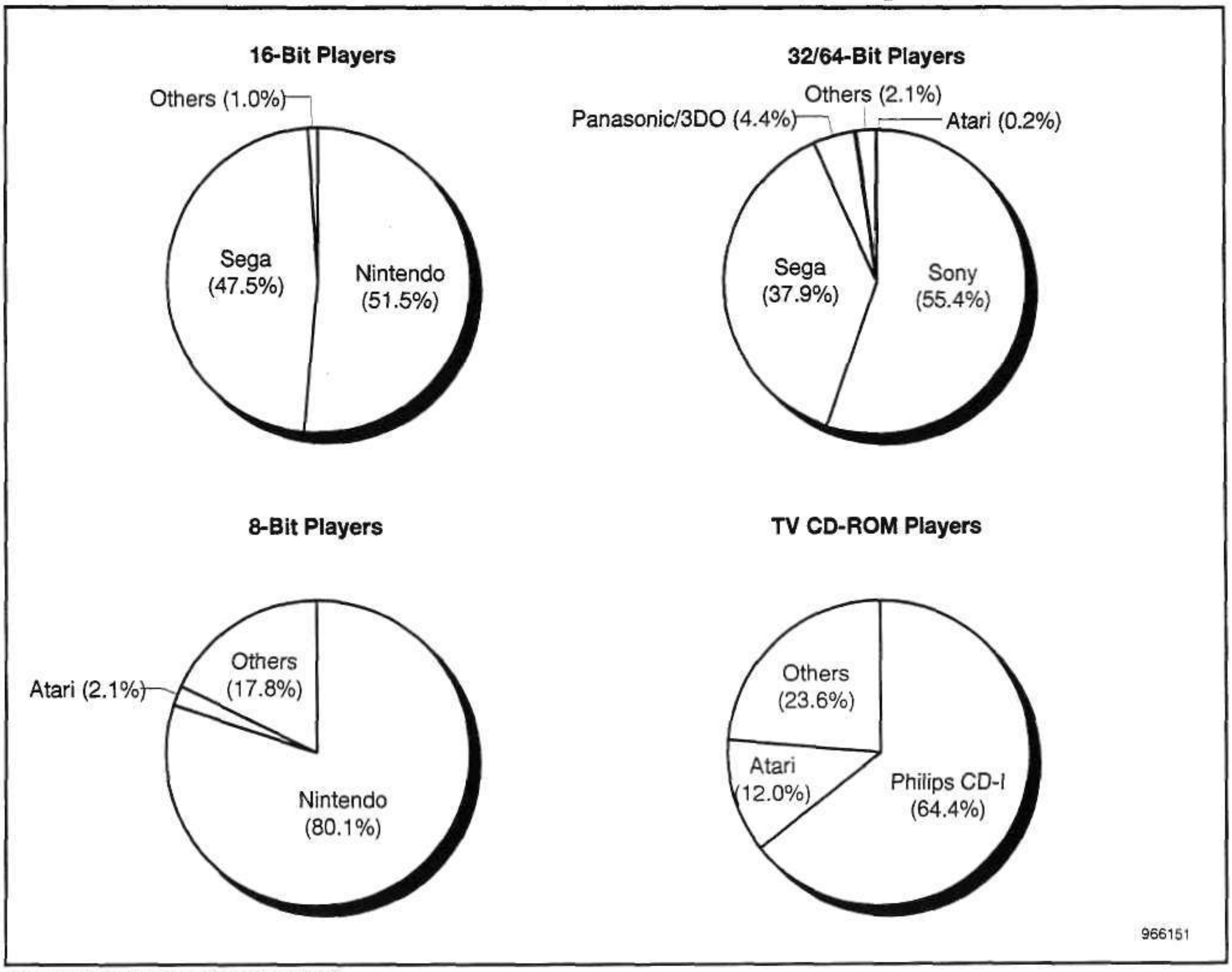


Source: Dataquest (September 1996)

Some of the important market, technology, and production trends are as follows:

- The development of the Internet appears destined to shape video gaming platforms of the future. Video game companies have already been encouraged by the success of electronic delivery mechanisms such as the Sega Channel and Nintendo Power Source. The next frontier for development is the interactive, social gaming experience that can be enabled by the Internet. A number of games and services have been introduced that are designed to create a virtual community for video game players using the Internet as a backbone.
- The year 1996 saw the introduction of products designed to offer Internet access through a video game console. Sega introduced the Sega Saturn Net Link, a 28.8-Kbps modem that can be plugged into a slot in the Saturn. Combined with a custom-designed Internet browser, the Saturn can be used as an inexpensive Internet access terminal. The Bandai Pippen @World was introduced at E3 in 1996. This hybrid product is primarily an Internet access terminal but also has the ability to run various multimedia and gaming CD-ROM-based titles.
- The introduction of a DVD drive in the video game environment will come in the PC first and will then migrate to the dedicated console as a peripheral. It will probably be late 1998 before a new platform with an integrated DVD drive is introduced to the market.

Figure 5-12
Worldwide Video Game Market Share, 1995 (Based on Unit Shipments)



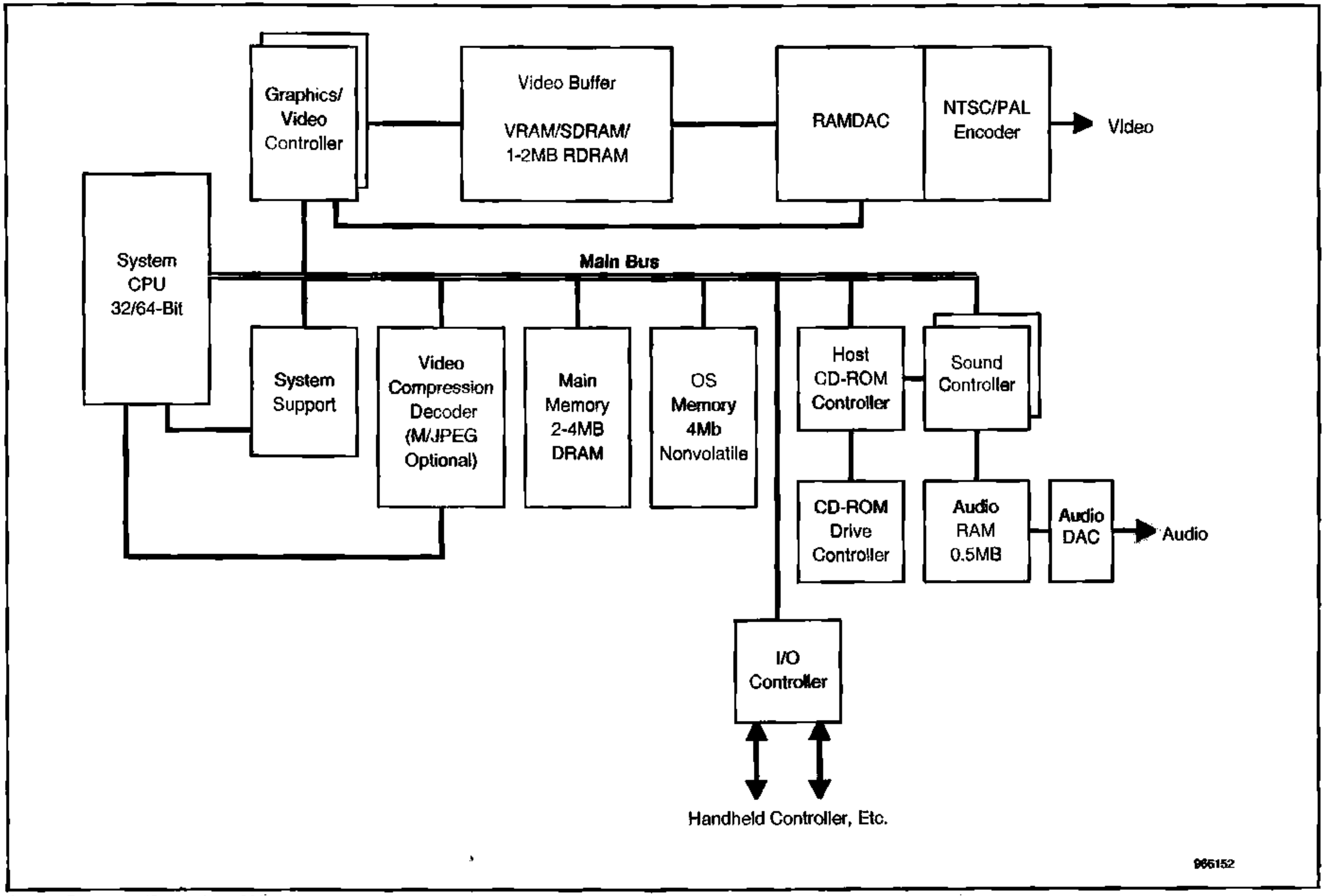
Source: Dataquest (September 1996)

- The Nintendo 64 departs from the model followed by Sega and Sony of delivering software in a CD-ROM format opting for cartridge-based media instead. The key issues here are a trade-off of system hardware cost versus software production and distribution costs. With Nintendo the only remaining game manufacturer supplying software in cartridge format, the production of video game cartridges should drop sharply.
- Nintendo did bring a 32-bit platform to the market during 1995, the Virtual Boy. The Virtual Boy game unit breaks the mold of the console-attached-to-TV standard. It is difficult to classify this product as either a handheld device or a console device because it delivers a very different gaming experience. The Virtual Boy provides visually immersive, three-dimensional gaming using a self-contained display that resembles a large pair of goggles. A 32-bit RISC processor running at 20 MHz and a dual-LED display create a smooth, three-dimensional display. The game platform was introduced in the United States in August 1995 at $180. The price was dropped to $160 three months later in reaction to consumer resistance to higher-priced games.
- In addition to the Sega Saturn, Sega is also promoting the Nomad. This system is Sega's first portable 16-bit video game system. It is compatible with the library of more than 600 Sega Genesis game cartridges.
- Atari, the video game pioneer, exited from the market at the end of 1995.
- Following the loss of support from AT&T, Toshiba, Creative Labs, and Sanyo for the 3DO platform, 3DO sold exclusive rights to control the use of its M2 64-bit platform to Matsushita Electric. 3DO effectively relinquished control over the technology's application in most markets in exchange for $100 million in licensing fees plus royalties from Matsushita. The 3DO M2 system employs the PowerPC in its design.
- The dramatic rise in the value of the yen has created a major challenge for Japanese manufacturers of video games. The strong yen has forced these companies to move production of video game players offshore to meet critical price targets for increasing consumer demand. Although most production is taking place in Asia/Pacific, Sony has mentioned the possibility of producing the PlayStation in Mexico.

Figure 5-13 presents a generic block diagram of a RISC video game controller. Key chip opportunities include:

- 32/64-bit RISC or CISC MPU
- 2MB to 4MB DRAM (VRAM for some designs)
- 1MB to 2MB VRAM, SDRAM, or RDRAM
- 32KB SRAM
- CMOS ASIC (100,000 to 200,000 gates) graphics/sound processing
- NTSC/PAL encode
- Sound DAC/amplification
- MPEG/JPEG decompression (optional)
- CD-ROM drive controller

Figure 5-13
Generic Block Diagram of RISC Video Game Controller



Source: Dataquest (September 1996)

Cameras, Watches, and Clocks

Table 5-15 presents the Americas region production in these areas. Production for the most part has moved to Asia for all but the very high-end products.

Table 5-15
Americas Revenue from Production of Cameras, Watches, and Clocks (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Cameras	24	25	27	28	29	29	30	30	2.1
Watches	110	115	120	127	131	136	142	148	4.3
Clocks	60	62	66	69	72	75	78	81	4.2
Total	194	202	213	224	232	240	250	259	4.0

Source: Dataquest (September 1996)

Digital Cameras

The term "digital camera" is used to refer both to video cameras that are mounted on a PC for use in videoconferencing applications and to still cameras that record images on memory chips, magnetic film, or a disk instead of conventional film. The digital cameras discussed in this section use the latter definition. Digital cameras were originally targeted at vertical markets such as real estate, fashion, and law enforcement. However, to the pleasant surprise of manufacturers, consumers are purchasing digital cameras and driving a stronger-than-expected market. A number of new companies are jumping into this market. The merger of the camera and a computer represents the easiest way to get photographs into a PC. Images can be transferred to the hard drive of a computer, where they can be viewed, edited, or added to documents. Although the images created by digital cameras are inferior to the quality achieved by traditional film cameras, the image that can be captured in a PC through a digital camera is superior to the method of using a scanner to transfer a photo into a computer. The picture quality of the latest digital cameras is comparable to S-VHS or hi-8 video images.

Some of the digital camera models available in the market are: Kodak's DC 20, DC 40, and DC 50, Apple's QuickTake 100 and 150, Casio's QV-10, Logitech's FotoMan Pixtura, Ricoh's DC-1 and RDC-1, Toshiba's PROSHOT, Minolta's RD-175, Epson's Photo PC, Chinon's ES-1000 and ES-3000, Polaroid's PDC-2000, Canon's PowerShot 600, Casio's QV-10, QV-10A, and QV-30, Fuji's DS-220, Ricoh's RCD-1, Dycam's 10-C and Sony's DKC-ID1. New product announcements are expected from companies including Kyocera and NEC in the coming months.

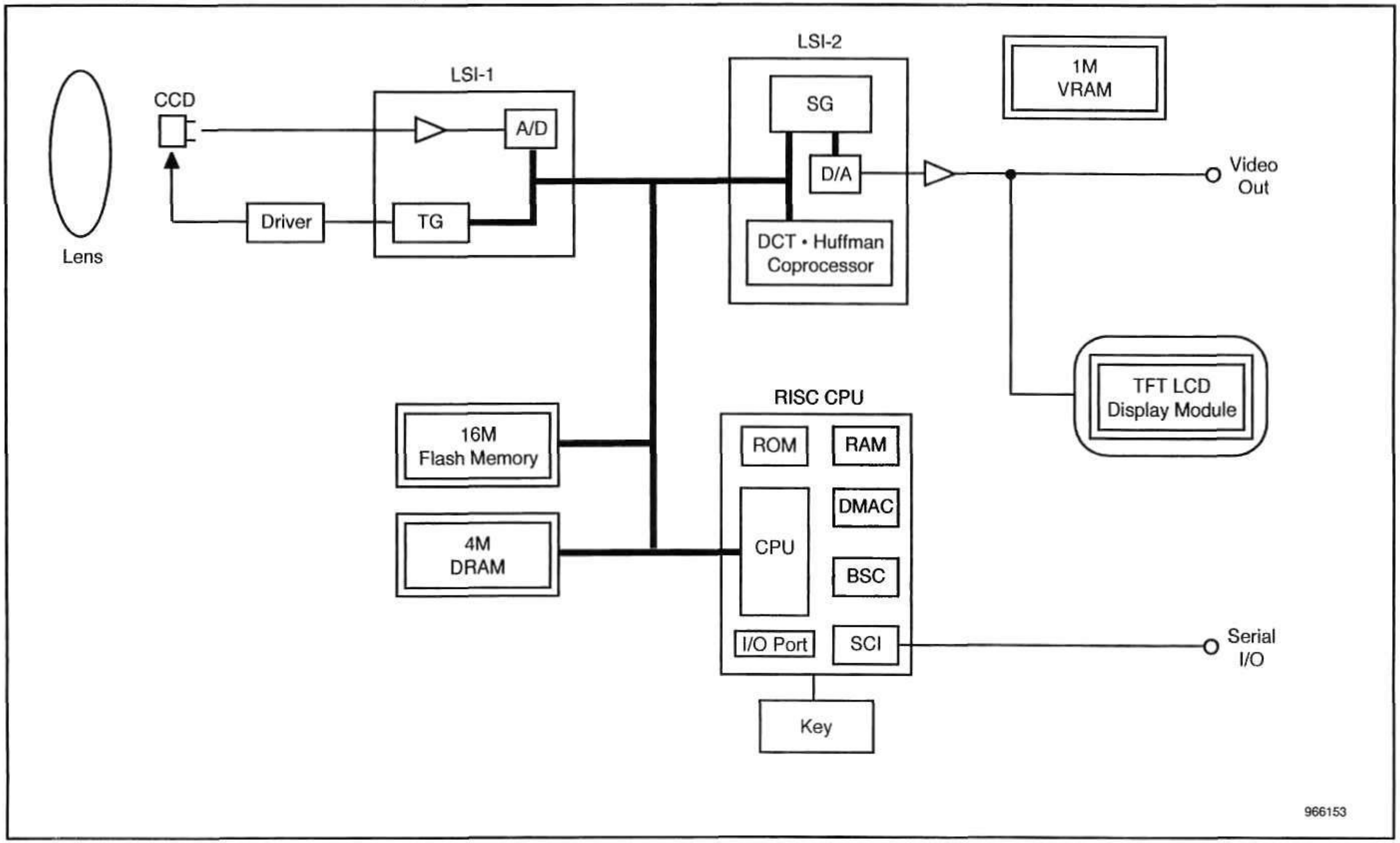
Prices for digital cameras range from $500 for cameras such as the Epson Photo PC and the Chinon ES-1000 to $1,800 for the advanced Ricoh RDC-1. Even with these high prices, industry observers expect market sales to be four times higher in 1996 than in the previous two years combined. Recent announcements from major manufacturers would support this prediction.

Digital cameras incorporate a variety of semiconductor types, including microcontrollers, DRAM, flash memory, ASICs, and charge-coupled devices (CCDs). The most expensive semiconductor in a digital camera tends to be the CCD. Figure 5-14 is a block diagram of Casio's QV-10 digital camera.

Advanced Photo System (APS) Cameras

Another type of new camera uses film coated with a magnetic layer that is capable of storing digital data. Data can be stored on lighting, composition, and print formats, as well as other parameters that can be used to improve the quality of prints. This type of film, called the Advanced Photo System, was introduced in March 1996 by erstwhile rivals Fuji and Kodak. Despite much hype surrounding its introduction, Advanced Photo System cameras have yet to be sold in any large quantity. A botched product launch attempt has kept cameras out of many stores and stalled sales.

Figure 5-14
Block Diagram of Casio's QV-10 Digital Camera



Source: Casio

Chapter 6
Appliances and Other Consumer Equipment

Figures 6-1 through 6-3 and Tables 6-1 and 6-2 present production and market forecasts for appliances and other consumer electronics.

Highlights in the markets for appliances and other consumer equipment are as follows:

- Generally, appliances are following replacement market economics in the developed countries. Because of prohibitive transportation costs, most appliances are produced in the end-use market.
- Major appliances are growing ever more sophisticated. Following the path laid down by consumer electronics, they are acquiring MCU (4-bit, mostly) control, digital signal processor (DSPs), microprocessors, sensors, and a variety of electronic features.
- Motor-driven appliances such as refrigerators, washers, and dryers are gradually moving to solid-state controls for direct-drive motors. Use of fuzzy logic is promising new opportunities for semiconductors. For more information, see Chapter 7, "Emerging Opportunities."
- There is an increasing trend away from electromechanical sensors toward silicon-based sensors, but they must become more cost-justifiable based on their performance. For more information, see Chapter 7, "Emerging Opportunities."
- Recent consumer surveys have indicated that home automation is on top of the wish list. LAN technology will enable all computerized appliances to be linked together, but lack of standardization in this area may temper consumer acceptance. For more information, see Chapter 7, "Emerging Opportunities."
- The "green" movement is forcing more appliance power conservation, with solid-state controls as a way of accomplishing design objectives. The upcoming U.S. Department of Energy standards for energy efficiency, potentially slated for 1999, may spur the use of electronic sensors in many appliance applications.

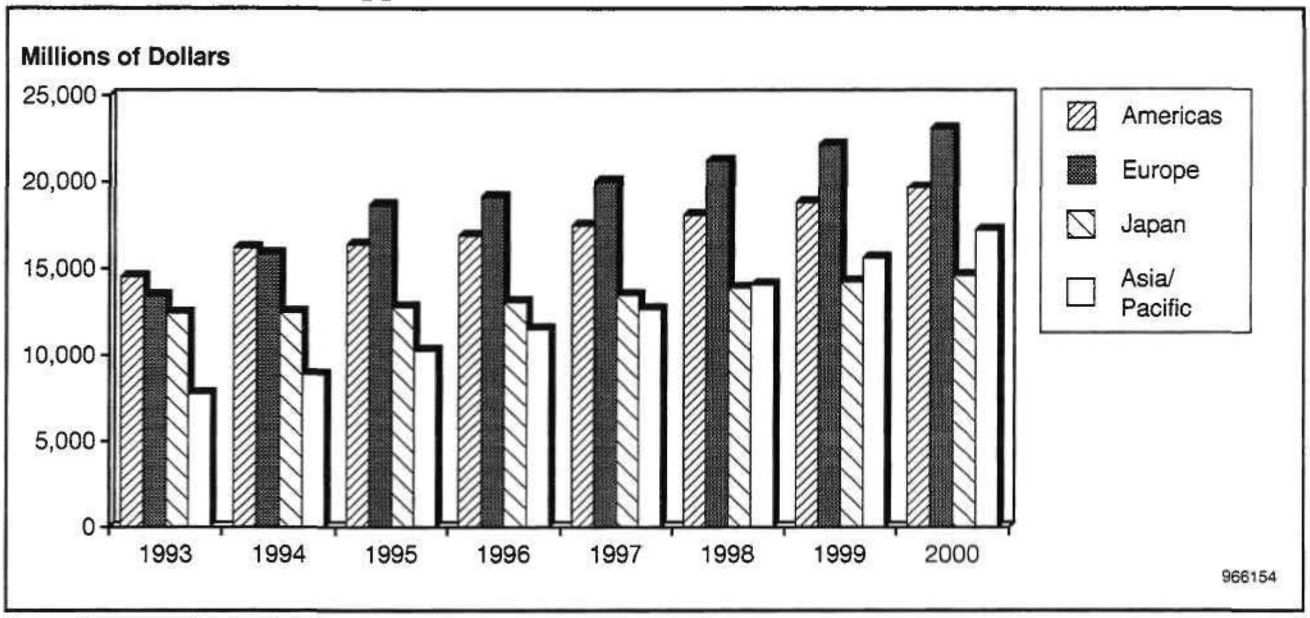
Microwave Ovens and Refrigerators

Tables 6-3 and 6-4 detail the market for microwave ovens. Tables 6-5 and 6-6 detail the market for refrigerators.

Dishwashers, Washers, and Dryers

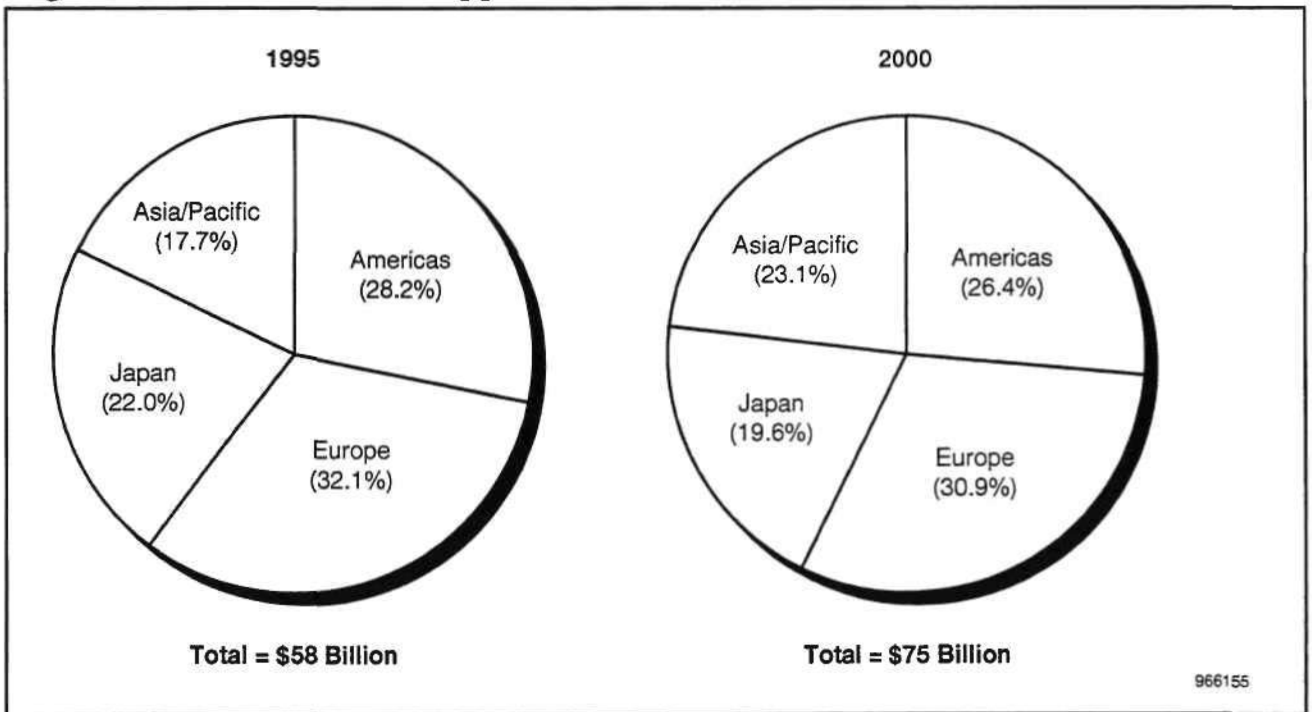
Tables 6-7 and 6-8 detail the market for dishwashers. Tables 6-9 and 6-10 detail the market for washers. Tables 6-11 and 6-12 detail the market for dryers.

Figure 6-1
Worldwide Electronic Appliance Production Revenue Forecast (Millions of Dollars)



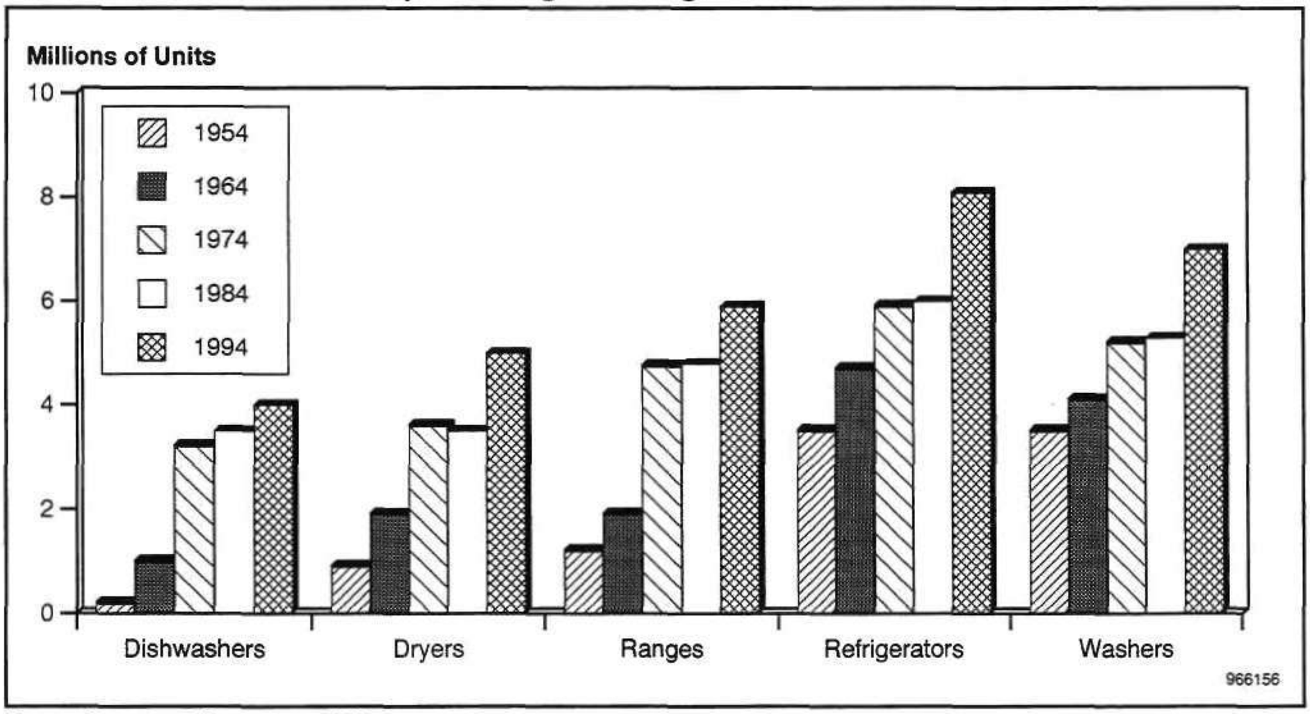
Source: Dataquest (September 1996)

Figure 6-2
Regional Share of Electronic Appliance Production Revenue (Percent)



Source: Dataquest (September 1996)

Figure 6-3
U.S. Major Appliance Unit Shipments, 1954 to 1994
(Includes Dishwashers, Dryers, Ranges, Refrigerators, and Washers)



Source: Dataquest (September 1996)

Table 6-1
Americas Appliance Production Revenue Forecast (Millions of Dollars)

Segment	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Ranges and Ovens (Gas and Electric)	1,382	1,518	1,544	1,586	1,653	1,702	1,769	1,842	3.6
Microwave Ovens	558	635	638	660	695	724	756	786	4.3
Clothes Washers and Dryers	3,791	4,004	3,998	4,144	4,355	4,437	4,603	4,761	3.6
Dishwashers	1,230	1,404	1,411	1,467	1,529	1,582	1,652	1,729	4.1
Refrigerators	5,354	5,729	5,669	5,912	6,171	6,400	6,652	6,927	4.1
Room Air Conditioners	2,233	2,919	3,128	3,127	3,087	3,241	3,385	3,619	3.0
Total	14,548	16,209	16,388	16,895	17,489	18,086	18,818	19,664	3.7

Source: Dataquest (September 1996)

Table 6-2
Americas Appliance Market Forecast (Thousands of Units)

Segment	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Ranges and Ovens (Gas and Electric)	10,982	12,277	12,072	12,324	12,539	12,898	13,224	13,515	2.3
Microwave Ovens	10,973	12,583	12,214	12,486	12,639	12,976	13,324	13,683	2.3
Clothes Washers	9,676	10,050	10,006	10,274	10,487	10,827	11,162	11,467	2.8
Clothes Dryers	7,116	7,484	7,438	7,435	7,580	7,856	8,130	8,384	2.4
Dishwashers	5,746	6,340	6,374	6,432	6,553	6,830	7,093	7,355	2.9
Refrigerators	12,860	13,662	13,866	14,208	14,562	15,031	15,465	15,913	2.8
Freezers	2,252	2,370	2,395	2,437	2,493	2,570	2,639	2,712	2.5
Room Air Conditioners	4,401	5,608	5,855	5,982	6,112	6,222	6,336	6,454	2.0
Total	64,007	70,375	70,222	71,577	72,965	75,210	77,373	79,482	2.5

Source: Dataquest (September 1996)

Table 6-3
U.S. Microwave Oven Brand Share Leaders, First Quarter 1995 through Fourth Quarter 1995 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sharp	24.8	24.7
GE	13.1	16.8
Sears/Kenmore	11.3	12.1
Panasonic	10.7	9.0
Tappan	5.9	5.1
Magic Chef	5.4	4.1
Emerson	5.1	2.8
Samsung	4.5	3.1
Whirlpool	5.0	7.3
Goldstar	3.7	2.9
Others	10.5	12.1
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-4
U.S. Microwave Oven Brand Share Leaders, Second Quarter 1995 through First Quarter 1996 (Percent

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sharp	24.3	23.7
GE	12.9	16.9
Sears/Kenmore	11.6	12.4
Panasonic	10.6	8.9
Tappan	5.6	4.7
Magic Chef	5.5	4.1
Emerson	5.4	3.0
Samsung	5.0	3.5
Whirlpool	4.8	7.8
Goldstar	4.0	3.1
Others	10.3	11.9
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-5
U.S. Refrigerator Brand Share Leaders, First Quarter 1995 through Fourth Quarter 1995 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sears/Kenmore	20.8	21.5
GE	18.1	19.3
Whirlpool	11.4	11.8
Amana	10.2	11.7
Frigidaire	6.4	6.2
Maytag	4.3	4.8
KitchenAid	4.3	5.0
Hotpoint	4.7	3.8
Admiral	3.6	3.0
Magic Chef	3.2	2.9
Others	13.0	10.0
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-6
U.S. Refrigerator Brand Share Leaders, Second Quarter 1995 through First Quarter 1996 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sears/Kenmore	21.9	22.4
GE	17.2	18.2
Whirlpool	11.7	12.2
Amana	9.9	11.1
Frigidaire	6.4	6.5
Maytag	4.8	5.4
KitchenAid	4.4	5.3
Hotpoint	4.3	3.5
Admiral	3.5	2.9
Magic Chef	3.3	3.2
Others	12.6	9.3
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-7
U.S. Dishwasher Brand Share Leaders, First Quarter 1995 through Fourth Quarter 1995 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sears/Kenmore	23.4	23.1
Maytag	17.5	19.4
GE	17.9	17.9
Whirlpool	15.0	14.1
KitchenAid	9.3	11.6
Hotpoint	4.2	3.0
Frigidaire	2.9	2.6
Tappan	1.4	1.2
Magic Chef	1.4	1.3
White/Westinghouse	1.5	1.0
Others	5.5	4.8
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-8
U.S. Dishwasher Brand Share Leaders, Second Quarter 1995 through First Quarter 1996 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sears/Kenmore	25.6	25.3
Maytag	17.3	18.9
GE	17.0	17.0
Whirlpool	15.1	14.5
KitchenAid	8.0	10.2
Hotpoint	3.8	2.6
Frigidaire	3.3	3.0
Tappan	1.5	1.2
Magic Chef	1.4	1.2
White/Westinghouse	1.1	0.8
Others	5.9	5.3
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-9
U.S. Clothes Washer Brand Share Leaders, First Quarter 1995 through First Quarter 1995 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sears/Kenmore	30.9	30.4
Whirlpool	18.8	18.4
Maytag	14.7	17.7
GE	9.3	9.0
Amana	4.6	4.8
Roper	2.7	2.0
Frigidaire	2.7	2.5
Hotpoint	3.2	2.5
White/Westinghouse	2.6	2.2
KitchenAid	1.9	2.2
Others	8.6	8.3
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-10
U.S. Clothes Washer Brand Share Leaders, Second Quarter 1995 through First Quarter 1996 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sears/Kenmore	29.6	29.2
Whirlpool	19.6	19.1
Maytag	14.5	17.3
GE	10.3	9.9
Amana	4.7	4.9
Roper	2.9	2.2
Frigidaire	2.8	2.7
Hotpoint	2.8	2.2
White/Westinghouse	2.5	2.2
KitchenAid	1.7	1.9
Others	8.6	8.5
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-11
U.S. Clothes Dryer Brand Share Leaders, First Quarter 1995 through Fourth Quarter 1995 (Percent)

Brand	Unit Market Share (%)	Revenue Market Share (%)
Sears/Kenmore	30.0	30.5
Whirlpool	19.1	19.1
Maytag	12.6	14.9
GE	12.1	11.5
Amana	4.5	4.5
White/Westinghouse	2.8	2.3
Frigidaire	2.7	2.3
Roper	2.2	1.7
Hotpoint	2.5	2.2
Speed Queen	1.7	1.6
Others	9.8	9.4
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-12
U.S. Clothes Dryer Brand Share Leaders, Second Quarter 1995 through First Quarter 1996 (Percent)

Brand	Unit Market Share (%)	
Sears/Kenmore	29.4	30.1
Whirlpool	19.4	19.4
Maytag	13.3	15.2
GE	12.2	11.8
Amana	4.4	4.5
White/Westinghouse	3.0	2.4
Frigidaire	2.8	2.5
Roper	2.4	1.8
Hotpoint	2.2	2.0
Speed Queen	1.3	1.3
Others	9.6	9.0
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Air Conditioners

Top OEMs in air conditioners are as follows:

- Sears/Kenmore
- Fedders
- Whirlpool
- GE
- Carrier
- Amana
- Frigidaire
- White/Westinghouse
- Emerson
- Friedrich

Ranges

Top OEMs in ranges are as follows:

- GE
- Electrolux (Frigidaire)
- Whirlpool
- Electrolux
- Maytag (Magic Chef, Hardwick, Jenn Air)
- Raytheon (Caloric)
- Brown
- Peerless Premier

Other Consumer Equipment

Tables 6-13 and 6-14 detail the market for other consumer equipment.

Top OEMs in home security systems are as follows:

- Honeywell
- Black & Decker
- Sony
- Audiovox
- Yale

Table 6-13
Worldwide Revenue from Production of Other Consumer Equipment
(Millions of Dollars)

Revenue	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Other Consumer Equipment	11,869	13,098	14,945	14,243	15,138	15,898	16,496	17,433	3.1
Total	11,869	13,098	14,945	14,243	15,138	15,898	16,496	17,433	3.1

Source: Dataquest (September 1996)

Table 6-14
Americas Revenue from Production of Other Consumer Equipment
(Millions of Dollars)

Segment	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Automatic Garage Door Openers	351	409	426	443	462	483	504	527	4.3
Others	1,078	1,118	1,157	1,197	1,243	1,292	1,343	1,397	3.8
Total	1,429	1,527	1,583	1,640	1,705	1,775	1,847	1,923	4.0

Source: Dataquest (September 1996)

Chapter 7
Emerging Opportunities

Consumer electronics of all types, in particular, white appliances, are destined for increased use of semiconductor devices. From home entertainment, communications, and ambient climate control to kitchen appliances and even plant watering operations, home appliances are expanding the field of semiconductor applications. Semiconductors are offering appliance manufacturers unlimited possibilities to add features and value (that is, differentiation) to their products. While TV, video, or audio system manufacturers have embraced semiconductor technologies, white good OEMs are not as knowledgeable about chip technologies and what to look for in an electronic component supplier. To enable market expansion, semiconductor manufacturers will need to educate appliance OEMs about the role and potential of semiconductors, how to use them appropriately, and how to specify components. For planning purposes, appliance OEMs have to be aware that manufacturing semiconductors is a longer and more involved process than producing a sheet of metal.

Home LANs

Recent consumer surveys have indicated that home automation was on top of the wish list in terms of energy conservation, entertainment, and cost savings. In the future, there will be a multitude of computers at home. Some will perform traditional computing tasks, while others will be used mainly for games, communications, controlling other devices in the home, and other purposes. It is quite likely that all these computers will be tied together somehow, perhaps using wireless technology. The era of the home hub may be coming, but to be really successful and accepted by consumers, the technology has to be simple, maintenance free, and nearly invisible to typical users.

Home builders are now offering built-in office space in all house price ranges with cable or fiber-optics prewiring, LAN, and high-speed transmission lines. Plastic fiber optics promises data transmission speeds nearing those of glass fiber for a fraction of the cost. In the United States, Boston Optical has started selling this plastic fiber, which was developed jointly with General Motors Corporation, Honeywell Inc., and Boeing Company. In Japan, Sony, NEC, Toray Industries, and Toshiba have started a similar consortium.

Anticipating increased use of LANs, bus technology suppliers are developing protocols with the hope of capturing early market leadership. These house LANs create a communications pathway among the home's appliances, heating, ventilation, and air conditioning (HVAC) systems, computing and cable equipment, and outside agencies such as the power company so that energy use can be optimized and outside communications can be automatic. They are also being driven by the increasing number of consumers looking for comfortable ways to work efficiently at home.

The consumer's ultimate wish is to have easy-to-use devices and compatible products. Confronted by too many systems, consumers are reluctant to invest in any one system in an industry cluttered with incompatible systems and therefore ripe for fallout.

Leading bus contenders in the United States include:

- CEBus—An EIA-supported protocol that is enjoying widespread acceptance. One of its advantage is its versatility: it can be used with cable television, air conditioning, phone wiring, or even radio frequency. Intellon Corporation has a power line RF modem IC using spread spectrum technology capable of 10-Kbps data rates. Intellon recently tested its technology on the Tele-Communications Inc. (TCI) and Microsoft set-top box platform. AMP Inc.'s OnQ-mand system enables home automation operation via television sets, and Diablo Research Corporation proposes an energy monitoring system. Maytag's upcoming Jenn-Air dryer will be one of the first appliances to be equipped with CEBus technology, which will add $50 to $75 to manufacturing costs. Costs are being reduced for implementing this technology in consumer products such as refrigerators, hot water heaters, and air conditioners.
- LonWorks—A proprietary approach advocated by Echelon Corporation. Echelon network controllers are made by Motorola and Toshiba. Motorola and Toshiba are now quoting prices between $2 and $3 for Neuron controller chips, compared to $15 a few years ago. In 1995, 50,000 homes were scheduled to have LonWorks devices installed.
- Totally Automated Building System (TABS) from NetMedia—This approach merges PC control, customizable software, and complete systems integration. TABS began shipping early this year.
- SmartHouse protocol—Molex Inc. offers packages of components using this protocol. The wiring package for example, provides high-speed Internet access and enables modem, fax, and phone lines as well as video distribution throughout the home.
- X10 Protocol—Several companies offer products incorporating this protocol. For example, IBM's new Home Director Software, which will ship in fall 1996, will allow users to control lights, consumer electronics, appliances, and sprinklers, among other functions, with no need for special wiring.
- Serv-Touch—Offered by P-Serv Technologies Pte., this system allows users to activate remotely up to 48 devices by using the phone. The system is awaiting FCC approval and could be on the market soon.

USB and IEEE 1394

With the advent of multimedia and digital telephony, end users want computers that are easier to set up and use and that enable them to easily plug in any kind of peripheral. Facing the large sampling of additional devices that can be hooked up to the computer, connectivity becomes a critical factor. Universal Serial Bus (USB) and IEEE 1394 are emerging as new industry standards for external bus. Both technologies are driven by the same philosophy: true plug-and-play computers. Both are standard architectures that are open to all and are inexpensive to implement. They have the pluses of automatic self-configuration coupled with simple connectors and wiring.

There is no doubt that the personal computer landscape will be changed by USB and IEEE 1394, but there is a question of the degree and pace of that change. It is possible that these two new bus technologies will be limited to a higher-performance/lower-cost interface role in the near future, thereby merely broadening the application set of the personal computer. However, Dataquest believes that these buses have the potential to transform the personal computer to a modular set of components in the same fashion that stereo systems were transformed a few decades ago.

IEEE 1394 is designed as a high-speed local interface allowing plug-and-play with devices that rely on high-rate data transfer, including various types of video and multimedia equipment. USB is viewed as complementary to IEEE 1394, to be used for applications and peripherals for which speed is less of an issue (keyboards, mice, joysticks, and so on). Key players such as Microsoft, IBM, Sony, Philips, HP and Compaq Computer Corporation are supporting both buses in their newest products or prototypes.

In considering the existing market, one has to ask whether the current PC market leaders will lead the charge or will be dragged kicking and screaming into the new paradigm. On the other hand, the consumer electronics giants clearly have an opportunity with the emergence of the modular PC to gain access to significant new revenue streams.

USB-based products have started to appear on the market with a strong push from Intel. Given current indicators based on Dataquest's discussions with PC and consumer electronics manufacturers, it is Dataquest's belief that the industry will see IEEE 1394-based PC peripherals in 1997. It is unlikely that existing PC companies will lead the charge, however. Early leaders of this effort are more likely to be consumer electronics giants with line extensions for imaging products that sneak up on the PC peripherals market. Initial efforts may focus on DVD players and digital cameras, as these are opportunities to capitalize on technology transitions in the market.

The convergence of consumer entertainment electronics with the personal computer, coupled with ease of setup and upgrading will not only appeal to computer/electronics addicts but will also attract new buyers. Also, the same bus chipset (USB or IEEE 1394) will be needed in both the peripherals and the host computer. The word "peripheral" is just taking a much broader meaning, including virtually any household electronic device. For semiconductor makers, this can only mean larger volumes of chips to produce coupled with the opportunity to bring the integrated chip onto the CPU motherboard.

For more discussion of this topic, see the Dataquest Perspective titled "The Right Connections to Stay in Business, or, Do Not Miss the Bus!" SAMM-WW-DP-9603.

Home Theater Technologies

Social trends and technological advancements are supporting the phenomenal growth potential of the home theater system market. Home theater combines high-quality video and audio equipment to reproduce a movie theater surround sound environment. Home theater audio systems include surround sound processors, amplifiers, receivers, subwoofers, center-channel speakers, and satellite surround speakers. Key to the development of these systems are technologies like Dolby AC-3 and Home THX 5.1. AC-3 will first appeal mainly to hard-core audiophiles in 1996 and 1997, but manufacturers are betting that AC-3 equipment will be among their leading profit-generating products, and therefore are developing and producing equipment rapidly to establish a leadership role for themselves.

Dolby Surround AC-3 reproduces powerful audio with dynamism, presence, and realism by delivering six separate channels of sound. The five main channels (three sound and two surround channels) operate across a full frequency range from 3Hz to 20,000Hz, assuring low-distortion audio reproduction. Optionally, users can add a subwoofer to each channel. The sixth channel is a low-frequency channel that can contain additional bass information for maximum effect from explosions, crashes, or similar sounds. All six channels are digital and use less space than a single channel on a CD because they use an advanced encoding system. The appeal of this method is that it is possible to add AC-3 sound tracks to conventional laser discs and other sources.

Home THX is a set of performance parameters that Lucasfilm Ltd. developed. Home THX makes it possible to bring out the maximum potential and quality of AC-3 sources by avoiding or correcting tonal and spatial errors introduced by the home acoustic environment, which is smaller and more intimate than cinema environment. Home THX controllers contain several units of circuitry, including:

- Re-equalization to correct overly bright front channel sound
- Electronic crossover to improve bass dynamic range
- Timbre matching to smooth the front-to-surround panning
- Decorrelation to enhance the surround spatiality and envelopment

Audio system vendors believe that home theater technology will expand the audio market and, thus, are promoting new products in this arena. Pioneer is featuring audio/video (A/V) receivers, Yamaha is proposing a seven-channel digital sound field processor and amplifier. Kenwood offers an AC-3 power amplifier with a touch pad preamplifier controller. Denon is also entering the home theater market with A/V receivers, preamplifiers, and sound processors.

Digital sound still relies on analog components and offers opportunities to semiconductor makers that want to exploit the fact that most audio semiconductors are not entirely digital. General-purpose DSPs are quite expensive for audio applications, opening opportunities for digital sound processor chips for under $10. Availability of AC-3 chipsets that cost less than current models should coincide with availability of DVD.

Smart Appliances

Evolving appliance technologies make it easier to use appliances such as dishwashers and clothes washers, refrigerators, and microwaves, among others, as well as to control the home environment (air-conditioning and sprinkler systems, for example). Driven by stricter environmental regulations and by consumer demand for convenience, electronic controls are becoming increasingly popular in home appliances. However, appliance OEMs are still uncertain about their return on investment in this arena. Major home appliance OEMs that are aggressively exploring use of electronic controls include Maytag, KitchenAid, Hoover, Sharp, and Emerson.

What future appliances will deliver, and what role sensors and activators will play, depends on the cost and globalization of the market.

- **Sensors:** Sensors are used to measure water level, pressure, air humidity, voltage, current, and many other parameters. Because of tighter governmental regulations around the world, electronic sensors are vying to replace their electromechanical counterparts. However, the demand for the latter will not die for some time because of cost. Use of electronic controls provide appliance OEMs with two major advantages:
  - More accurate measurements and faster corrective action is enabled
  - A wider range of parameters can be measured. Some parameters just cannot be electromechanically measured. This provides OEMs with the possibility of adding features and value and the opportunity to differentiate their products.
- **Fuzzy logic:** This software tool mathematically computes the subjectivity of human perception into the strict binary language of computers. Fuzzy logic enables real-time and automatic monitoring of the appliance's function. Fuzzy logic is being integrated in vacuum cleaners, clothes washers and dryers, microwaves, and dishwashers, among others. In ovens, for example, fuzzy logic sensors can determine if food is completely cooked, as well as what is to be cooked, and can check the food consistency and texture, allowing the oven to adjust cooking conditions accordingly. In a washing machine, sensors measure level of soil in water, level of water, temperature, level of foam, detergent levels, arm rotation, and other parameters. The unit collects all the input, examines the data against a mathematical model, and decides what to do next. Achieving higher performance in variable speed motors is a prime application for fuzzy logic. Semiconductors represent about 60 percent of the total material cost in a typical variable-speed motor command circuitry. Of that 60 percent, power switching and fast diodes account for 70 percent. Other components are ICs used in control and interfacing (15 percent each). By controlling instantaneously the amount of electrical power transferred to the motor, one can limit the current span and use a cheaper power stage. This is possible by using a fast embedded fuzzy logic coprocessor that optimizes in real time the motor flux and ultimately saves about one-third of the power stage.
- **Voice activation:** After appliances are trained to recognize particular voices, they can execute commands made verbally. Microwaves and ovens should be among the first appliances to display such features, but this technology is still in the prototype stage. Products could emerge at the end of 1997.

New Influential Regions in the World

It is important to keep an eye on several developing regions around the world as household disposable income rises, creating a new generation of consumers. About two-thirds of the world's population uses relatively few consumer electronic items, and a huge market awaits patient consumer electronics and appliance companies (and their suppliers).

Expect basic goods such as refrigerators, cookware (rice cookers, for example), personal and portable stereos, and color TVs to be in demand first. Markets such as China, India, Indonesia, Malaysia, Brazil, and Mexico are indicating huge potential. In most cases, these markets are best served by joint ventures with local companies.

For example, Central and South American countries absorbed over 15 million home appliances in 1994. Expected to grow at 5 percent per year over the next several years, this market could reach over 20 million units by 2000. Brazil alone represent 50 percent of the total South America market.

The Chinese consumer electronics market also represents impending growth. Sales of televisions in 1996 will be about 12 percent higher than 1995 sales, to reach 27 million units. Twenty-one-inch color TVs represent 80 percent of the market, but they are being replaced by 25-inch or larger sets. Demand for other audio/video equipment will grow similarly. Home appliances such as ovens, microwaves, washing machines, refrigerators and air conditioners are highly sought. For instance, 15 million washing machines could be sold by the end of 1996, compared to 12.5 million units sold in 1995. Fully automatic machines account for over a third of the market. They are very popular with urban populations, while rural families prefer semiautomatic units. This market is expected to grow at a rate of 13 to 18 percent over the rest of the decade.

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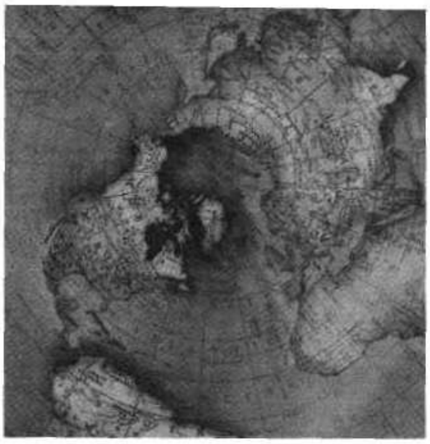

Dataquest

Consumer Electronics Semiconductor Application Markets

Market Trends

Program: Consumer Multimedia Semiconductor and Applications Worldwide
Product Code: MSAM-WW-MT-9601
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Filing: Market Trends

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Chapter 1
Introduction

This document is the sixth in a series of six that provide reference information and analysis about the principal system application markets for semiconductors. The six areas are data processing, wireline communications, wireless communications, consumer electronics, automotive electronics, and a combined document on industrial and military and civil aerospace electronics. Each document brings forth basic information about the opportunity offered by particular systems:

- System market size (in production terms) in revenue, units, and average selling price
- System market and product feature trends
- Hardware architecture trends and semiconductor device opportunities
- Semiconductor content and market forecast
- A listing of key OEMs

The information in this report is gathered from both primary and secondary sources. Primary sources include surveys and interviews of industry vendors and customers, as well as analyst knowledge and opinion. Some of the primary sources include Dataquest's own services. Secondary sources include various governmental and trade sources on sales, production, trade, and public spending. Semiconductor content assumptions are based on both surveys of producing OEMs and physical teardown evaluations by Dataquest analysts of representative systems.

The forecast methodology is based on various methods and assumptions, depending upon the area. To form a solid basis for projecting system demand, capital, government, and consumer spending assumptions are made for various regions of the world. For specific markets, saturation and displacement dynamics are considered as well. Key exogenous factors such as new software introductions, exchange rates changes, and government policies also are considered. Semiconductor content forecasts are based upon interviews of system marketers and designers (including makers of enabling semiconductor technology) along with an analysis of historical trends.

Project Analysts: Dale Ford and Mark Gaare

Chapter 2
Executive Summary

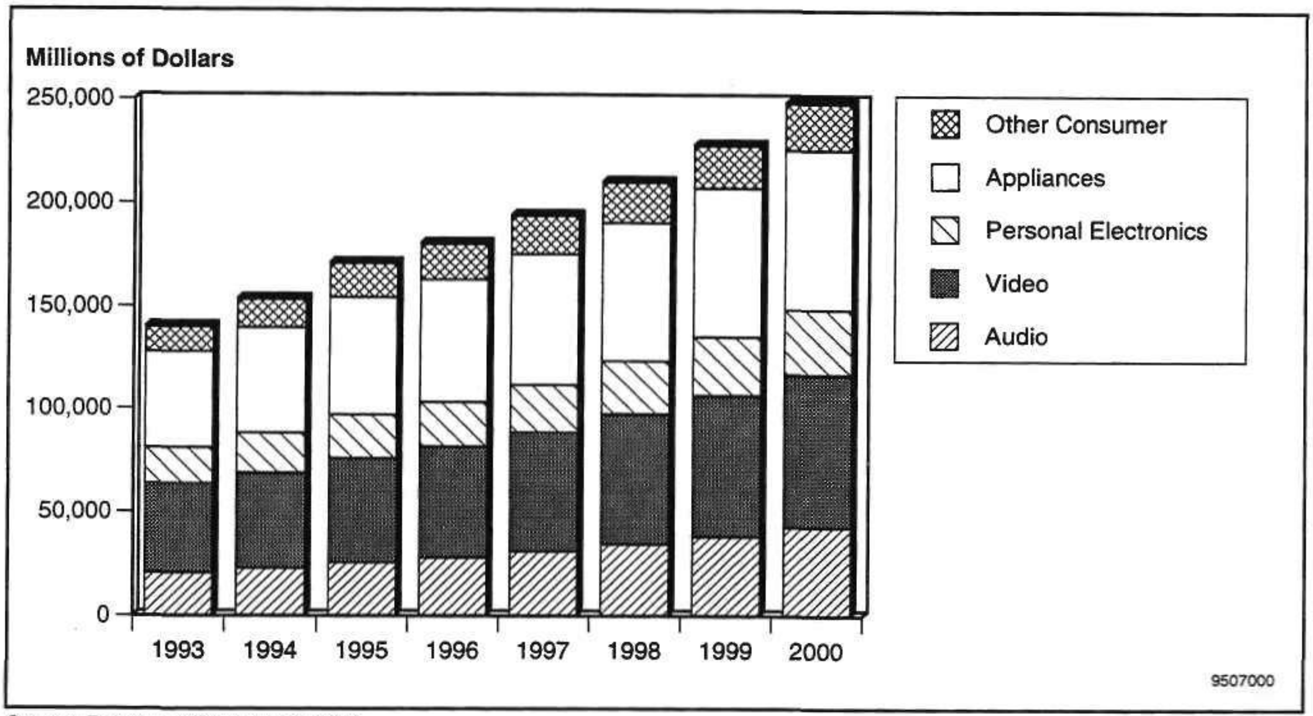
The consumer electronic equipment market represents a significant opportunity for semiconductor applications (see Figure 2-1 and Table 2-1 for our forecast for consumer electronic equipment production). While the worldwide market for consumer electronic equipment is projected to have a compound annual growth rate (CAGR) of 7.7 percent for the next five years, the semiconductor market for consumer electronic products will have a CAGR of more than 15 percent in this same time frame (see Figure 2-2). This difference is driven by the digitization of consumer products from VCRs to dishwashers. New products being introduced—high-definition television (HDTV), digital VCRs, video-CD and digital video disc (DVD) products, MiniDisc (MD) and digital compact cassette (DCC) players, digital cable/satellite set-top boxes, and interactive video games—are boosting the opportunities for semiconductor products.

This worldwide trend is accentuated in the North American production arena. Table 2-2 and Figure 2-3 show that consumer electronic equipment production in North America will grow by 3.9 percent CAGR through 1998. However, semiconductor consumption for the consumer equipment production will grow by 19.2 percent CAGR at the same time (see Figure 2-4). The importance of the consumer electronics market is even greater in Japan and the Asia/Pacific region than in North America. Figure 2-5 shows that over 70 percent of consumer electronics production takes place in these regions.

Figure 2-6 shows one measure of the increasing opportunities in the consumer market and provides a forecast of the number of microcontroller ICs used in the home, automobile, and office. The commanding share forecast for the home by the year 2000 is driven by consumer products found in almost every room in the house, as shown in the list in the same figure. Figure 2-7 provides an overview of the penetration of major consumer electronics products into U.S. homes. Although some products, such as televisions, have reached near saturation, other products, such as camcorders, still have room for significant expansion. The market for high-penetration products such as TVs is mainly found in replacements and upgrades. New technology developments targeted at existing products will drive an increase in upgrades of these products.

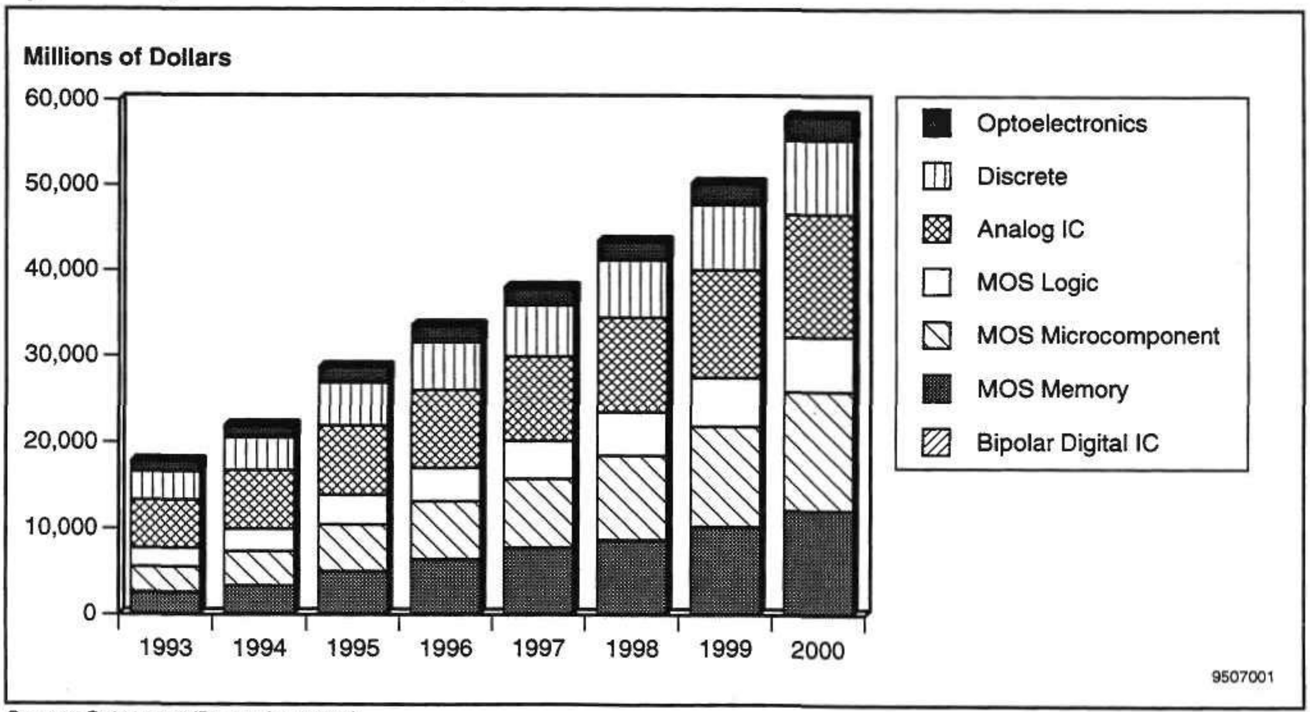
Several new exciting products will take the stage in consumer electronics markets during the next five years. This report will provide information on many of these new products.

Figure 2-1
Worldwide Consumer Electronic Equipment Production Revenue Forecast (Millions of Dollars)



Source: Dataquest (December 1995)

Figure 2-2
Worldwide Semiconductor Consumption for Consumer Equipment Production, by Device (Millions of Dollars)



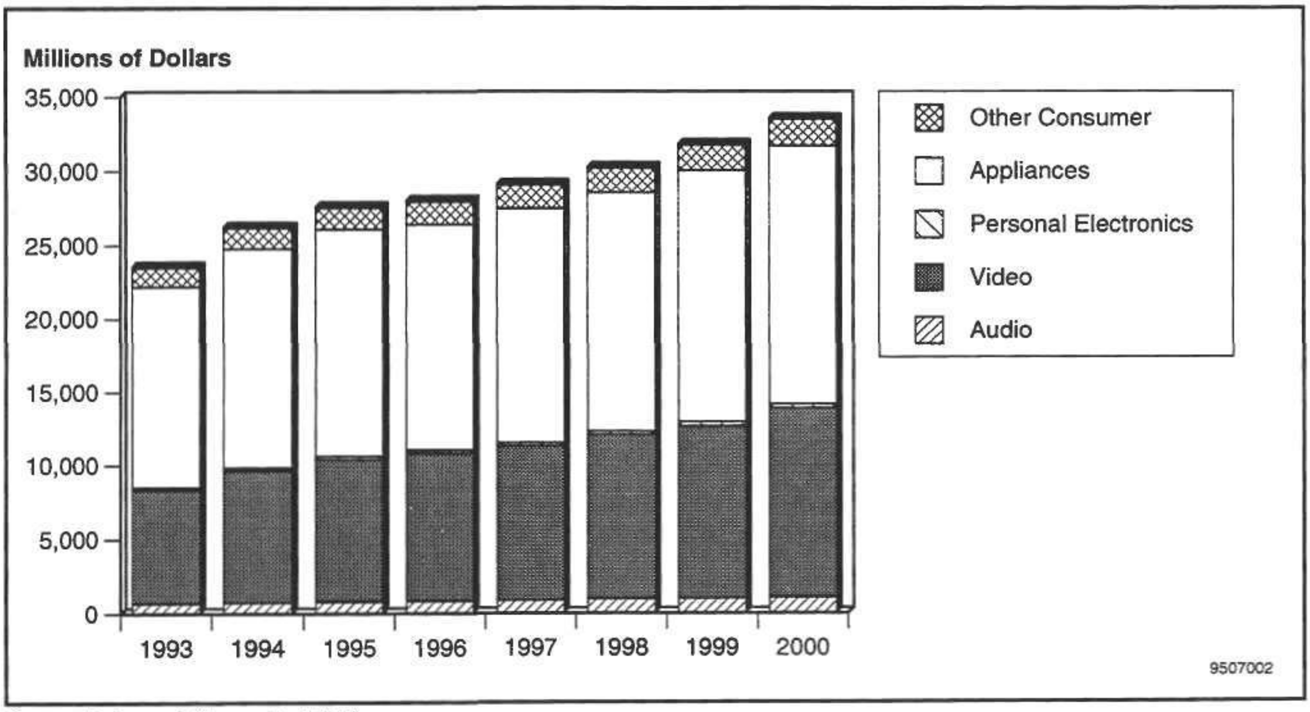
Source: Dataquest (December 1995)

Table 2-1
Worldwide Consumer Electronic Equipment Production Revenue Forecast (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Audio	20,543	22,904	25,556	27,974	31,020	34,537	38,329	42,890	10.9
Video	43,236	46,009	50,510	53,769	57,675	63,284	68,570	74,410	8.1
Personal Electronics	17,433	19,286	21,110	21,669	23,203	25,698	28,617	31,489	8.3
Appliances	46,616	51,564	57,250	59,608	63,486	67,136	72,039	77,391	6.2
Other Consumer	12,310	13,623	16,262	17,215	18,518	19,598	20,543	22,313	6.5
Total	142,132	155,379	172,682	182,232	195,899	212,251	230,097	250,494	7.7

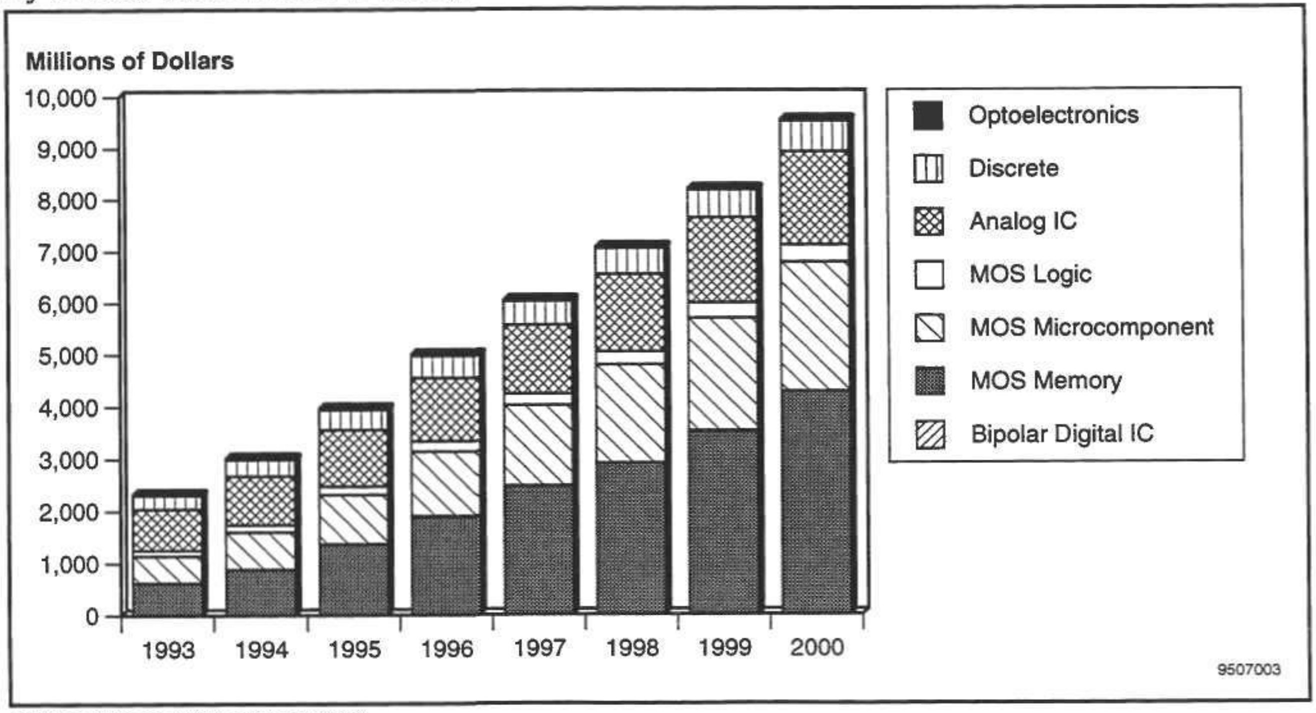
Source: Dataquest (December 1995)

Figure 2-3
North American Consumer Electronic Equipment Production Revenue Forecast (Millions of Dollars)



Source: Dataquest (December 1995)

Figure 2-4
North American Semiconductor Consumption for Consumer Equipment Production, by Device (Millions of Dollars)



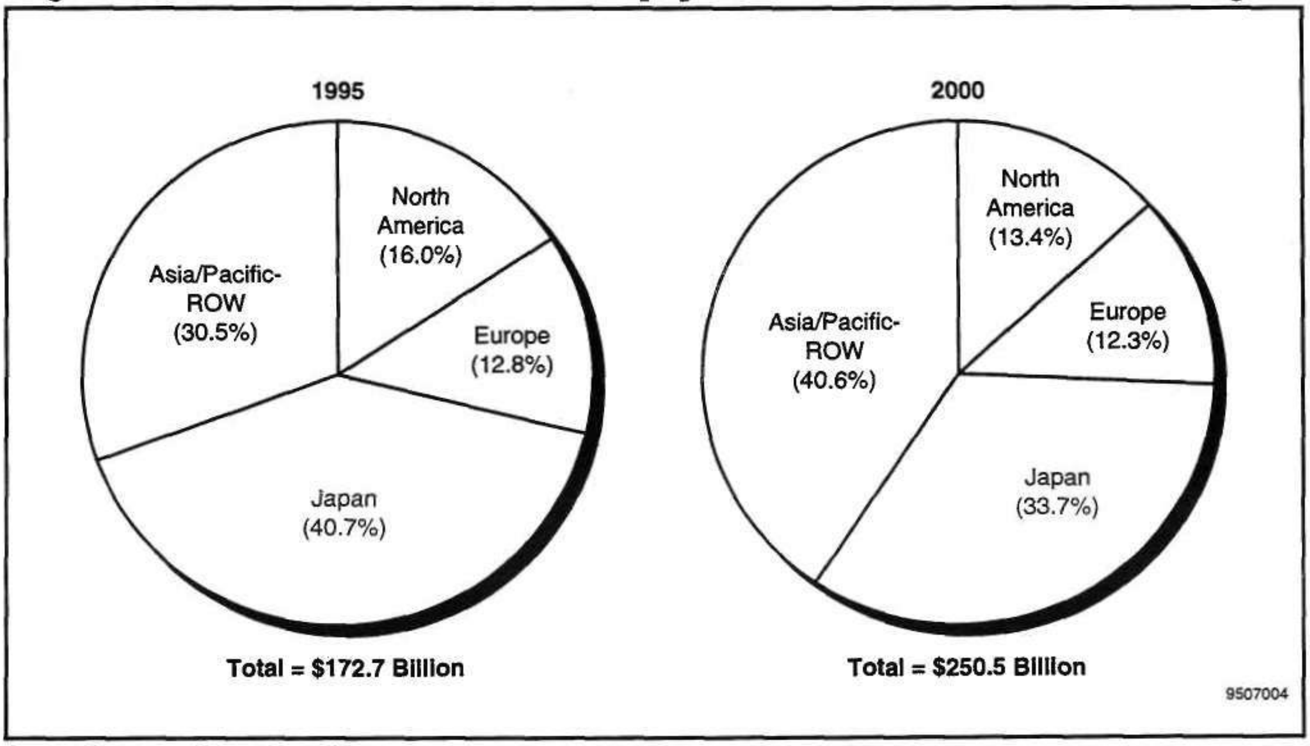
Source: Dataquest (December 1995)

Table 2-2
North American Consumer Electronic Equipment Production Revenue Forecast (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Audio	716	766	811	864	908	960	1,019	1,078	5.9
Video	7,622	8,869	9,588	9,973	10,405	11,134	11,692	12,847	6.0
Personal Electronics	203	210	223	233	241	250	264	276	4.4
Appliances	13,669	14,942	15,470	15,351	15,917	16,186	17,047	17,502	2.5
Other Consumer	1,296	1,395	1,461	1,539	1,593	1,655	1,724	1,798	4.2
Total	23,507	26,182	27,552	27,960	29,063	30,185	31,745	33,502	4.0

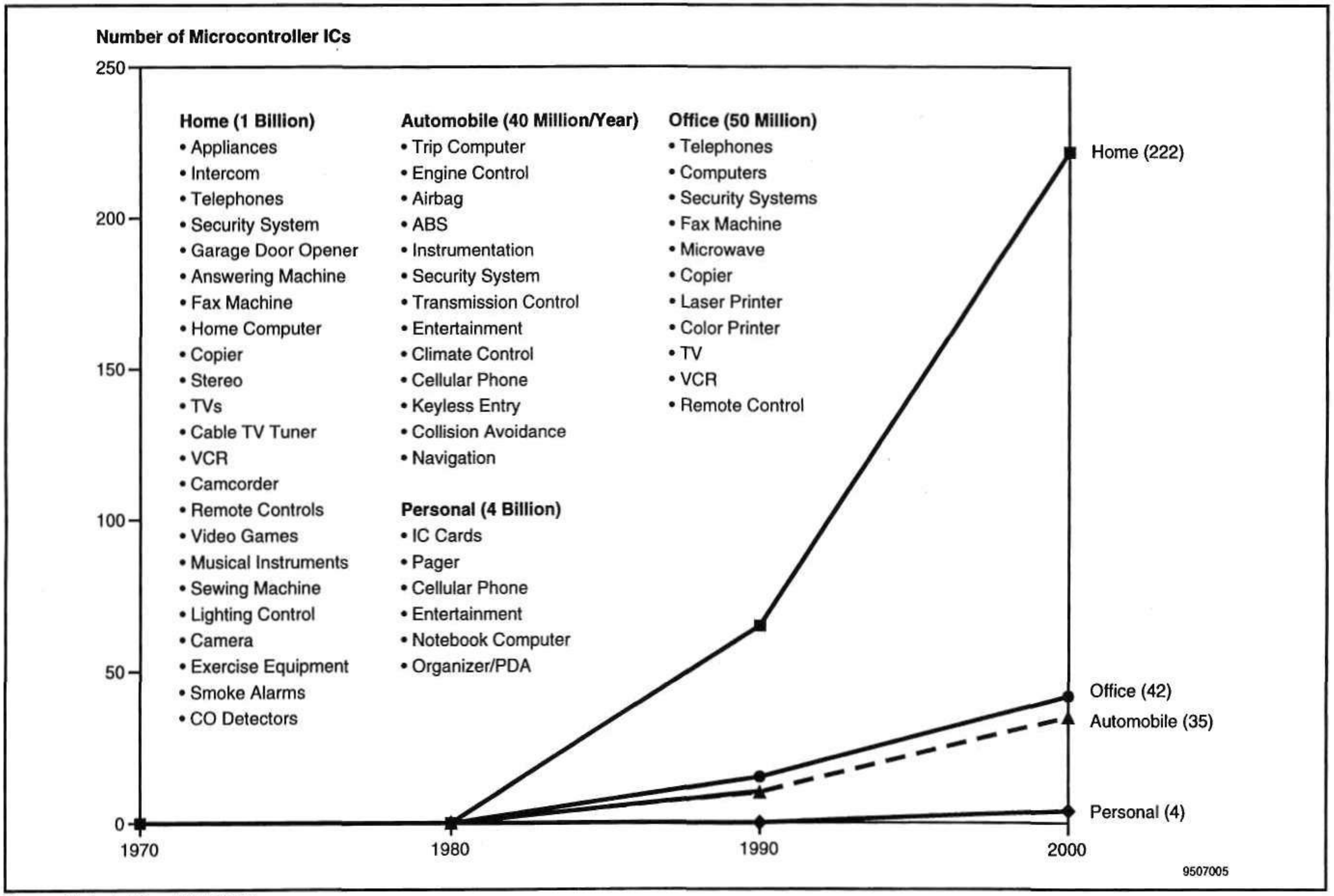
Source: Dataquest (December 1995)

Figure 2-5
Regional Share of Consumer Electronics Equipment Production Revenue (Percentage)



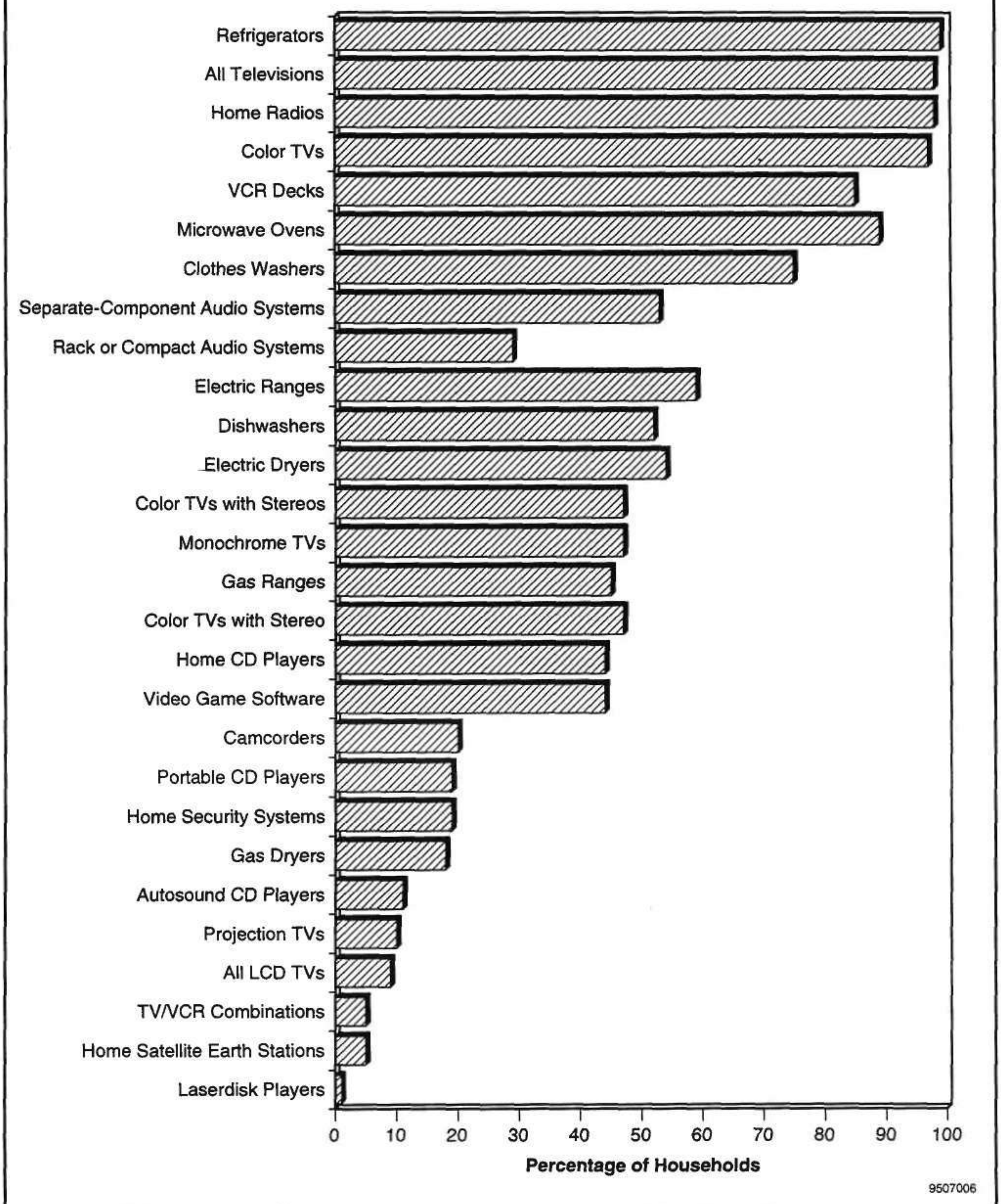
Source: Dataquest (December 1995)

Figure 2-6
Microcontroller Penetration of the Home and Consumer Markets



Source: Motorola (December 1995)

Figure 2-7
U.S. Household Penetration of Consumer Electronics Products, January 1994 (Percentage)



Source: EIA, Appliance Magazine, Dataquest (December 1995)

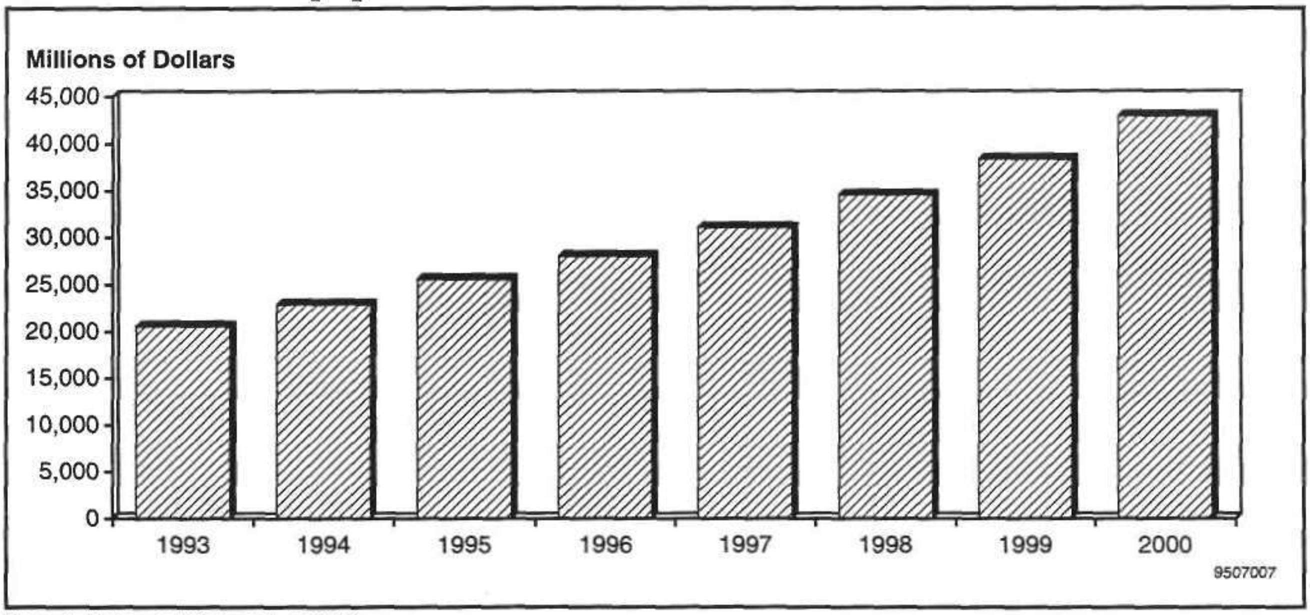
Chapter 3
Audio Equipment

Worldwide audio equipment production is expected to grow at a healthy 10.9 percent CAGR through 2000 (see Figure 3-1). Audio systems sales in the United States will help drive this growth, thanks to growing replacement sales and growing demand for step-up products. An example of this is the changer-equipped CD systems that are replacing single-CD systems. Figure 3-2 illustrates the commanding role the Asia/Pacific region will play in audio products, with more than 60 percent of production taking place there by 2000. Table 3-1 shows North American production of audio products. Major audio electronics manufacturers with U.S. facilities include Emerson Radio, Pioneer Electronics, Sanyo, Tandy, and Toshiba.

Portable products and digital technology are having the most significant impact on the audio electronics market. The Sony Walkman concept first applied to cassette players has continued into products such as personal CD players and personal portable stereos, or boom boxes. New products such as the MD and the DCC represent a combination of digital and portability features. As the various brand share tables in this chapter show, Sony plays a commanding role in every segment of the audio electronic equipment market. The only segment where it does not command a leading share is stereo speakers. Bose is the leader in this category, but even here Sony captured the No. 3 slot in 1994.

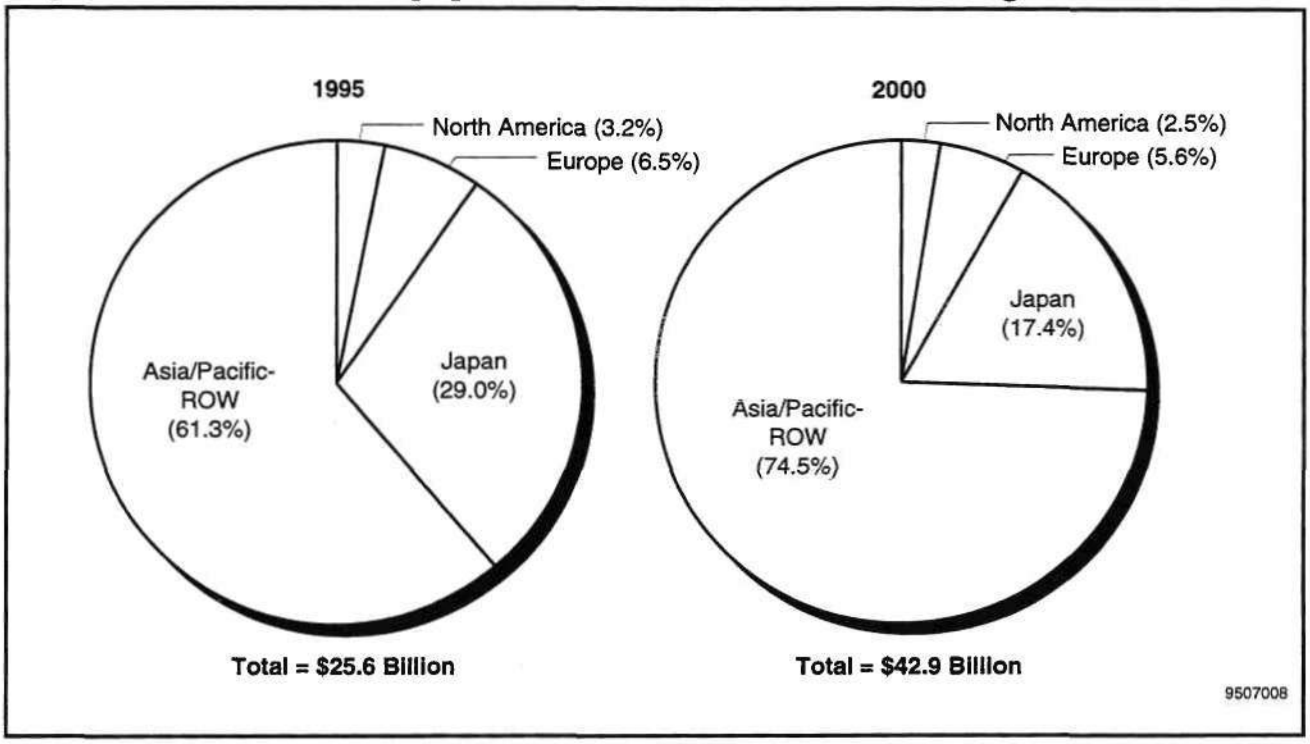
This chapter will present a worldwide production forecast for personal portable stereos and a discussion of the MD and DCC players. Brand share information is also presented for other major audio products.

Figure 3-1
Worldwide Audio Equipment Production Revenue Forecast (Millions of Dollars)



Source: Dataquest (December 1995)

Figure 3-2
Regional Share of Audio Equipment Production Revenue (Percentage)



Source: Dataquest (December 1995)

Table 3-1
North American Audio Equipment Production Revenue Forecast (Millions of Dollars)

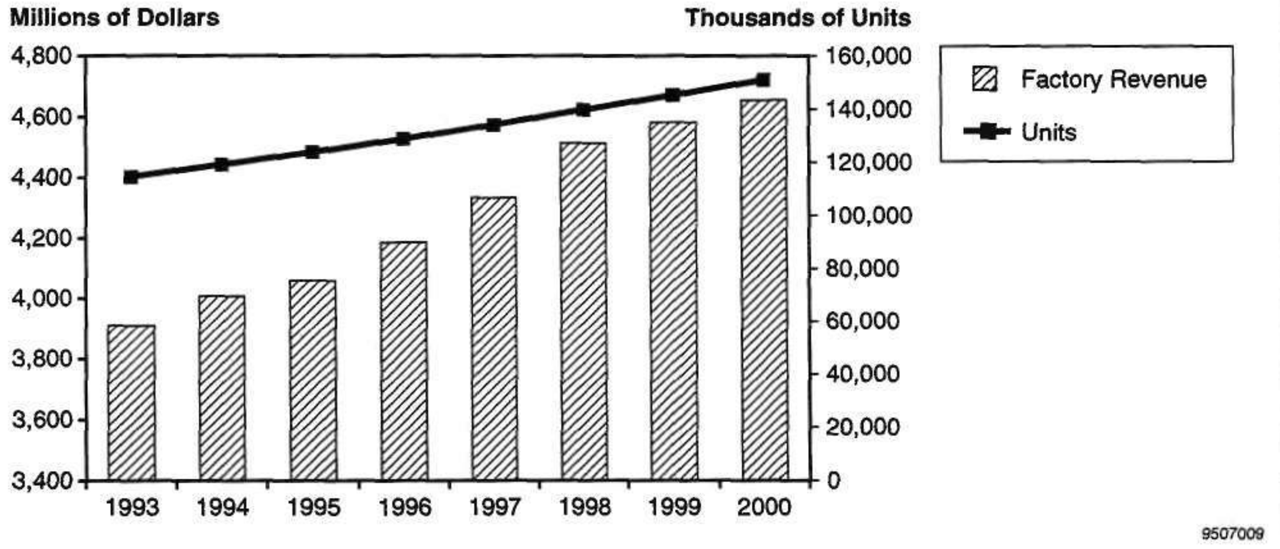
Segment	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Compact Disc Player	33	41	50	62	76	94	115	136	22.1
Radio	165	184	194	204	212	221	231	241	4.5
Personal/Portable Stereo	33	35	36	39	42	45	47	49	6.4
Stereo Component	226	239	252	266	276	288	302	317	4.7
Musical Instrument	242	250	261	274	282	292	302	313	3.7
Tape Recorder	17	17	18	19	20	20	21	22	3.9
Total	716	766	811	864	908	960	1,019	1,078	5.9

Source: Dataquest (December 1995)

Personal/Portable Stereos (Boom Boxes and Headsets)

Figure 3-3 and Table 3-2 show the worldwide production forecast for personal/portable stereos. Although these systems represent a high-volume opportunity, the growth in revenue will remain very low. Figure 3-4 provides a regional breakout of personal/portable stereo production. The dominance of the Asia/Pacific region in production of personal/portable stereos will increase through 2000, reaching 87 percent of worldwide production. Table 3-3 lists the North American production forecast for personal/portable stereos. Sony commanded more than 30 percent of the U.S. market in 1994 for boom boxes (see Tables 3-4 and 3-5).

Figure 3-3
Worldwide Personal/Portable Stereo Production Revenue and Unit Shipment Forecast (Millions of Dollars)



Source: Dataquest (December 1995)

CD Players

Beyond personal CD players, much of the growth in the CD player market is driven by upgrades to the new CD-changer players that accommodate multiple CDs. Tables 3-6 and 3-7 show brand share leaders for CD players in the United States.

Personal CD Players

Tables 3-8 and 3-9 list U.S. brand share leaders in personal CD players.

MiniDisc (MD) Players

Sony's latest plunge into the consumer market is the MD, Sony's replacement for the analog cassette, in terms of recordability, portability, and sonic fidelity. MD is similar to a standard compact disc (CD) player in looks and features but offers much improved portability and the ability to record at slightly less than CD quality. Sony concedes the product is not intended to replace today's CD but to be its portable counterpart. MD uses a compression technique known as Adaptive Transform Acoustic Coding (ATRAC) to fit 74 minutes of near CD-quality music on a 2.5-inch optical disc. ATRAC is designed to remove frequencies the human ear is less sensitive to and therefore least likely to notice missing. Shockproofing is achieved by incorporating a RAM buffer. If the laser does mistrack during play, the music will continue to flow for up to 10 seconds, which is good for mobile applications.

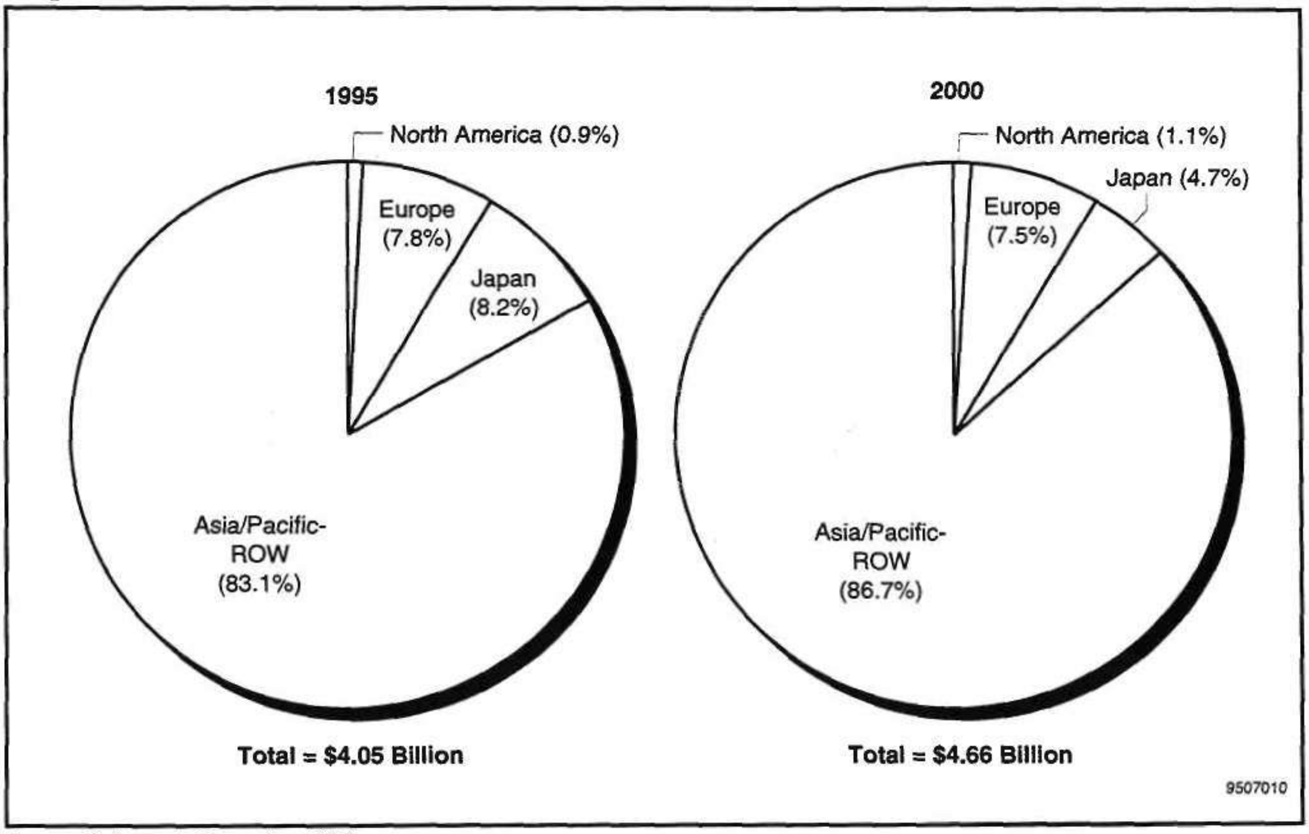
Although the early shipments were swept off shelves quickly, demand for the first-generation devices has quickly dropped. Low demand has limited the entrance of new companies to the market and the introduction of new models by existing players. To date, at least 14 electronics companies have acquired MD manufacturing licenses from Sony, including Sharp,

Table 3-2
Worldwide Personal/Portable Stereo Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	114,525	119,062	123,792	128,787	134,099	139,763	145,264	150,984	4.1
Factory ASP ($)	34	34	33	32	32	32	32	31	-1.2
Factory Revenue ($M)	3,909	4,007	4,059	4,185	4,333	4,513	4,583	4,656	2.8
Semiconductor Content ($)	8	8	8	7	7	7	7	7	-2.0
Semiconductor TAM ($M)	874	917	933	963	998	1,035	1,031	1,028	2.0

Source: Dataquest (December 1995)

Figure 3-4
Regional Share of Personal/Portable Stereo Production Forecast



Source: Dataquest (December 1995)

Table 3-3
North American Personal/Portable Stereo Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	510	535	565	605	655	710	738	768	6.3
Factory ASP ($)	65	65	64	64	64	64	64	64	0
Factory Revenue ($M)	33	35	36	39	42	45	47	49	6.3
Semiconductor Content ($)	12	12	12	12	12	12	12	13	1.6
Semiconductor TAM ($M)	6	6	7	7	8	8	9	10	8.1

Source: Dataquest (December 1995)

Kenwood, Sansui, Clarion, Aiwa, RCA, and Sanyo. In September 1995, Matsushita began selling a MiniDisc portable audio player. Matsushita's entry is significant because it was one of the original developers of the rival audio format called digital compact cassettes (DCC). Sony currently dominates the market for MD products with more than 50 percent of the market. However, in September, Sharp estimated that shipments of its MD products to Japan would reach 1.2 million units in 1995, quadrupling its shipments for 1994. Retailers report that play/record portables are outselling their play-only counterparts by at least 3:1.

Table 3-4
U.S. Boom Box Brand Share Leaders, First Quarter 1994 through Fourth Quarter 1994 (Percentage)

	Unit Market Share	Revenue Market Share
Sony	32.8	34.4
RCA	7.5	7.1
Magnavox	7.2	7.0
Sanyo	5.8	6.1
Panasonic	4.8	4.8
General Electric	4.8	3.8
GPX	4.7	3.0
Emerson	4.0	2.7
Sharp	3.9	5.1
JVC	3.0	5.3
Others	21.5	20.7
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-5
U.S. Boom Box Brand Share Leaders, Third Quarter 1994 through Second Quarter 1995 (Percentage)

	Unit Market Share	Revenue Market Share
Sony	33.6	35.1
Magnavox	7.9	7.7
RCA	7.8	7.3
Sanyo	5.8	5.7
Panasonic	4.8	5.2
GPX	4.4	2.8
General Electric	4.0	3.6
Sharp	3.7	4.4
Emerson	3.3	2.5
JVC	2.9	5.5
Others	21.8	20.2
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Cassette Tape Decks

Tables 3-10 and 3-11 list the brand share leaders for cassette tape decks in the United States.

Personal Tape Players

Tables 3-12 and 3-13 list the brand share leaders in the United States.

Table 3-6
U.S. CD Player Brand Share Leaders, First Quarter 1994 through Fourth Quarter 1994 (Percentage)

	Unit Market Share	Revenue Market Share
Sony	27.3	26.5
Pioneer	10.5	10.9
Kenwood	7.9	8.7
Technics	7.4	6.9
RCA	6.5	4.1
JVC	6.1	5.8
Magnavox	4.7	4.1
Fisher	3.4	5.1
Panasonic	3.0	2.2
Radio Shack Brands	2.9	2.9
Others	20.3	22.8
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-7
U.S. CD Player Brand Share Leaders, Third Quarter 1994 through Second Quarter 1995 (Percentage)

	Unit Market Share	Revenue Market Share
Sony	25.8	26.1
Pioneer	11.6	11.2
Technics	8.2	7.5
Kenwood	7.0	6.9
JVC	6.4	6.1
RCA	6.2	4.4
Magnavox	4.0	3.3
Panasonic	3.7	2.9
Fisher	3.4	5.4
Radio Shack Brands	2.7	3.5
Others	21.0	22.7
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-8
U.S. Personal CD Player Brand Share Leaders, First Quarter 1994 through Fourth Quarter 1994 (Percentage)

	Unit Market Share	Revenue Market Share
Sony	44.7	43.1
RCA	10.3	8.6
Panasonic	8.6	9.3
Koss	4.6	4.0
Radio Shack Brands	3.8	3.4
Magnavox	3.7	3.6
Kenwood	3.5	4.8
JVC	2.8	3.6
Fisher	2.6	3.7
Sanyo	2.2	1.7
Others	13.2	14.2
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-9
U.S. Personal CD Player Brand Share Leaders, Third Quarter 1994 through Second Quarter 1995 (Percentage)

	Unit Market Share	Revenue Market Share
Sony	45.1	43.3
RCA	11.0	9.4
Panasonic	10.0	10.9
Magnavox	4.2	4.0
Koss	4.0	3.4
Fisher	2.9	4.7
Sanyo	2.8	2.3
Radio Shack Brands	2.7	2.4
JVC	2.5	3.1
Kenwood	2.1	2.9
Others	12.7	13.6
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-10
U.S. Cassette Tape Deck Brand Share Leaders, First Quarter 1994 through Fourth Quarter 1994 (Percentage)

	Unit Market Share	Revenue Market Share
Sony	24.8	27.7
Pioneer	10.2	10.1
JVC	7.3	7.2
General Electric	6.8	2.3
Kenwood	6.3	9.8
Radio Shack Brands	6.0	5.2
Technics	5.0	5.2
Teac	3.4	2.3
Panasonic	3.3	1.9
Onkyo	2.8	3.6
Others	24.1	24.7
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-11
U.S. Cassette Tape Deck Brand Share Leaders, Third Quarter 1994 through Second Quarter 1995 (Percentage)

	Unit Market Share	Revenue Market Share
Sony	23.4	30.6
Pioneer	11.3	10.7
Kenwood	6.3	7.6
JVC	5.5	4.9
Teac	5.3	3.5
General Electric	5.3	1.8
Technics	5.2	5.2
Radio Shack Brands	4.7	3.9
Panasonic	3.0	2.0
Onkyo	2.2	2.1
Others	27.8	27.7
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-12
U.S. Personal Tape Player Brand Share Leaders, First Quarter 1994 through Fourth Quarter 1994 (Percentage)

	Unit Market Share	Revenue Market Share
Sony	40.1	46.5
General Electric	12.7	9.0
Panasonic	7.2	9.0
GPX	6.4	4.5
Aiwa	4.2	5.4
Radio Shack Brands	3.8	4.1
Emerson	2.9	1.9
Sanyo	2.7	2.3
Philco	2.5	1.8
Lenoxx Sound	2.1	1.0
Others	15.4	14.5
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-13
U.S. Personal Tape Player Brand Share Leaders, Third Quarter 1994 through Second Quarter 1995 (Percentage)

	Unit Market Share	Revenue Market Share
Sony	41.2	47.8
General Electric	12.0	8.7
Panasonic	6.5	7.5
GPX	5.4	4.2
Radio Shack Brands	4.6	4.9
Aiwa	4.5	6.2
Lenoxx Sound	2.9	1.4
Emerson	2.5	1.7
Philco	2.3	1.4
Sanyo	2.0	1.7
Others	16.1	14.5
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Digital Compact Cassette (DCC) Players

DCCs were developed by Philips and Matsushita and are designed to replace the analog cassette as a home recording device. DCC provides backward compatibility, which allows the large installed base of analog cassettes to be played on the new machines. DCC achieves its sound quality by using Precision Adaptive Subband Coding (PASC), a compression scheme that enables near-CD-quality audio to be encoded on tape traveling at the same speed as required by an analog tape transport system. A thin-film head is used for digital recording and playback for both digital and analog. DCC is an innovative product, but it suffers from perceptions in the market that consider tape or "contact-based" mediums to be inferior to "noncontact-based" mediums such as discs. Even though DCC edges out MD in terms of sonic integrity (it sounds better), MD has been more successful. Philips has lowered the price on its DCC products in an attempt to boost sales, which have not met expectations. Only 150,000 units were sold in 1993. In addition to those from Philips, DCC decks are available under the Panasonic, Tandy, and Magnavox brand names.

Stereo Rack Systems

Tables 3-14 and 3-15 list the brand share leaders for stereo rack systems in the United States.

Stereo Receivers

Tables 3-16 and 3-17 list the brand share leaders for stereo receivers in the United States.

Table 3-14
U.S. Stereo Rack System Brand Share Leaders, First Quarter 1994 through Fourth Quarter 1994 (Percentage)

	Unit Market Share	Revenue Market Share
Sony	22.3	24.0
Fisher	8.3	13.0
Pioneer	8.1	13.0
Sharp	6.9	4.9
Soundesign	6.9	2.8
Technics	5.1	9.3
Aiwa	4.4	3.6
Magnavox	4.0	1.7
Panasonic	3.5	2.8
JVC	3.4	4.1
Others	27.1	20.8
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-15
U.S. Stereo Rack System Brand Share Leaders, Third Quarter 1994 through Second Quarter 1995 (Percentage)

	Unit Market Share	Revenue Market Share
Sony	20.7	23.6
Pioneer	8.6	12.8
Soundesign	7.2	4.2
Fisher	7.0	9.5
Aiwa	6.9	5.3
Sharp	6.3	4.5
Technics	6.0	10.2
JVC	4.2	5.3
Panasonic	3.8	3.8
Magnavox	3.4	1.7
Others	25.9	19.1
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-16
U.S. Stereo Receiver Brand Share Leaders, First Quarter 1994 through Fourth Quarter 1994 (Percentage)

	Unit Market Share	Revenue Market Share
Sony	22.3	21.2
Pioneer	17.4	16.0
Kenwood	10.5	9.9
JVC	8.9	6.4
Technics	6.0	4.9
Onkyo	5.9	7.8
Radio Shack Brands	4.9	5.1
Denon	3.7	5.4
Yamaha	3.3	4.4
Fisher	3.1	4.1
Others	14.0	14.8
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-17
U.S. Stereo Receiver Brand Share Leaders, Third Quarter 1994 through Second Quarter 1995 (Percentage)

	Unit Market Share	Revenue Market Share
Sony	24.2	24.9
Pioneer	17.0	14.8
JVC	10.6	8.8
Kenwood	9.4	8.1
Technics	7.3	6.3
Onkyo	5.6	7.9
Yamaha	3.5	5.3
Radio Shack Brands	3.0	3.0
Fisher	2.5	2.6
Denon	2.2	3.9
Others	14.7	14.4
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Stereo Speakers

Main driving forces behind the growth of the stereo speaker industry are audio-for-video and new designs for speakers-specific applications. The home theater concept, where consumers want speakers to faithfully reproduce movie soundtracks, is a high-end example of this. Speaker designs are taking into account the different demands for movie soundtrack reproduction and music reproduction. Some systems incorporate a switch that allows the user to select the desired music or soundtrack mode. Tables 3-18 and 3-19 list the U.S. brand share leaders in this market.

Table 3-18
U.S. Stereo Speaker Brand Share Leaders, First Quarter 1994 through Fourth Quarter 1994 (Percentage)

	Unit Market Share	Revenue Market Share
Bose	17.9	28.4
Radio Shack Brands	10.0	4.5
Sony	9.1	7.4
Pioneer	8.6	5.9
KLH	5.9	1.9
Infinity	5.8	8.1
JBL	3.9	5.0
Yamaha	3.0	1.6
Advent	2.9	2.3
Technics	2.8	1.1
Others	30.1	33.8
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 3-19
U.S. Stereo Speaker Brand Share Leaders, Third Quarter 1994 through Second Quarter 1995 (Percentage)

	Unit Market Share	Revenue Market Share
Bose	17.6	27.8
Sony	9.2	7.1
Radio Shack Brands	8.3	3.5
KLH	7.4	2.5
Pioneer	6.5	4.2
Infinity	6.4	8.6
JBL	4.8	5.7
Yamaha	3.6	2.1
Technics	3.0	1.3
Advent	2.7	2.6
Others	30.5	34.6
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Chapter 4
Video Equipment

Video equipment is positioned in the consumer market as entertainment equipment, and together with audio equipment has been serving as a market and technology driver for the electronics equipment and semiconductor industries. In particular, it has spurred the development and commercialization of numerous production technologies and systems, which have also promoted the growth of industries that supply necessary components and materials.

Home use of entertainment equipment assures wide market penetration because it is less affected or impeded by social and cultural barriers. Video equipment demand potentially covers the entire world and grows with the economic development in each country. At the same time, establishment of video equipment production bases in the areas offering low-cost labor has helped expand regional economies, which in turn has created the economic base that stimulates video equipment demand.

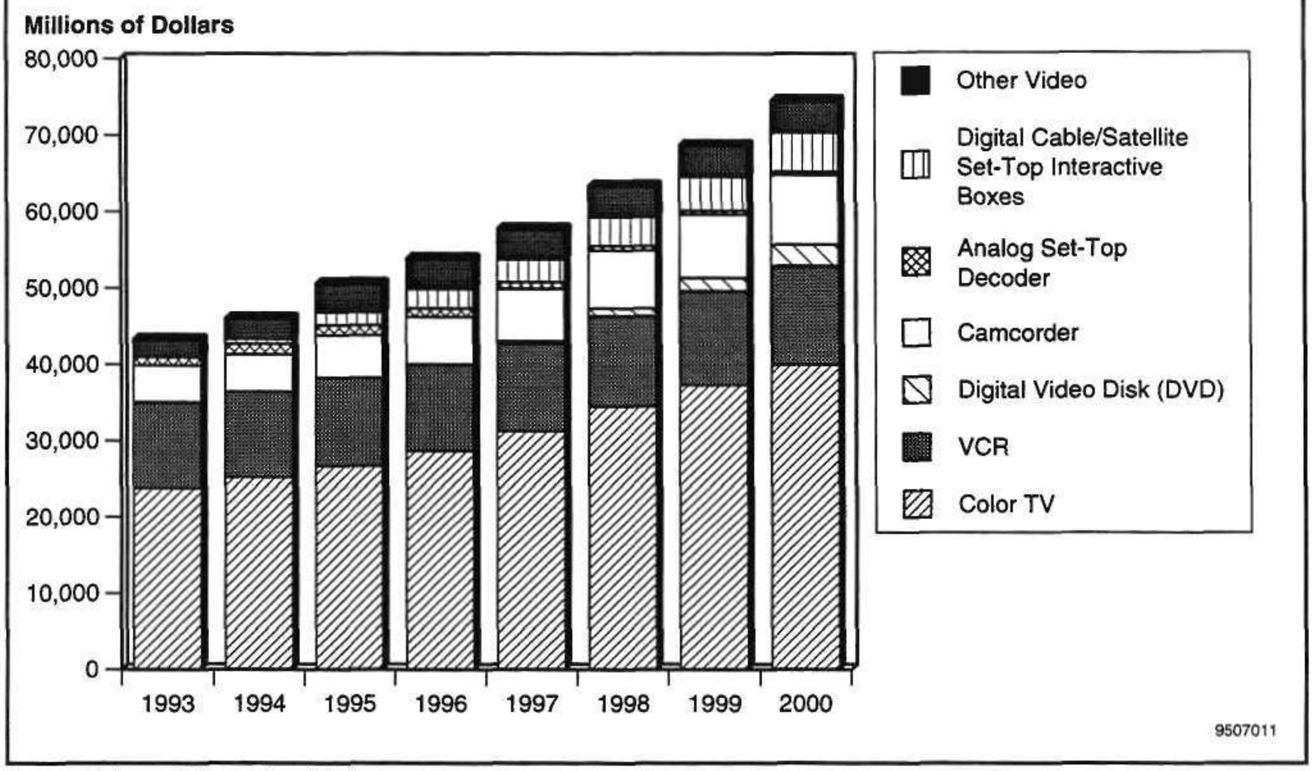
Figure 4-1 and Table 4-1 show the anticipated worldwide growth forecast of video equipment production. The CAGR for the next five years in video equipment is expected to be 8.0 percent. Particularly strong growth is anticipated in digital set-top boxes, with 25 percent CAGR forecast growth. Japan will be displaced as the leading producer of video equipment as production locations shift to the Asia/Pacific region: 40.4 percent of video equipment production will take place in the Asia/Pacific region by 2000 (see Figure 4-2). The forecast for North American video equipment production is given in Figure 4-3 and Table 4-2. Although color televisions represent the dominant slice of revenue production in North America, new technology developments are pushing production rates of VCRs, camcorders, and set-top boxes at much higher levels. The "Other Video" equipment category includes items such as video-CD players, LCD TV, black-and-white TV, and emerging products. Table 4-3 lists major North American video research and design and manufacturing locations.

Major announcements related to video R&D and manufacturing investments in North America include the following:

- JVC selected Tijuana, Mexico, as the location for a new North American color TV manufacturing facility. The new factory will have the capacity to turn out 10,000 20-inch and 27-inch color TVs monthly and will also feed chassis to the color TV assembly facility in Elmwood Park, New Jersey. Output is scheduled to begin in spring 1996.
- Mitsubishi announced plans to build a television R&D center in Orange County, California.
- Philips Consumer Electronics will add complete new production lines at its facility in Ottawa, Ohio, to give it the capacity to turn out 500,000 32-inch tubes and 300,000 35-inch tubes annually. The 32-inch production is expected to begin in summer 1996 and 35-inch production in 1997.

- Sanyo Video Components completed a $25 million expansion with the opening of its second plant in Tijuana, Mexico. The expansion tripled Sanyo's local production capacity for audio-video parts. The new facility can produce 3 million flyback transformers and 2.5 million tuners annually. The first plant, which opened in 1993, produces about 6 million deflection yokes a year.
- Thomson Consumer Electronics has begun expansion of its color TV and picture tube operations in North America. It plans to spend $52 million to expand capacity at its picture tube plant in Marion, Indiana. The company recently boosted production of 25-inch color tubes. The new expansion will increase production of 31-inch and 35-inch tubes by 20 percent and allow for start-up of production of 32-inch tubes. The plant currently produces 4 million of Thomson's total U.S. output of 6.5 million tubes. Thomson will also invest $2 million to double the production capacity of projection TVs at its main color TV manufacturing site in Bloomington, Indiana.
- LG Electronics, formerly known as Goldstar, acquired a 57.5 percent interest in Zenith in 1995. Part of the LG Electronics investment will enable Zenith to make improvements such as upgrading its Melrose, Illinois, and Mexico picture tube plants.

Figure 4-1
Worldwide Video Equipment Production Revenue Forecast (Millions of Dollars)



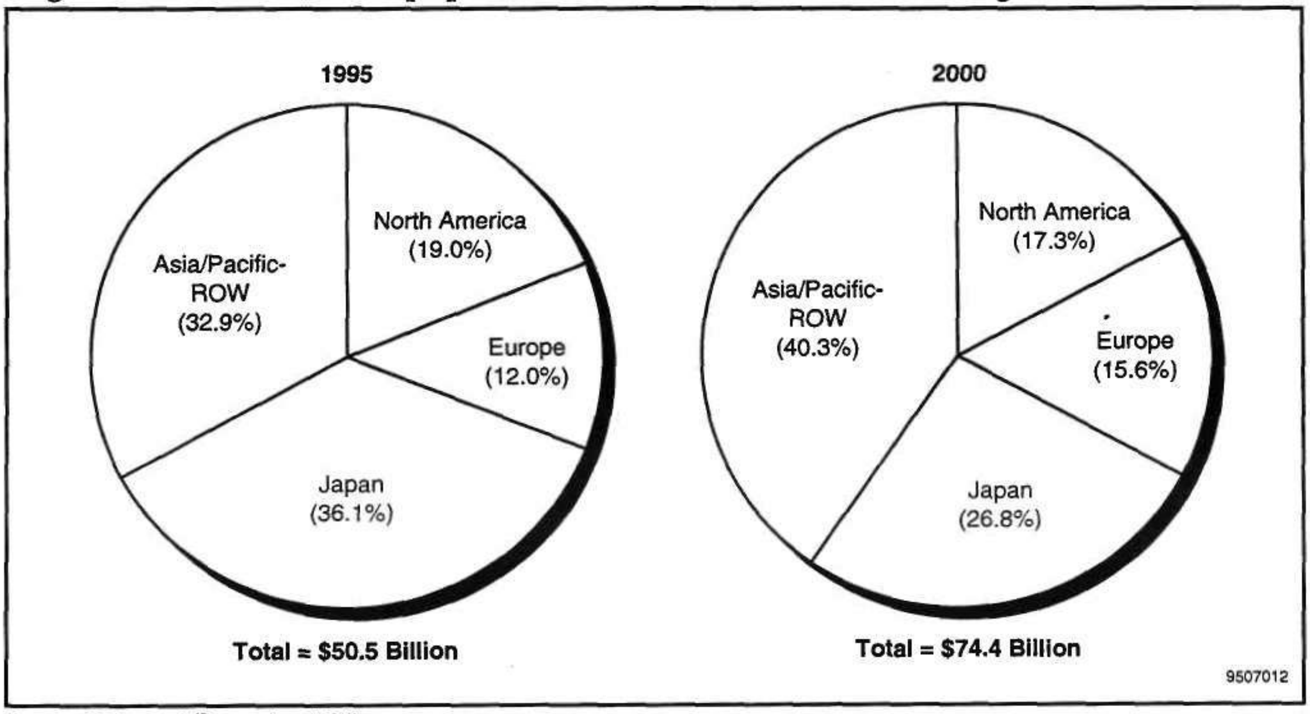
Source: Dataquest (December 1995)

Table 4-1
Worldwide Video Equipment Production Revenue Forecast (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Color TV	23,810	25,271	26,724	28,694	31,299	34,516	37,335	40,000	8.4
VCR	11,241	11,184	11,567	11,375	11,467	11,891	12,303	12,885	2.2
Digital Video Disc (DVD)	0	0	0	35	345	963	1,700	2,790	-
Camcorder	4,876	4,935	5,602	6,183	6,813	7,533	8,274	9,087	10.2
Analog Set-Top Decoder	1,104	1,382	1,312	1,127	887	594	527	486	-18.0
Digital Cable/Satellite Set-Top Interactive Boxes	1	534	1,572	2,433	2,858	3,690	4,296	4,963	25.9
Other Video	2,204	2,702	3,734	3,921	4,005	4,099	4,136	4,200	2.4
Total	43,236	46,009	50,510	53,769	57,675	63,284	68,570	74,410	8.1

Source: Dataquest (December 1995)

Figure 4-2
Regional Share of Video Equipment Production Revenue (Percentage)



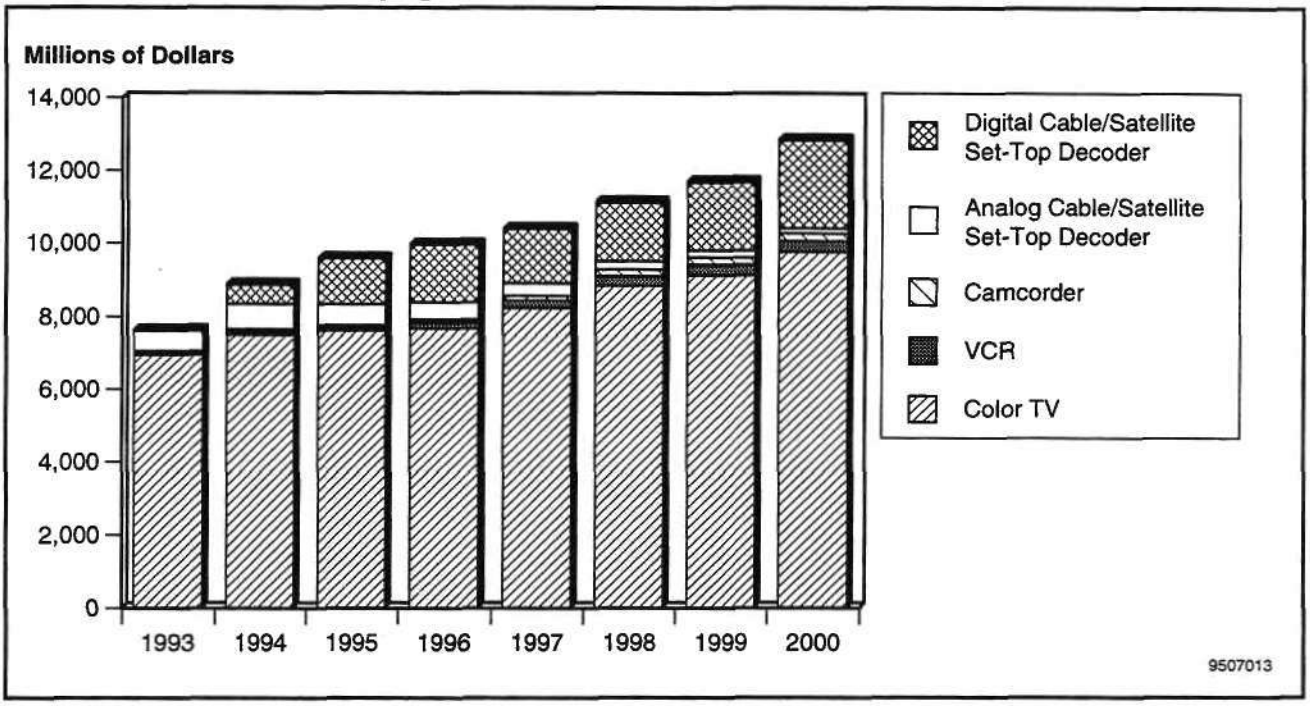
Source: Dataquest (December 1995)

Market Trends

Today, worldwide video equipment demand is stratified by the following distinguishable levels:

- Replacement and additional purchase demand in industrialized countries where the first-time buyer market is nearing a saturation point
- First-time purchase for low end and low cost
- Demand for hybrid products such as TV/VCR combinations
- Demand for next-generation video equipment, including wide-screen TV, HDTV, DVD, and video-CD

Figure 4-3
North American Video Equipment Production Revenue Forecast (Millions of Dollars)



Source: Dataquest (December 1995)

Table 4-2
North American Video Equipment Production Revenue Forecast (Millions of Dollars)

Segment	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Color TV	6,966	7,508	7,630	7,681	8,242	8,845	9,131	9,770	5.1
VCR	70	107	74	155	203	265	306	311	33.1
Camcorder	31	44	62	88	126	180	193	207	27.2
Analog Cable/Satellite Set-Top Decoder	556	689	570	465	348	235	188	135	-25.0
Digital Cable/Satellite Set-Top Decoder	0	521	1,252	1,583	1,486	1,610	1,875	2,424	14.1
Total	7,622	8,869	9,588	9,973	10,405	11,134	11,692	12,847	6.0

Source: Dataquest (December 1995)

As shown in Figure 2-7, color TVs and VCRs are now found in almost all U.S. homes, whereas newer video technologies such as camcorders have more room for growth. The majority of homes in the United States and Canada have more than one TV, and many families have more than one VCR. Most purchases in these categories are for replacement or upgrade of existing products. Lower interest rates and strong new home sales stimulated consumer durable spending beginning in the early part of 1994, which led to robust sales of video equipment in the United States. However, in spite of higher consumer confidence in 1995, video electronics sales growth slowed. The following sections provide more detailed discussion of the high-volume video equipment—color TVs, VCRs, and camcorders. Emerging opportunities in HDTV, video-CD, and DVD also are

Table 4-3
North American Video R&D and Manufacturing

Company	R&D Center	Manufacturing Sites
Emerson	North Bergen, NJ	North Bergen, NJ
JVC		Elmwood Park, NJ
Matsushita		Franklin Park, IL; Mexico
Mitsubishi	Brazelton, GA	Brazelton, GA
	Santa Ana, CA	Santa Ana, CA
	Orange County, CA	
Philips	Knoxville, TN	Greenville, TN; Ottawa, Ohio; Mexico
Thomson Consumer	Indianapolis, IN	Bloomington, IN; Marion, IN; Mexico
Sanyo		Tijuana, Mexico
Sony	San Jose, CA	San Diego, CA; Mexico
		Mount Pleasant, PA
Zenith	Glenview, IL	Melrose Park, IL; Mexico

Source: Dataquest (September 1994)

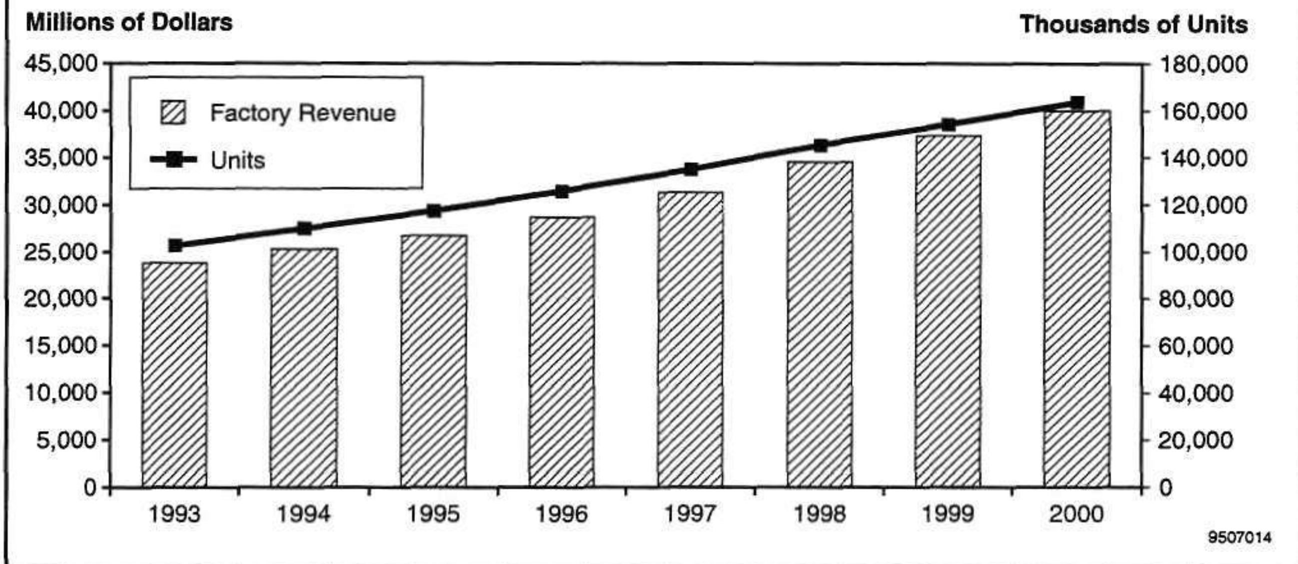
discussed at the end of this chapter. Detailed information on analog and digital set-top boxes is presented in Chapter 5, where interactive products are discussed.

Color Television

Figure 4-4 and Table 4-4 present the worldwide color television production forecast. There will be a significant shift in production from North America and Japan to the Asia/Pacific region during the next five years: 43.4 percent of worldwide production is expected to take place there by 2000. Tables 4-5 and 4-6 show the North American color TV market and production forecast, respectively. Figure 4-5 shows the regional distribution of color TV production. Figure 4-6 shows the sales mix of color TVs sold in the United States. RCA was the leading brand in the United States during 1994 and 1995. Tables 4-7 and 4-8 list leading color television brands. Key market trends and product developments affecting the color television market include the following:

- TV/VCR combinations will continue to grow significantly as several manufacturers introduce new models. These are preferred by families as a unit for children, because they save room and are easy to operate.
- Direct view screens of 20 inches and less are losing favor to screen sizes of 25 inches and more. A continued shift of the sales mix to larger screen sizes is expected. Screen sizes over 30 inches already represented almost 12 percent of the market in 1994.
- Stereo TVs grew to represent 42.5 percent of color TV sales in 1993. Their market share slipped slightly in 1994 to 42.2 percent of the market.
- Plasma displays made a big splash at the fall 1995 COMDEX show. These displays are about 4 inches thick and are expected to find their earliest application in "hang-on-the-wall" TVs. It appears that a market

Figure 4-4
Worldwide Color Television Production Revenue and Unit Shipment Forecast (Millions of Dollars)



Source: Dataquest (December 1995)

that was always "just 10 years away" is finally close to becoming a reality. Fujitsu and Panasonic were exhibiting the most impressive large flat panel designs based on their color plasma technology. Sony also demonstrated its Plasmatron display, which employs plasma-addressed liquid crystal (Palc) technology. Mitsubishi has also announced plans to introduce a flat panel TV-display using plasma technology. Fujitsu looks like it is probably about a year ahead of other plasma panel competitors. Its 42-inch color plasma display featuring 300-candela-per-square-meter brightness, a wide aspect ratio of 16:9, 24-bit color, 852 x 480 resolution, a 160-degree viewing cone, and a 70:1 contrast ratio outclassed virtually everything else in sight and captured constant media attention at the show. Major investments in research and production capacity have been announced by leading Japanese television manufacturers. Market introductions of plasma displays are scheduled to begin in the second quarter of 1996. However, pricing on these displays will create a barrier for early market acceptance. Fujitsu is targeting a price of $5,000 during mass production in 1996. This means that complete consumer systems should be available for less than $10,000.

- New technology developments are paving the way for introduction of three-dimensional televisions (3-D TVs) that allow viewers to see 3-D images without wearing special glasses. Sanyo has already exhibited a 3-D video projection system and announced that it intends to begin shipping systems outside Japan in late 1996. Shipments for use in commercial applications, arcade games, and medical equipment began in 1994. Its 40-inch 3-D LCD system employs twin LCD projectors that cast the images onto a double lenticular lens screen. This screen then separates the signals into right-side and left-side images, resulting in the illusion of 3-D images without the use of special glasses. Also, a company called HinesLab Inc. announced in September 1995 that it had patented a display system that achieves true stereo 3-D images. The

Table 4-4
Worldwide Color Television Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	102,610	109,901	117,385	125,775	134,855	145,168	154,094	163,631	6.9
Factory ASP ($)	232	230	228	228	232	238	242	244	1.4
Factory Revenue ($M)	23,810	25,271	26,724	28,694	31,299	34,516	37,335	40,000	8.4
Semiconductor Content ($)	29	30	30	30	30	31	33	34	2.4
Semiconductor TAM ($M)	3,003	3,312	3,502	3,813	4,091	4,468	5,021	5,487	9.4

Source: Dataquest (December 1995)

Table 4-5
North American Color Television Market Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Color TV Only									
Units (K)	25,306	27,310	27,594	28,490	29,535	30,618	32,602	34,713	4.7
Factory ASP ($)	318	292	294	287	294	294	294	294	0
Factory Revenue ($M)	8,047	7,975	8,113	8,177	8,683	9,002	9,585	10,206	4.7
TV/VCR Combination									
Units (K)	1,792	2,229	2,382	2,640	2,864	3,107	3,371	3,657	9.0
Factory ASP ($)	368	350	344	337	333	331	330	330	-0.8
Factory Revenue ($M)	659	780	819	890	954	1,029	1,112	1,207	8.1

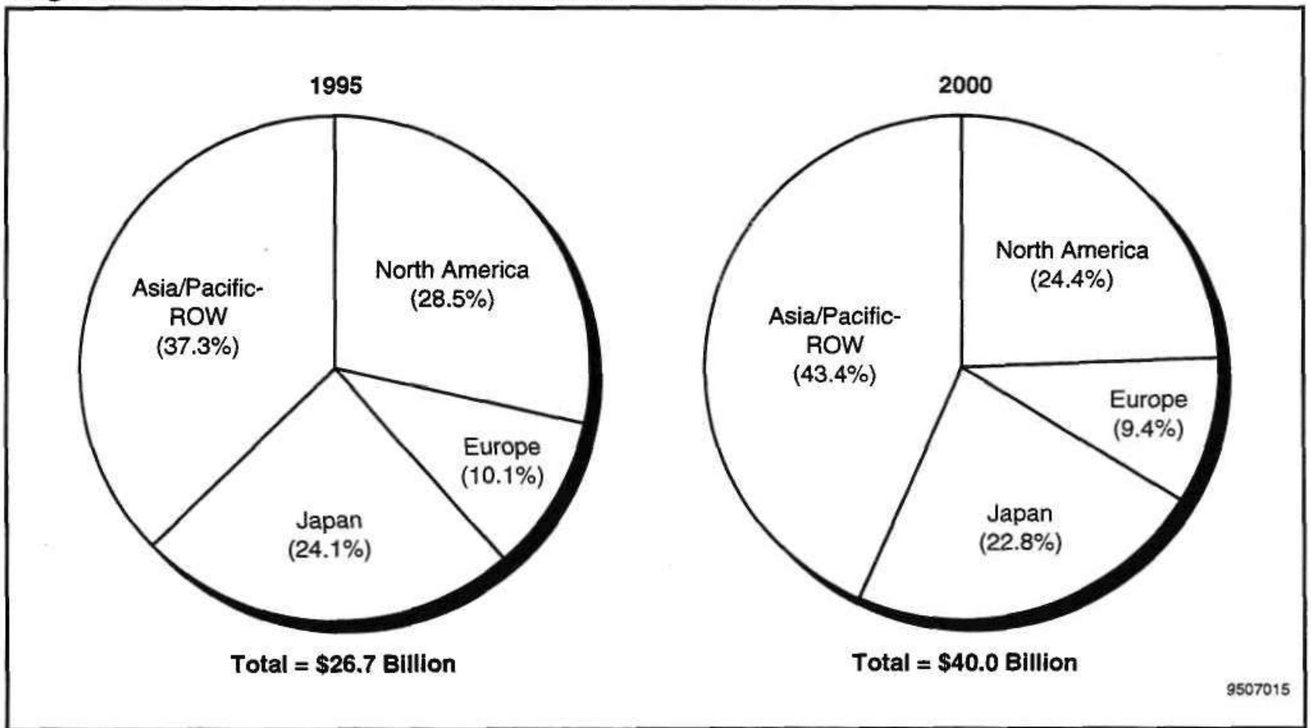
Note: Includes direct view stereo and nonstereo TV. Does not include monochrome TV, color LCD TV, or projection TV.
Source: Dataquest (December 1995)

Table 4-6
North American Color Television Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	20,656	22,043	22,857	23,009	23,857	24,735	26,467	28,319	4.4
Factory ASP ($)	337	341	334	334	345	345	345	345	0.7
Factory Revenue ($M)	6,966	7,508	7,630	7,681	8,242	8,845	9,131	9,770	5.1
Semiconductor Content ($)	29	29	29	29	30	30	30	30	0.1
Semiconductor TAM ($M)	597	645	657	663	713	742	794	850	5.3

Source: Dataquest (December 1995)

Figure 4-5
Regional Share of Color Television Production Revenue

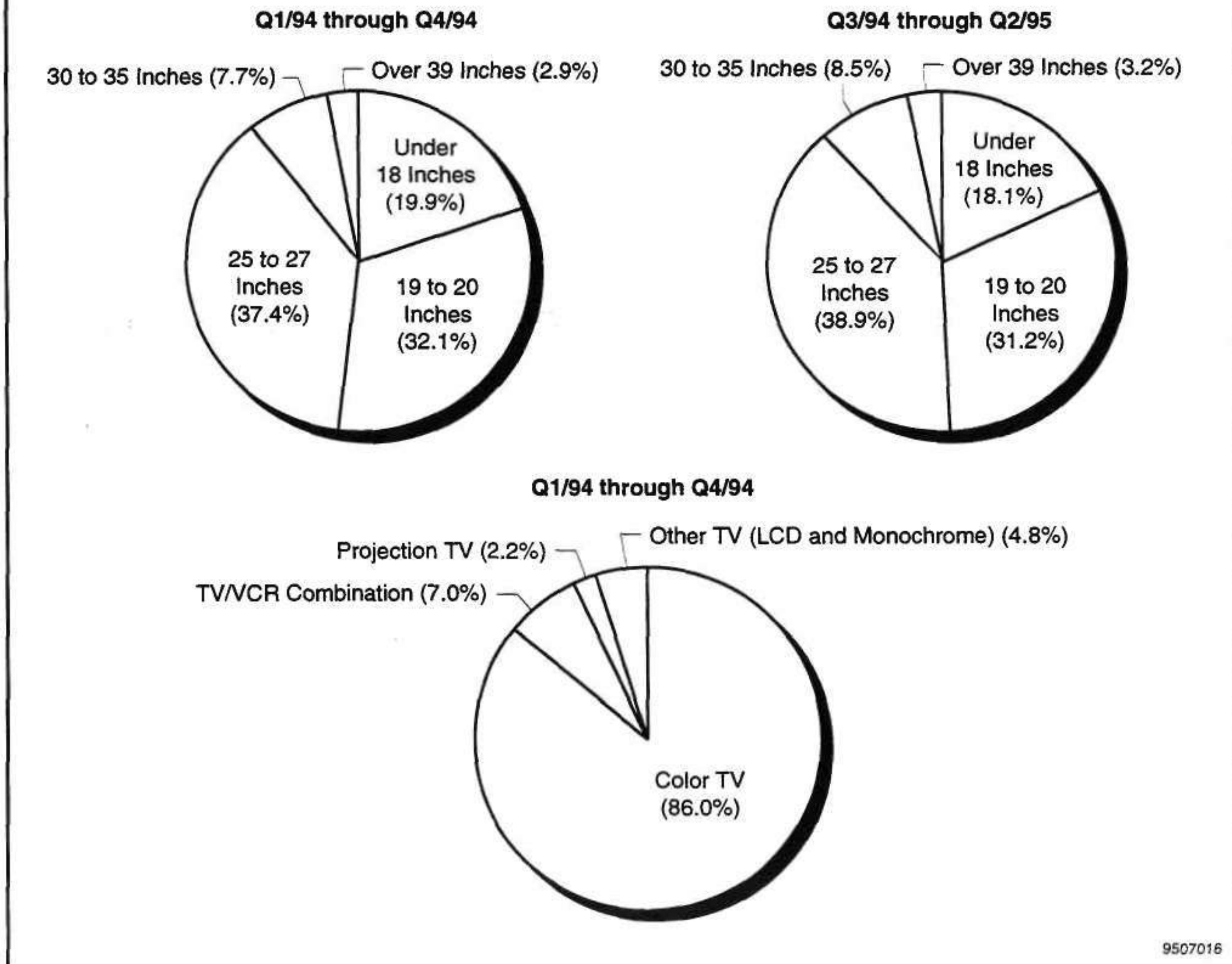


Source: Dataquest (December 1995)

company claims that its system uses conventional optics and is built into a single display panel that affords users a greater degree of freedom, allowing anyone to sit in front of a monitor and experience realistic moving images. Finally, engineers from the University of Alabama have demonstrated a prototype that pumps moving holographic stereogram images through an active matrix LCD. The prototype, called ICVision, is constructed using a 1-inch diagonal active matrix LCD from Kopin Corporation and a diffractive optical element for directing light through a series of slits, which form the left and right halves of the stereo image.

- Digital micromirror display (DMD) technology continues to be advanced by Texas Instruments. Texas Instruments has been working on DMD technology for decades. It has now developed a prototype DMD device that measures 2 centimeters squared and holds 400,000

Figure 4-6
North American Color Television Sales Mix (Unit Basis)



Source: Dataquest (December 1995)

movable aluminum mirrors, each about 16 square microns. By controlling the mirror's movement, the device projects a brighter image than today's LCD-based video projectors. Employing processing techniques the company calls Digital Light Processing (DLP), TI has developed a prototype projection display that was demonstrated at Dataquest's 1995 Semiconductor Conference. Potential partners that could help TI bring this technology to the market include Sony and Thomson Consumer Electronics.

- The "V-Chip" (the V stands for violence) that identifies programs by content and allows consumers to block out objectionable shows was introduced in 1994. Although the major TV networks have voiced opposition to this scheme, President Clinton and both houses of Congress favor legislation that mandates the use of V-chip technology in all new TV sets. The fate of this law hangs on a budget resolution in Washington. Meanwhile, hundreds of Canadian households will participate in a trial implementation of the V-chip. The V-chip could find its way into

Table 4-7
U.S. Color Television Brand Share Leaders, First Quarter 1994 through Fourth Quarter 1994 (Percentage)

	Unit Market Share	Revenue Market Share
RCA	16.1	17.6
Magnavox	15.0	12.7
Zenith	12.0	13.0
Sony	6.6	9.0
General Electric	6.6	5.0
Sharp	6.0	3.7
Sanyo	5.3	3.3
Emerson	5.0	2.7
Toshiba	3.1	5.5
Panasonic	2.9	3.6
Others	21.4	23.9
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 4-8
U.S. Color Television Brand Share Leaders, Third Quarter 1994 through Second Quarter 1995 (Percentage)

	Unit Market Share	Revenue Market Share
RCA	16.2	17.2
Magnavox	16.1	14.3
Zenith	12.3	12.8
Sony	7.1	9.4
General Electric	6.3	4.4
Sharp	6.0	3.8
Sanyo	4.9	3.0
Emerson	4.4	2.4
Panasonic	3.5	3.9
Toshiba	3.3	5.9
Others	19.9	22.9
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

set-top boxes, VCRs, and TVs. Zilog has already announced that its Z89300 TV control and on-screen display chip family have the recommended TV program rating decoding and control capability. In volume production, this chip will be priced in the $4-to-$6 range.

Functionally, color TVs have reached near maturity, and the focus is being placed on improvement of productivity in the manufacturing process through digitization. Integration of peripherals devices into semiconductor chips allows reduction of components, thus reduction of inspection/ adjustment points. Also, an increasing use of microcomputers enables signal processing control by computer bus, leading to standardization of chassis design. Figure 4-7 shows a block diagram of a currently available multifunction, high-performance color TV.

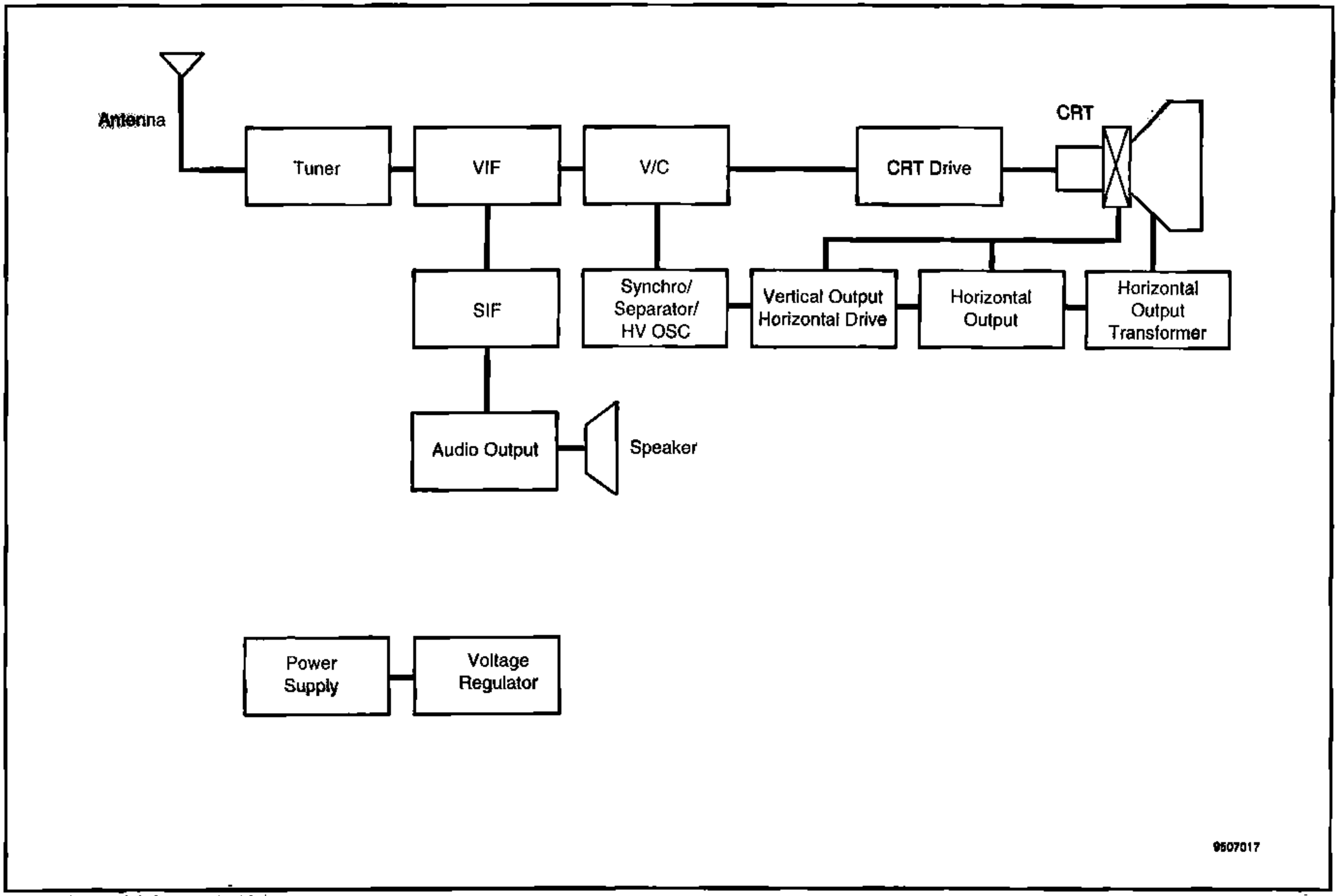
Major technological trends in electronic circuits for video equipment are classified as follows:

- Digital processing of image, voice, and mechanical control signals. Digital processing of video and voice signals for low-end products has been incorporated into ICs except for CRT video and horizontal output circuits, which are configured by discrete devices.
- Since the adoption of the Ghost Cancellation Reference (GCR) by the Federal Communications Commission (FCC) in May 1993, awareness of its technology has increased. Many more stations are including the reference in their transmission. Ghost cancellation technology is also being introduced to the public through a consumer standalone unit. With time, ghost cancellation will become more widely accepted, and the technology will become a commonly integrated feature of the television receiver or VCR.
- Interframe signal processing by using TBC technology and semiconductor memory. Improved-definition TV (IDTV) and EDTV use digital memories to scan 525 lines at a frequency twice that used in the National Television Standards Committee (NTSC) standard. The use of digital memory also allows currently available color TVs to adopt technologies to improve picture quality by eliminating or reducing cross-color and jitter.
- Closed-captioning decoders. Closed-captioning decoders for the hearing impaired are now mandatory on U.S. market TVs.
- Use of the bus system for interactive control of ICs. In particular the I2 bus technology patented by Philips is beginning to be adopted by color TVs.
- Incorporation of new features. Digitization of signal processing has promoted incorporation of new features, such as picture in picture, digital still, and on-screen display.

VCRs

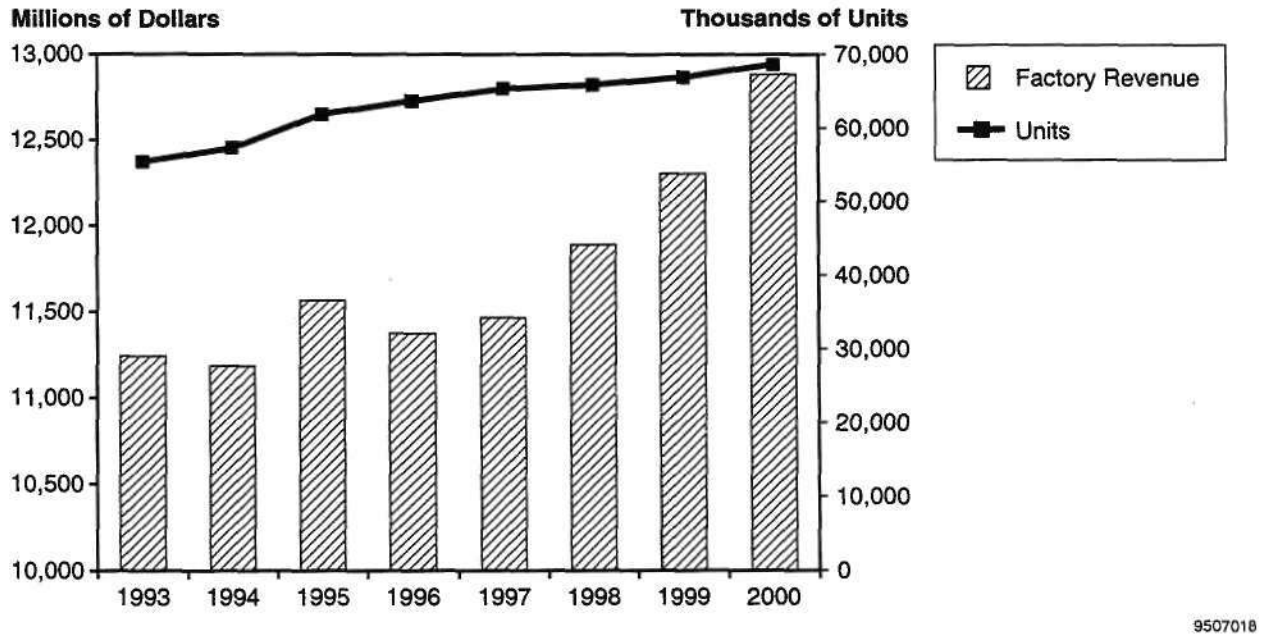
Figure 4-8 and Table 4-9 show the forecast for worldwide VCR production. Because household penetration rates are more than 90 percent, Dataquest expects unit shipments and revenue for the next five years to remain essentially flat. Sales are now sustained by replacement, upgrades, and households adding a VCR. Following the trends for other video equipment, production increasingly will shift to the Asia/Pacific region.

Figure 4-7
Block Diagram of Currently Available Multifunction, High-Performance Color TV



Source: Dataquest (December 1995)

Figure 4-8
Worldwide VCR Production Revenue and Unit Shipment Forecast (Millions of Dollars)



Source: Dataquest (December 1995)

Table 4-9
Worldwide VCR Production Forecast

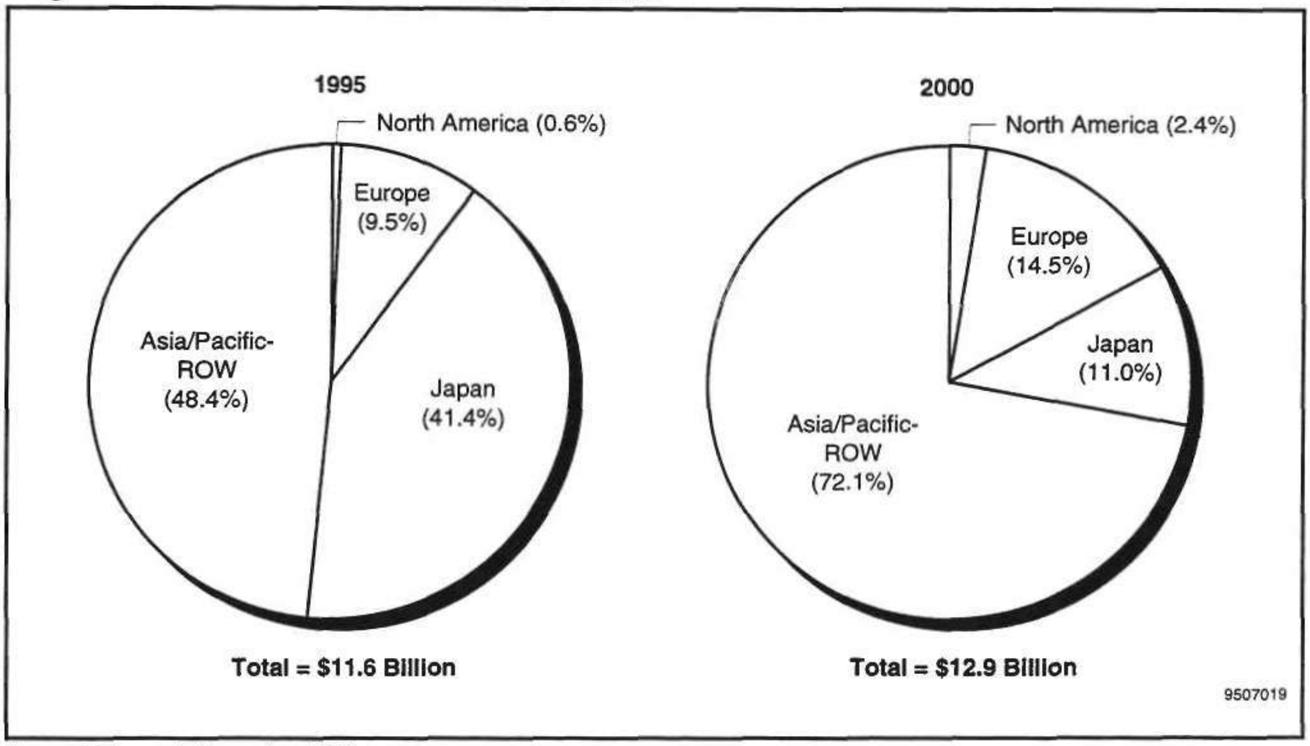
	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	55,296	57,209	61,844	63,638	65,313	65,891	66,919	68,662	2.1
Factory ASP ($)	203	196	187	179	176	180	184	188	0.1
Factory Revenue ($M)	11,241	11,184	11,567	11,375	11,467	11,891	12,303	12,885	2.2
Semiconductor Content ($)	42	43	43	42	41	39	39	39	-2.1
Semiconductor TAM ($M)	2,333	2,470	2,656	2,657	2,667	2,585	2,579	2,654	0

Source: Dataquest (December 1995)

Figure 4-9 shows the distribution of VCR production by region. Tables 4-10 and 4-11 show the North American VCR market and production forecast, respectively. Tables 4-12 and 4-13 list the leading VCR brands. Key trends to note among VCRs are as follows:

- The most popular upgrade feature is stereo audio. The 1996 market for home VCR desks will be heavily stereo-oriented. There will probably be a decline in the sale of mono models in the United States. Other advanced features include special effects with four heads and the S format, which offers more effective scan lines.
- The VCR Plus programming standard for simplified program recording is nearly a standard feature on step-up VCRs.

Figure 4-9
Regional Share of VCR Production Revenue



Source: Dataquest (December 1995)

Table 4-10
North American VCR Market Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	14,004	14,788	15,232	15,413	15,713	15,930	16,146	16,365	1.4
Factory ASP ($)	229	218	206	195	192	195	197	200	-0.6
Factory Revenue ($M)	3,207	3,224	3,138	3,005	3,017	3,106	3,181	3,273	0.8

Note: Does not include TV/VCR combinations or camcorders
Source: Dataquest (December 1995)

Table 4-11
North American VCR Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	302	469	325	673	871	1,127	1,183	1,243	30.7
Factory ASP ($)	231	228	228	231	233	235	245	250	1.8
Factory Revenue ($M)	70	107	74	155	203	265	306	311	33.1
Semiconductor Content ($)	31	31	31	32	33	33	33	34	1.5
Semiconductor TAM ($M)	9	15	10	22	28	37	39	42	32.8

Source: Dataquest (December 1995)

Table 4-12
U.S. VCR Brand Share Leaders, First Quarter 1994 through Fourth Quarter 1994 (Percentage)

	Unit Market Share	Revenue Market Share
RCA	13.9	14.6
Magnavox	12.1	11.4
Emerson	8.0	5.5
Panasonic	7.7	8.0
General Electric	5.8	5.0
Zenith	5.3	6.0
JVC	5.0	6.0
Sony	4.7	7.0
Sharp	4.5	4.1
Goldstar	3.1	2.4
Others	29.9	30.0
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 4-13
U.S. VCR Brand Share Leaders, Third Quarter 1994 through Second Quarter 1995 (Percentage)

	Unit Market Share	Revenue Market Share
RCA	14.2	14.9
Magnavox	12.5	11.8
Panasonic	8.2	8.6
Emerson	8.0	5.6
General Electric	5.3	4.6
Zenith	5.0	5.7
Sharp	5.0	4.5
JVC	5.0	6.1
Sony	4.6	6.7
Goldstar	2.7	2.2
Others	29.5	29.3
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

In terms of basic features and functions, VCRs have reached a stage of near perfection. Basic signal processing circuits are increasingly digitized by using analog-to-digital converters (ADCs) and digital-to-analog converters (DACs) and are eventually integrated into semiconductor chips incorporating digital signal processors (DSPs). New developments are expected in restoration of original signals, in addition to accurate replay, as well as the ability to provide output according to diverse consumer demand. Digitization has boosted the number of ICs capable of handling NTSC, PAL, and SECAM formats. Also, the use of on-screen display ICs and filter-equipped ICs is reducing the number of components and adjustment points at the factory. Copy-protection circuitry from Macrovision is becoming more popular as both Philips and Texas Instruments are producing copy-protection chips. Figure 4-10 shows a block diagram of a typical VCR.

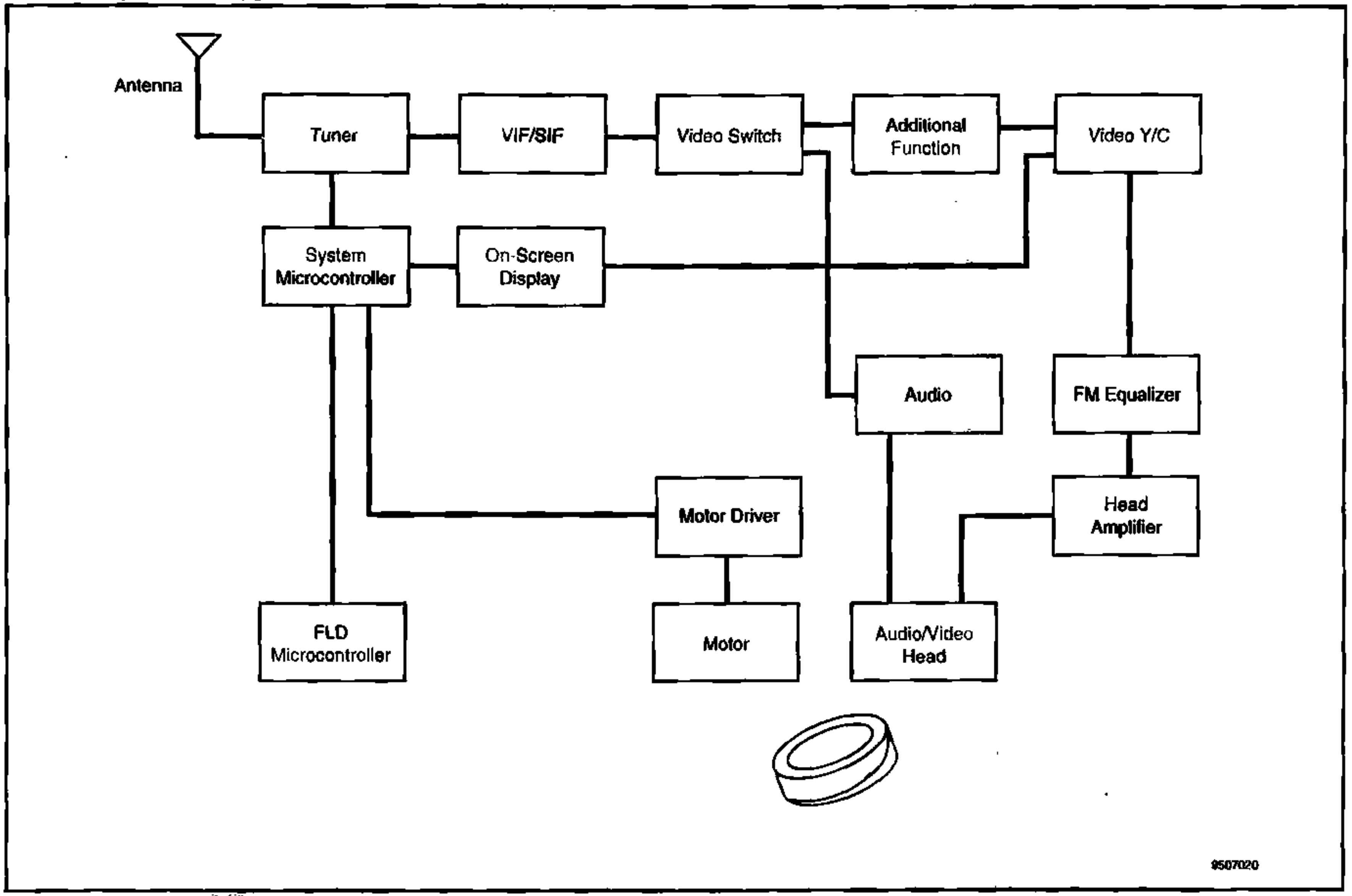
A new standard called Data-VHS (D-VHS) is being developed by VCR manufacturers, led by JVC. The new D-VHS system will be backward-compatible with the VHS format and would also add a bitstream recording capability to allow recording of compressed digital data. The standard would use existing Super VHS media and would be capable of offering 49 hours of recording per cassette. D-VHS will also record analog broadcasts such as NTSC and PAL. This feature would open new applications for VCRs in uses such as data storage and multimedia systems. JVC has consulted with Hitachi, Matsushita, and Philips Electronics in developing this new standard. Also, the following companies have expressed support for the D-VHS format: LG Electronics, Mitsubishi Electric, Samsung Electronics, Sanyo Electric, Sharp, Sony, Thomson Consumer Electronics, and Toshiba. Thomson is looking at D-VHS as an extension of its RCA Digital Satellite System (DSS) equipment line. D-VHS could record the actual digital direct-to-home satellite feeds of DirecTV and U.S. Satellite Broadcasting (USSB) programming.

The inclusion of digital recording capability will add \$300 to \$400 to the retail price of a VHS VCR. The first D-VHS VCRs are expected to hit the market in mid-1996. The higher price will present a significant barrier to market acceptance. A survey conducted by the EIA explored U.S. consumer interest in a digital VCR. When digital VCR was described to them, 29 percent of the VCR owners said they would be interested in purchasing it and 22 percent were unsure. However, when asked about the price they would be willing to pay, 25 percent of respondents said they would pay \$400, 11 percent would pay \$600, three percent would pay \$800, and five percent would pay \$1,000.

Camcorders

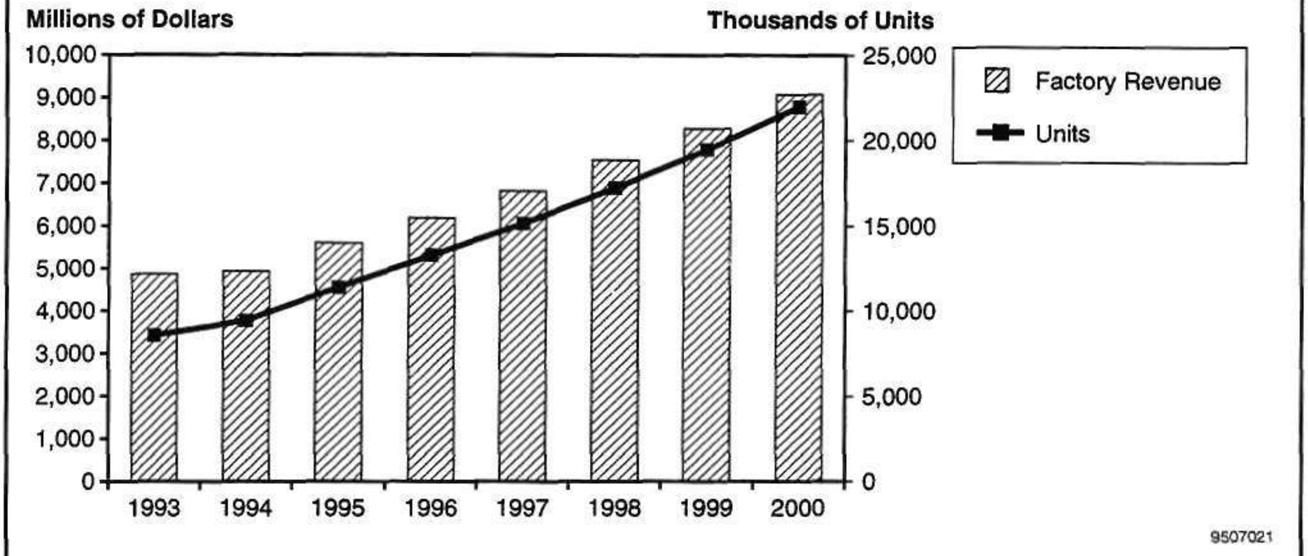
Figure 4-11 and Table 4-14 present Dataquest's forecast for worldwide camcorder production. Growth in revenue and shipments will be healthy during the next five years. Tables 4-15 and 4-16 present the North American market and production forecast, respectively. Figure 4-12 shows the production distribution by region. Japan is the primary location for production of camcorders. In spite of some shifting of production to the Asia/Pacific region, Japan will still produce the large majority of camcorders through 2000. Tables 4-17 through 4-18 show the leading camcorder

Figure 4-10
Block Diagram of a Typical VCR



Source: Dataquest (December 1995)

Figure 4-11
Worldwide Camcorder Production Revenue and Unit Shipment Forecast (Millions of Dollars)



Source: Dataquest (December 1995)

Table 4-14
Worldwide Camcorder Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	8,566	9,433	11,396	13,300	15,147	17,224	19,465	21,997	14.1
Factory ASP ($)	569	523	492	465	450	437	425	413	-3.4
Factory Revenue ($M)	4,876	4,935	5,602	6,183	6,813	7,533	8,274	9,087	10.2
Semiconductor Content ($)	145	134	124	115	112	110	109	107	-2.8
Semiconductor TAM ($M)	1,246	1,260	1,409	1,533	1,698	1,890	2,113	2,363	10.9

Source: Dataquest (December 1995)

Table 4-15
North American Camcorder Market Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	3,381	3,530	3,750	3,905	4,072	4,247	4,433	4,626	4.3
Factory ASP ($)	611	600	586	570	550	535	520	515	-2.5
Factory Revenue ($M)	2,066	2,118	2,198	2,226	2,240	2,272	2,305	2,383	1.6

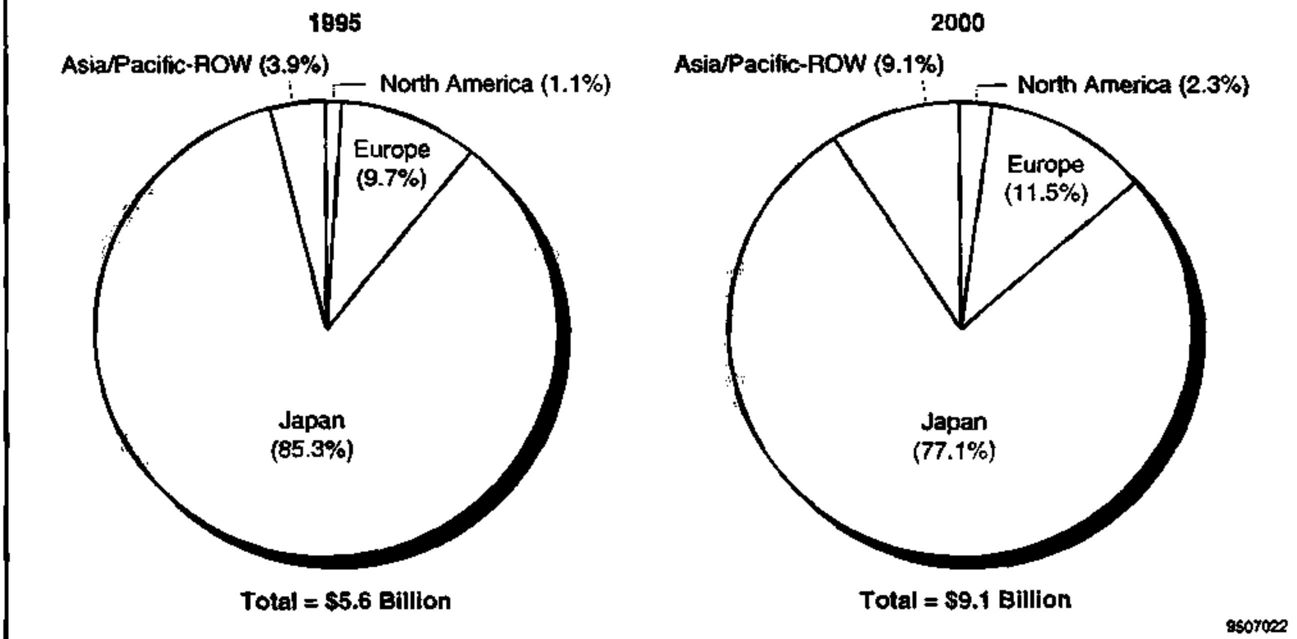
Source: Dataquest (December 1995)

Table 4-16
North American Camcorder Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	50	75	113	169	253	380	429	485	33.9
Factory ASP ($)	611	581	552	524	498	473	449	427	-5.0
Factory Revenue ($M)	31	44	62	88	126	180	193	207	27.2
Semiconductor Content ($)	92	87	85	84	84	85	85	86	0.0
Semiconductor TAM ($M)	5	7	10	14	21	32	36	41	34.0

Source: Dataquest (December 1995)

Figure 4-12
Regional Share of Camcorder Production Revenue



Source: Dataquest (December 1995)

brands in the United States. Key trends to note among camcorders are as follows:

- More than 20 percent of U.S. homes have camcorders, although it is primarily homes with children that are buying camcorders.
- The strong movement to compact versions is helping fuel new sales. S versions are beginning to win over resolution-conscious moviemakers.
- Viewfinders that rely on LCDs rather than on traditional optical techniques are contributing to the impressive market surge for camcorders. The percentage of camcorders equipped with LCD monitors is more than doubling annually in Japan and abroad, according to statistics from Sharp, a leader in LCD technology implementation in camcorders.

Table 4-17
U.S. Camcorder Brand Share Leaders, First Quarter 1994 through Fourth Quarter 1994 (Percentage)

	Unit Market Share	Revenue Market Share
Sony	26.4	28.8
RCA	16.1	15.7
Panasonic	14.7	16.0
JVC	8.8	8.4
Sharp	10.4	10.5
Magnavox	5.4	4.3
Hitachi	3.5	4.1
General Electric	4.6	3.2
Canon	2.7	3.0
LXI	2.0	1.4
Others	5.4	4.6
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 4-18
U.S. Camcorder Brand Share Leaders, Third Quarter 1994 through Second Quarter 1995

Brand	Unit Market Share	Revenue Market Share
Sony	24.5	26.8
RCA	16.6	16.2
Panasonic	12.8	13.4
JVC	11.7	11.5
Sharp	11.1	11.7
Magnavox	4.8	3.6
Hitachi	4.5	5.2
General Electric	4.1	2.8
Canon	2.4	2.6
LXI	1.7	1.2
Others	5.8	5.0
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

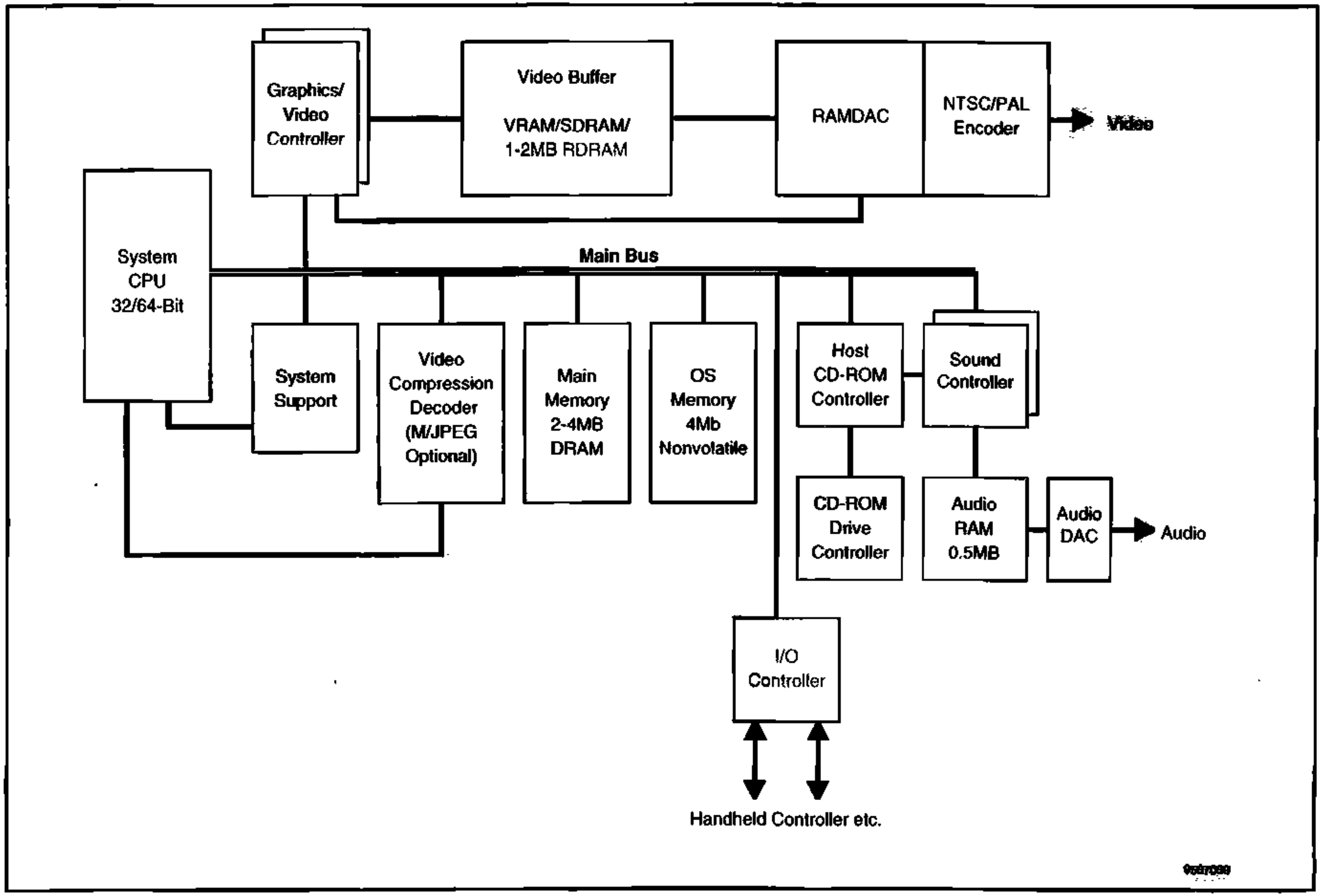
- The VHS-C format appears to be capturing a greater share of the U.S. market at the expense of the full-size VHS camcorders. According to the Photo Marketing Association, in 1991, the full-size VHS standard represented 42 percent of the U.S. camcorder market, with 8mm accounting for 37 percent and VHS-C for 22 percent. By 1994, the mix had shifted to: VHS, 26 percent; VHS-C, 38 percent; and 8mm, 36 percent. By the end of 1995, it appeared that VHS-C and 8mm were neck and neck at 41 percent, and VHS was declining to 18 percent of the market.

Figure 4-13 shows a block diagram of a typical camcorder. Some technology features and trends with implications for semiconductor opportunities are:

- CCD makers are increasing their share in the camcorder market. CCDs are becoming smaller and are accommodating more picture elements.
- CCD output signals, which have been conventionally analog processed, are converted to digital signals through a 10-bit DAC, and after Y/C signal processing by the DSP are sent to the processing stage such as blur correction and electronic zooming. Auto focus/auto iris/auto white balance (AF/AE/AWB) detection has been integrated into digital circuits on a single chip. Peripherals circuits related to blur correction consist of fuzzy logic circuits for motion detectors, blur-correction control, and memory control, which are incorporated into standard cells (DSP).
- Mechanism control is handled by an 8-bit microcomputer (servo microcomputer). With the increasing emphasis on portability, development efforts are being shifted from low power consumption to lower operation voltage to 3.3V (3V). Further demand for high-performance camcorders will encourage digital processing, incorporation of a battery charge circuit into a single chip, and development of a single/hybrid chip.
- In the video equipment market, advanced technology developed for industrial use (broadcast equipment) is finding its way to consumer applications that demand much lower levels of picture quality. Various technologies unique to consumer products, such as blur correction, have been commercialized. At the same time, because color TVs, VCRs, and camcorders share common features, new technology developed for any of them is diffused to others.
- Vibration or shake compensation has become a key feature in camcorders, equal in importance to compact, lightweight design and strong-magnification zooms. There are two approaches to shake compensation, one electronic and the other optical. Recently, almost all but the low-end camcorders have adopted some version of electronic shake compensation.
- With the adoption of digital camera circuits, many camcorders feature digital zooms allowing greater magnification. For example, combining a 12X optical zoom lens with a 2X digital zoom function makes it possible to record images at 24X magnification.

The first digital camcorders were introduced in 1995. These camcorders are based on the Digital Video (DV) format specification for home-use digital camcorders that was agreed to by 55 manufacturers as part of the HD Digital VCR Conference. Matsushita and Sony were the first manufacturers to offer digital camcorders, followed by JVC and Sharp. Hitachi is expected to introduce its digital camcorder at the winter Consumer Electronics Show. The Hitachi camcorder will record on a floppy disk that can be inserted into a PC instead a tape. As with most of the new digital video products, the steep pricing of these new camcorders will limit the potential market to semiprofessionals and the top 1 percent to 2 percent of the consumer camcorder market. Pricing on these early models ranges from $2,200 to $4,700.

Figure 4-13
Block Diagram of a Typical Camcorder



Source: Dataquest (December 1995)

To record image signals, camcorders using the DV format adopt the digital component system, recording luminance and chrominance (Y and C) signals separately. This format provides a resolution of 500 horizontal lines. Instead of the standard 0.3-MHz color signal bandwidth, the DV format works with a 1.4-MHz bandwidth. The format also calls for a built-in time base correction (TBC) function to diminish jitter. Audio recording involves the use of pulse code modulation (PCM) stereo. There are two possible audio modes. For audio quality equal to that of compact discs and digital audio tapes (DAT), a 16-bit sound system using two channels and 48-KHz sampling frequencies can be used. The specification also defines a 12-bit audio system with four channels and 32-KHz sampling frequencies. The interface format for connecting to personal computers is still being finalized, but it appears that it will be based on the IEEE-1394 standard.

As mentioned previously, Matsushita was one of the first manufacturers to bring a digital camcorder to market. This first model integrated 2.5 million transistors into five main video chips on a 0.5-micron process. Two of the chips, error correction and digital modulation devices, are produced by LSI Logic. A pulse code modulation (PCM) device is made by Mitsubishi Electric. Mitsubishi can use the PCM chip for its camcorder with Matsushita's agreement.

HDTV

HDTV is high-definition television, or advanced television—a quantum leap in video quality. Everyone wants better TV. Consumers want clearer pictures with higher resolution, and broadcasters would love to give it to them. But is HDTV worth the price, especially in light of new technologies, both analog and digital, designed to squeeze more performance out of existing television systems?

The Challenges of U.S. HDTV

- Political: The FCC must approve the system and then allocate space in the frequency spectrum to transmit the signals.
- Broadcasters: Head-end gear for HDTV is currently very expensive compared with NTSC gear.
- Receivers: HDTV sets intended for consumers require very expensive components and may never achieve enough volume to reduce costs significantly.

Political

A lot is known about the arduous journey of HDTV through the U.S. political process. There are even five lobbying organizations that promote HDTV in Washington, D.C. HDTV will eventually be approved by the FCC, but the FCC is now also supporting standard-definition (digital) television (SDTV). Congress is putting pressure on the FCC to raise funds through spectrum auctions to reduce the national debt. If the FCC decides to auction HDTV spectrum, it would be a disincentive to broadcasters. Following are descriptions of the two key U.S. government bodies involved with HDTV:

- Federal Communications Commission: New spectrum is being allocated for digital broadcast TV. If these digital TV spectrum licenses are auctioned, they could be worth as much as $70 billion. If digital broadcast TV succeeds, the FCC would like to regain the spectrum currently used for analog TV channels and auction it for up to $23 billion. Congress recently voted to raise $14 billion by 2002 from spectrum auctions. Currently, 400 MHz of spectrum is allocated for broadcast TV; however, only about 120 MHz is used even in the biggest cities. The FCC chairman is Reed Hundt. Mark Corbitt is director of technical policy at the Office of Plans and Policy.

- Advisory Committee on Advanced Television Services (ACATS): A 50-member committee was established by the FCC in September 1987 to evaluate and recommend an HDTV standard for the United States. Former FCC Chairman Richard E. Wiley has been the chairman of ACATS since its inception. David Kettler is executive director of science and technology for BellSouth and cochairman of ACATS Systems Analysis Working Party. CBS executive Joseph Flaherty is cochairman of the ACATS Technical Subgroup. Robert Hopkins is chairman of the ACATS Expert Group on Scanning Formats and Compression. Jules Cohen is chairman of the ACATS Field-Testing Task Force.

Broadcasters

Faced with the high cost of HDTV equipment and the possibility of spectrum auctions, broadcasters are likely to place their investments elsewhere. Terrestrial broadcasters can always invest in more translators and more power for their transmitters. In October 1995, *TV Broadcast* magazine conducted a survey of TV station general managers. Of those surveyed, 88 percent of broadcasters expect to switch from tape to digital storage by 2000. Substantial costs will be incurred in the next five years to accomplish this. Also, 28 percent of broadcast general managers wish advanced television would just go away.

Receivers

The challenge that nobody wants to talk about is the cost of an HDTV receiver. The equation is really very simple. If consumers can't afford a special receiver, then broadcasters can't sell air time to advertisers because there will be no audience. Therefore, there is no return on the broadcasters' investment in expensive HDTV gear. Members of the Grand Alliance, the U.S. consortium of HDTV hopefuls, admitted in November 1995 that HDTV will not be available in the United States until 1998 at the earliest. Grand Alliance members remain confident that consumers will pay $3,500 for an HDTV receiver. Dataquest is much less optimistic about consumers' acceptance at these prices.

Plasma is a new flat panel display technology that could potentially reduce the cost of HDTV receivers. Fujitsu is about a year ahead of other plasma panel competitors. It previewed a 42-inch model at the COMDEX show in November 1995. Production is expected to begin in October 1996 at 10,000 units per month for ¥500,000 each (about $5,000 for the display alone).

Problems with Wide-Screen TVs and HDTV Receivers

The following are problems presented by wide-screen TVs and HDTV receivers:

- Will not fit on standard TV production and assembly lines, therefore more labor and cost is required to transport the work-in-progress from one station to the next

- Too wide to fit through a standard-size doorway
- Too wide to fit in standard wall unit furniture
- Electron gun must be quite far from the screen so it can scan its full width at a reasonable speed
- As screen gets wider, glass must be thicker (and heavier) for structural strength. Difficult to mold a flat screen
- Proposed viewing distance for HDTV is half that for standard NTSC TVs. Therefore, the number of viewers within the optimal distance will be more than halved.
- Very heavy—about 200kg
- Very expensive

Standards and Organizations

Grand Alliance: Digital HDTV Grand Alliance (United States). The alliance of the seven companies that proposed four all-digital HDTV systems to ACATS in 1993. Formed on May 24, 1993, the seven member companies are AT&T Microelectronics, Zenith Electronics Corporation, General Instrument Corporation (GI), Massachusetts Institute of Technology, Philips Consumer Electronics, Thomson Consumer Electronics, and David Sarnoff Research Center. AT&T and GI jointly built the video encoder, Philips constructed the decoder, Sarnoff and Thomson cooperated in building the transport subsystem, and Zenith built the modulation subsystem.

SDTV: Standard-Definition (digital) TV. FCC-approved standard for digital TV using standard-resolution NTSC displays within an HDTV broadcast system. Hitachi is the leading developer of down-conversion systems for turning HDTV signals into SDTV for display on standard TV sets.

MUSE HDTV: Multiple Sub-Nyquist Sampling Encoding (also known as Hi-Vision). Japanese standard for analog HDTV developed in 1968 by NHK. MUSE uses a display with interlaced scanning with 1,125 horizontal scanning lines at 60 fields per second. Since 1990, between nine and 11 hours of Hi-Vision has been transmitted every day by satellite in Japan. The commercial service launch for Hi-Vision is scheduled for late 1997. As of July 31, 1995, Hi-Vision TV sets cost about $5,618. A MUSE signal occupies 8 MHz of bandwidth. Narrow MUSE is a slimmed-down version occupying only 6 MHz of bandwidth. The system uses digital signal processing, but the frequency modulation is analog. Developed primarily by Sony.

MPT: Japan's Ministry of Posts and Telecommunications. In July of 1995, the MPT announced that Japan, too, would have a digital TV specification. The specification is similar to Europe's DVB. Digital satellite services are expected to begin in April 1996. Manufacturers of Hi-Vision HDTV sets strongly object being preempted. Full-scale broadcasting of Hi-Vision HDTV is still planned to start in 1997. MPT's Digital Broadcasting Systems Division director is Tomofumi Yasunari.

DVB: Digital Video Broadcasting Group, formed in September 1983. HDTV is no longer a priority in Europe, and HDTV efforts have been replaced by the pan-European DVB standard for digital TV. DVB is headquartered in Geneva, operating under the auspices of the European Broadcast Union and the German Ministry of Telecommunications. Two standards exist: DVB-S for satellite using QPSK, and DVB-C for cable using 64-QAM. COFDM is still being considered for the terrestrial standard. MPEG-2 main level, main profile. PCMCIA II will be used for the physical interface to accommodate different conditional access systems (instead of smart cards).

DAVIC: Digital Audio Visual Interoperability Council. Standard-setting organization for digital TV, formed in January 1994, headquartered in Europe, following the DVB project. The chairman is Dr. Leonardo Chiariglione. DAVIC Spec 1.0 was completed at a meeting in Melbourne, Australia, and presented at the International Television Symposium in Montreux, Switzerland, in June 1995. The chairman of the Set-Top Unit Technical Committee is K. Shimamura of NTT. The U.S. contact is Robert Luff, chief technical officer of Broadband Communications Group at Scientific-Atlanta. DAVIC spec 1.1 is planned for June 1996, and DAVIC spec 1.2 is planned for December 1996.

Current Specifications

Tables 4-19 through 4-21 present major HDTV technical specifications.

Table 4-19
Grand Alliance Specification

	Specification
Resolutions and Frame Rates	1280 x 720; progressive 24-, 30-, 60 frames per second 1920 x 1080; progressive 24-, 30 frames per second 1920 x 1080; interlaced 60-frames per second
Video Compression	MPEG-2 main level, high profile
Audio Compression	Dolby AC-3 digital audio (ACATS standard A/52)
Modulation	8-VSB
Data Rate	20 Mbps
Bandwidth	6-MHz bandwidth per channel (cable version can fit two HDTV signals within 6 MHz)
Others	188-byte MPEG-2 transport packets, packetized data transport structure with headers and descriptors; 4-byte header, 184-byte payload HDTV signal will be compressed by a factor of more than 60 to 1, from 1.2 billion bits per second to less than 20 million bits per second.

Source: Dataquest (December 1995)

Table 4-20
SDTV Specification

	Specification
Resolutions	640 x 480 (4:3 aspect ratio, VGA) 704 x 480 (16:9 aspect ratio, CCIR Rec. 601)
Frame Rates	60 interlaced fields per second, 24-, 30-, and 60 frames per second (progressive)
Video Compression	MPEG-2 main level, main profile
Audio Compression	Dolby AC-3 digital audio
Modulation	8-VSB

Source: Dataquest (December 1995)

Table 4-21
DAVIC 1.0 Specification

	Specification
Resolution	640 x 480
Video Compression	MPEG-2 main level, main profile
Audio Compression	Musicam
Modulation	64-QAM for hardwired networks (cable and telco)
Upstream Data Rates	1.544 Mbps and 256 Kbps

Source: Dataquest (December 1995)

Receiver Production and Market

Dataquest's forecast for worldwide production of HDTV receivers is shown in Table 4-22 and Figure 4-14. The North American market and production forecasts are presented in Tables 4-23 and 4-24, respectively. Table 4-25 shows sizes and prices for current HDTV models on the market. The following are some notes about market and production trends:

- Full-scale broadcasting of Hi-Vision HDTV is planned to start in 1997.
- Matsushita announced in August 1995 that it will be raising production of HDTV receivers from 4,000 per month to 10,000 per month. This will mean full capacity for its Ibaraki factory in Osaka Prefecture.
- 1995 sales of color TVs in Japan equaled 8.4 million units (EIAJ); wide-screen TVs (HDTV and NTSC) represented 3 million to 4 million of those units. In 1993, 1.4 million wide-screen units were sold. Some wide-screen TVs from Hitachi and Matsushita will now include a MUSE-to-NTSC converter.
- By April 1995, 30,000 MUSE receivers had been sold, as well as 100,000 MUSE-to-NTSC converters.

Manufacturers of HDTV Sets

Manufacturers of HDTV receivers are as follows:

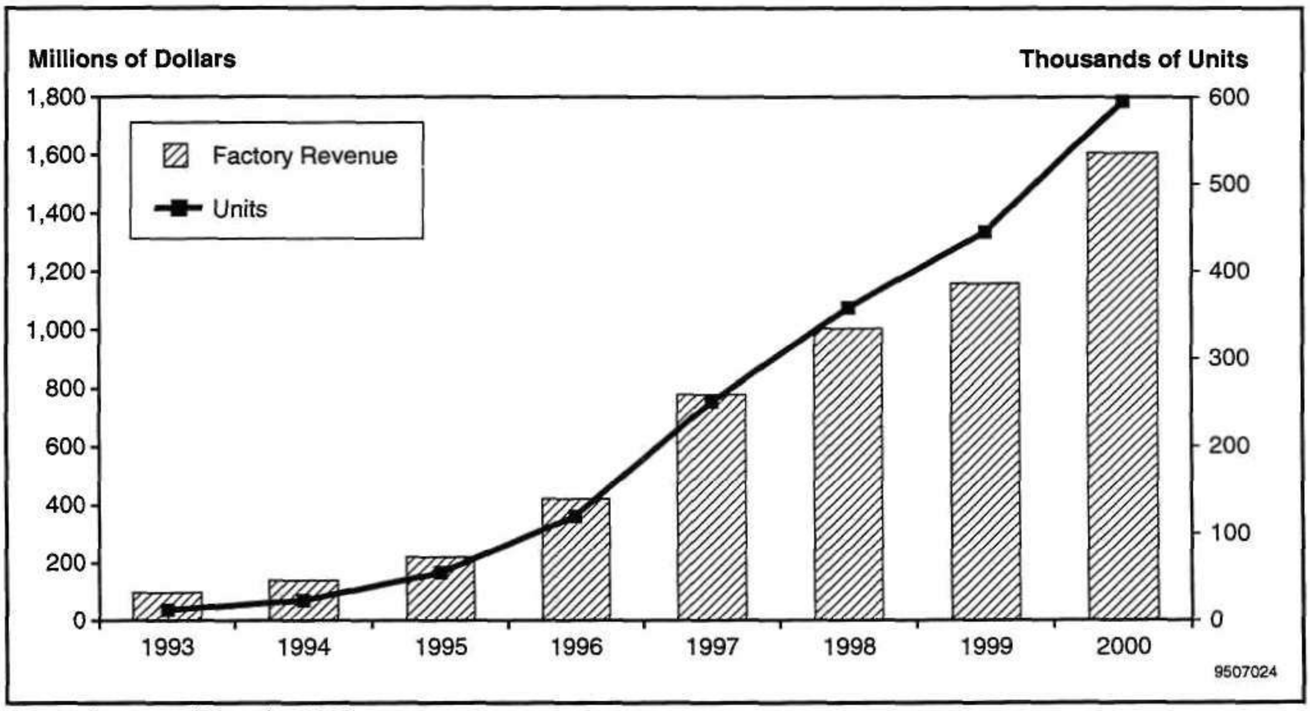
- Sony (also front- and rear-projection models)
- Toshiba
- Matsushita (Panasonic, JVC brands, also rear-projection models)
- Mitsubishi (also front- and rear-projection models)
- Sanyo
- Sharp (also front-projection models)
- Hitachi (also rear-projection models)
- Ikegami (also front-projection models)

Table 4-22
Worldwide HDTV Receiver Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	12	23	55	120	251	358	445	595	61.0
Factory ASP ($)	8,000	6,000	4,000	3,500	3,100	2,800	2,600	2,700	-7.6
Factory Revenue ($M)	96	138	220	420	778	1,002	1,157	1,607	48.8
Semiconductor Content ($)	700	540	450	400	363	340	315	300	-7.8
Semiconductor TAM ($M)	8.4	12.4	24.8	48.0	91.1	121.7	140.2	178.5	48.5

Source: Dataquest (December 1995)

Figure 4-14
Worldwide HDTV Receiver Production Forecast



Source: Dataquest (December 1995)

Table 4-23
North American HDTV Receiver Market Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1997-2000
Units (K)	0	0	0	0	1	8	15	35	227.1
Factory ASP ($)	0	0	0	0	3,100	2,800	2,600	2,700	-4.5
Factory Revenue ($M)	0	0	0	0	3	22	39	95	212.4

Source: Dataquest (December 1995)

Table 4-24
North American HDTV Receiver Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1997-2000
Units (K)	0	0	0	0	1	8	15	35	227.1
Factory ASP ($)	0	0	0	0	3,100	2,800	2,600	2,700	-4.5
Factory Revenue ($M)	0	0	0	0	3	22	39	95	212.4
Semiconductor Content ($)	0	0	0	0	363	340	315	300	-6.2
Semiconductor TAM ($M)	0	0	0	0	0.4	2.7	4.7	10.5	207.0

Source: Dataquest (December 1995)

Table 4-25
Sizes and Prices of HDTV Sets (Fourth Quarter of 1995)

Size	Type	Price (Yen)
20 Inches	MUSE-to-NTSC only	-
24 Inches	MUSE-to-NTSC only	-
28 Inches	Hi-Vision HDTV	400,000
32 Inches	Hi-Vision HDTV	500,000
36 Inches	Hi-Vision HDTV	700,000
52 Inches	Rear Projection	750,000
60 Inches	Rear Projection	-
70 Inches	Rear Projection	-
Up to 200 Inches	Front-Screen Projection (Mitsubishi and Sony are the leaders)	

Source: Dataquest (December 1995)

Semiconductor Opportunities

Clearly, HDTVs will be a semiconductor-rich opportunity. Increasingly, intellectual property in DSP-based digital transmission, video manipulation, compression, and audio, to name a few areas, will be crucial for market participation. Key chip function opportunities include the following:

- Digital tuning (MCU controlled)
- Demodulation circuits for VSB
- Moving Picture Expert Group (MPEG)-2 video decoder
- Digital video processing
- Forward error correction
- Transport depacketizer
- AC-2 (Dolby) six-channel CD audio decode
- Audio DAC and amplification
- 1MB to 2MB DRAM for decompression buffer
- Video RAMDAC (10 bit, 135 MHz)
- Infrared on-screen control display controls

- Closed captioning/ghost cancellation circuits
- Optionally: modem interfaces (for interactivity) and decryption

DVD (Digital Video Disc) and Video-CD

In September 1995, Philips, Sony, and Toshiba announced an agreement to develop a single standard for the high-density digital video disc. DVD is the next generation of compact disc technology that is predicted to impact significantly the world of consumer VCRs, as well as computer delivery of digital content, because of its several-gigabyte storage capabilities. The standard puts an end to a format war between two camps that was similar to the one that occurred in the early 1980s between the opposing consumer videotape camps, beta and VHS.

The agreement ended almost 10 months of format competition between the two primary camps: Multimedia CD (MMCD), led by Sony and Philips, and the Superdensity (SD) alliance, led by Toshiba, Matsushita, and Time Warner. The agreement between the two camps began lengthy negotiations to develop the final specification for DVD. From the perspective of the different manufacturers, perhaps the most important issue to be resolved is intellectual property rights. An immediate difficulty is the sheer number of companies involved in the DVD-format unification. At least nine have staked claims to become license holders: Sony, Philips Electronics, Thomson Multimedia, Hitachi, Matsushita, Toshiba, Mitsubishi, Pioneer, and JVC. In the announcement of the initial agreement, the parties stated their intent to release a final specification in December 1995. Delays in a final specification could affect the goal of bringing DVD players to the market in 1996. A preliminary forecast for the worldwide DVD market based on currently available information is presented in Table 4-26 and Figure 4-15. Some of the important elements of the DVD format that have been agreed to are as follows:

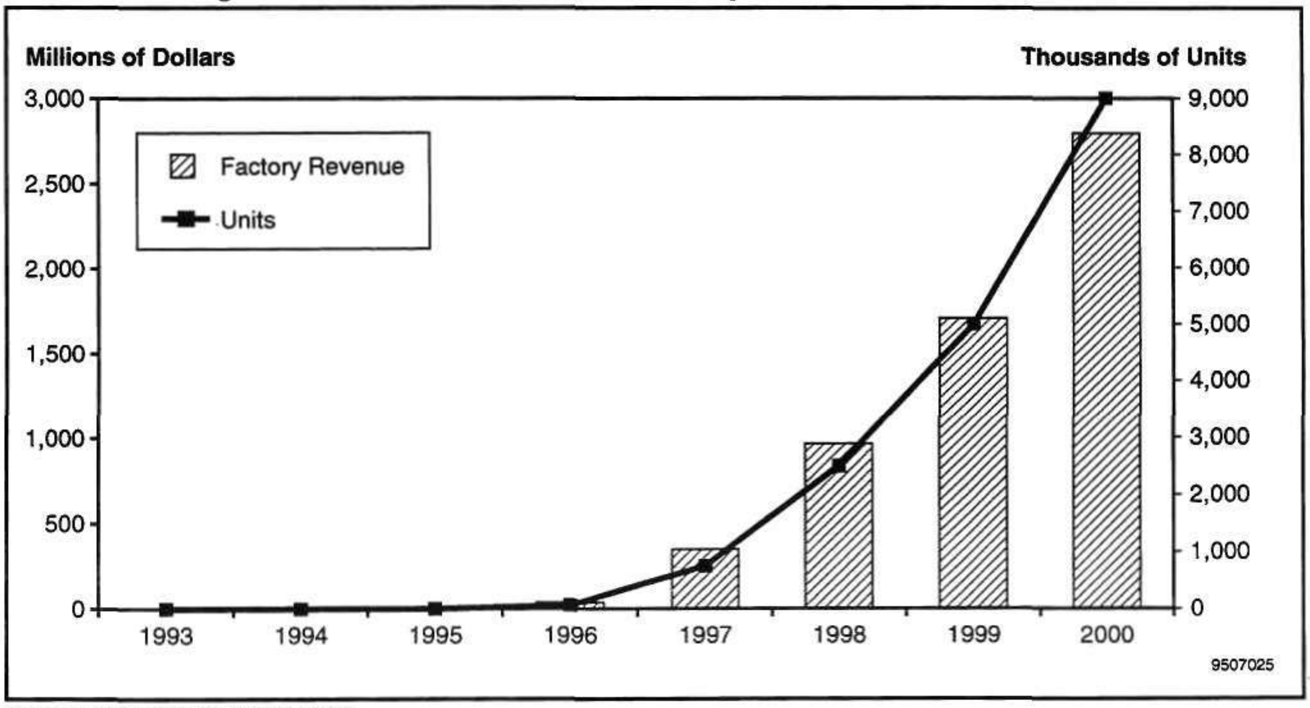
- 4.7GB per layer, single- and/or double-layer and side
- Backward-compatibility with all current CDs
- MPEG-2 the compression specification choice
- Compatibility between computer-based and consumer-based (television) products
- Technical specifications
- 0.6mm x 2 substrate thickness, bonded disc
- EFM Plus modulation/demodulation
- Reed-Solomon error-correction code

Table 4-26
Worldwide Digital Video Disc Preliminary Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	0	0	0	60	750	2,500	5,000	9,000	NM
Factory ASP ($)	0	0	0	575	460	385	340	310	NM
Factory Revenue ($M)	0	0	0	35	345	963	1,700	2,790	NM
Semiconductor Content ($)	0	0	0	145	115	97	88	85	NM
Semiconductor TAM ($M)	0	0	0	8.7	86.3	242.5	440.0	765.0	NM

NM = Not meaningful
Source: Dataquest (December 1995)

Figure 4-15
Worldwide Digital Video Disc (DVD) Preliminary Production Forecast



Source: Dataquest (December 1995)

Some of the important issues related to the rollout and development of DVD players are as follows:

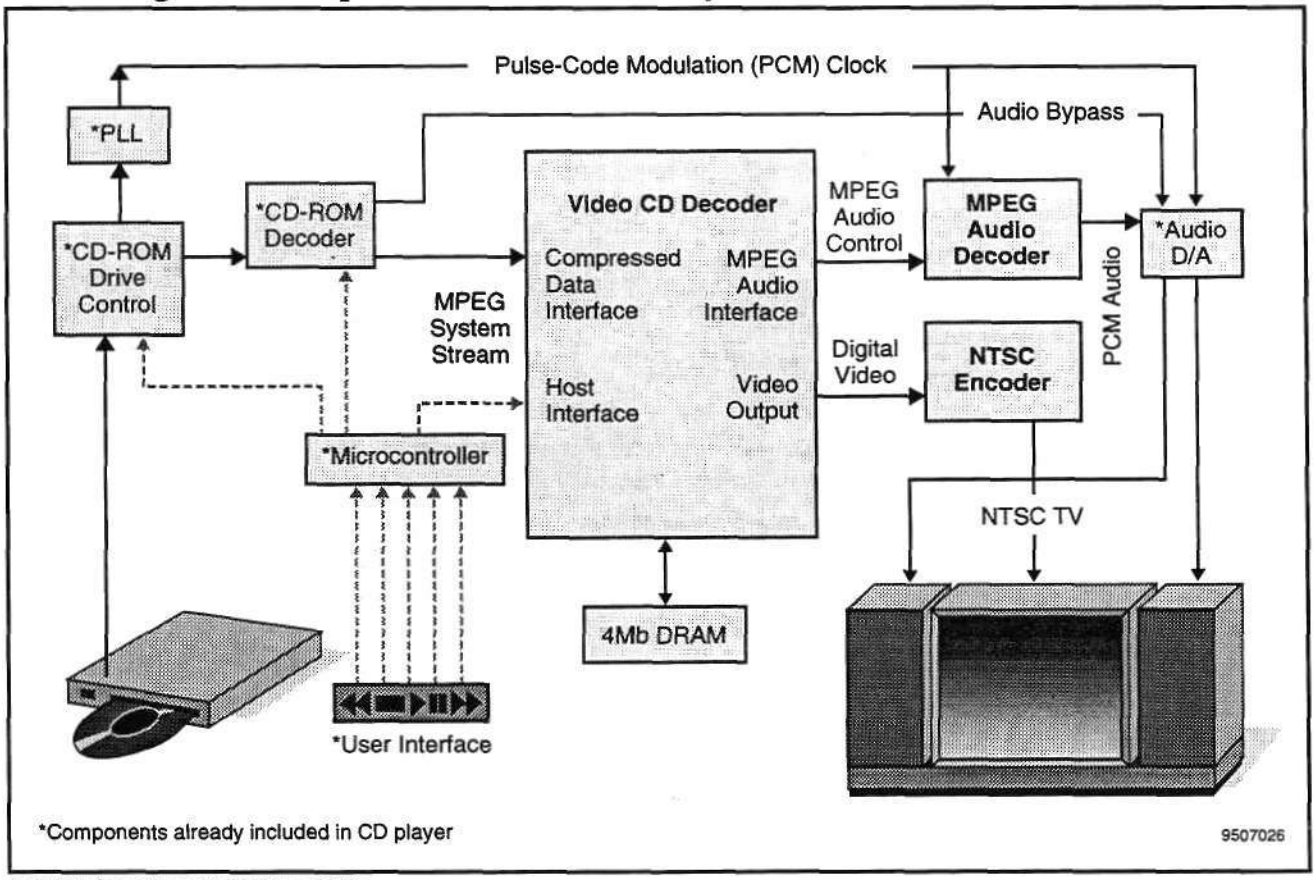
- Initial pricing for DVD players was targeted at $500. It appears that the initial players will have a hard time hitting that price, and it will probably be closer to $600. Critical components such as the red-laser diodes will drive higher initial costs; as they come down the price curve, it will be possible to lower system prices.
- There are concerns about the availability and supply of 635/650nm red-laser diodes, which are a key element in DVD's high-density storage capacity. Prototype and sample diodes were produced in 1995; however, manufacturers are still wavering about when volume production will be possible. Although this is a concern for manufacturers anxious to ramp production of DVD players quickly, it is not certain that market

demand will materialize to meet the production plans of DVD manufacturers during 1996 and 1997. Pricing will be a hurdle in early market growth.

- Initially, players will be ROM only and eventually RAM and erasable. The draft format of a rewritable disc called the DVD-RAM was determined in late 1995. The rewritable DVD-RAM uses phase change technology to store information, applying heat from the laser to change the recording layer from a polycrystalline structure to an amorphous state. The draft specification calls for a capacity between 2.6GB and 3GB, with the wavelength of the laser diode in the range of 650nm to 680nm.

The early-generation video disc player, Video-CD, continues to show promising growth, particularly in the Japan and Asia/Pacific karaoke market. These players use MPEG-1 technology and allow 74 minutes of storage for full-motion video. Figure 4-16 shows a block diagram for a Video-CD system. A DVD system will be similar to this diagram, with key differences being the use of 16Mb of DRAM and MPEG-2 technology. At 352 x 240/288 pixels, Video-CD's resolution is limited but could still find applications in portable players and minicomponent systems, many of which will use LCD displays. There are currently about 30 Video-CD models and 900 software titles available in Japan. One of the major manufacturers, Sharp, expects the market for MPEG-1-based Video-CD players to

Figure 4-16
Block Diagram of a Representative Video-CD System



Source: Dataquest (December 1995)

reach 400,000 units in 1995 and 900,000 units in 1996. C-Cube Microelectronics announced major design-wins for its MPEG decompression chips in Sony and Sharp Video-CD players. C-Cube has set an aggressive schedule to narrow the ultimate cost differential between audio CD and Video-CD systems to $30. Its initial MPEG-1 devices should allow manufacturers to produce Video-CD players for about $100 over the cost of audio CD products. The company hopes to halve that to $50 by 1997.

Chapter 5
Interactive Products and Personal Electronics

Interactive consumer products include those that allow users real-time control of information presented on the TV screen. The primary examples covered here include interactive television and associated set-top decoder boxes and video games. Some visionaries are projecting that these technologies may merge at least partially in the coming decade with each other or with the standard TV set.

Interactive Television and Set-Top Box Definitions

"Set-top box" is a generic term that means different things to different industries. The seven product categories presented in Table 5-1 have all been referred to as "set-top boxes," based merely on their location in relation to the TV set.

This section will focus on the first category, pay TV receivers. Within the combined pay TV industries, the terminology used is "subscriber terminal." Figure 5-1 presents a diagram of an interactive system that shows how a subscriber terminal would be used in a cable, satellite, or telephone system. The following terms are also synonymous with pay TV receivers:

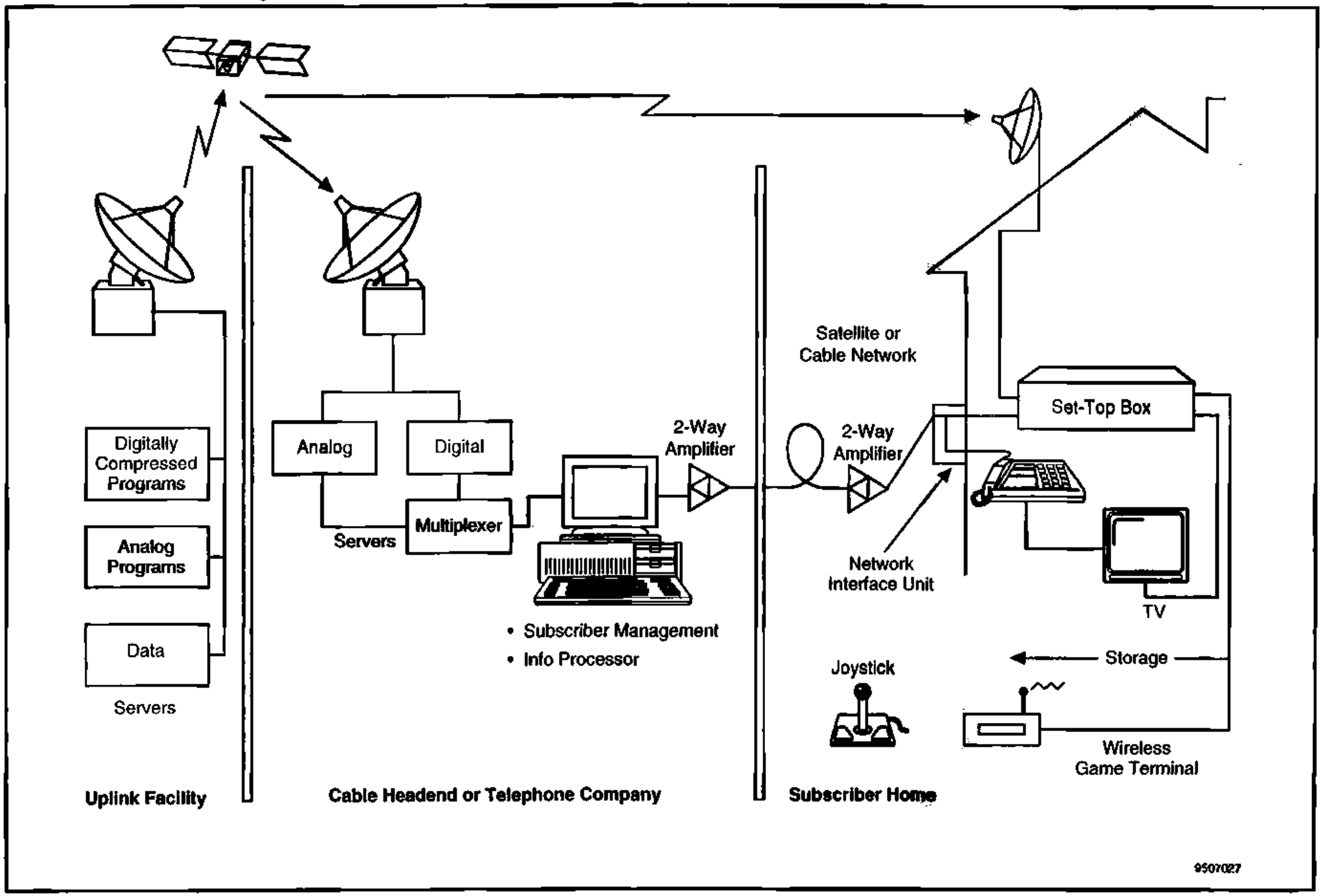
- Integrated receiver/decoder (IRD): satellite industry
- Customer-premises equipment (CPE): telco industry
- Subscriber terminal, cable converter: cable industry
- Compuverter, pay TV receivers

Table 5-1
Descriptions of Various Products Referred to as "Set-Top Boxes"

Product	Description
Pay TV Receivers	Includes cable, DBS, C-band satellite, MMDS, LMDS, and now telco
Dedicated Game Consoles	Examples: Sony PlayStation and Sega Saturn
Read-Only Multimedia Computers	Examples: 3DO and Philips CD-I. Formerly known at Dataquest as TV CD-ROM players. This category is being replaced by dedicated game consoles.
Backchannel Transmitters	Allow user to play along with networked sports and game shows—TV Answer, for example
Audio and Data Decoders	Used for nonvideo signals transmitted out-of-band in the vertical blanking interval, in-band video, or in-band audio. Include digital cable radio and closed captioning.
Navigational Systems	A special type of data decoder for electronic programming guides. Dedicated hardware systems exist, but most are being integrated into pay TV receivers. Examples include StarSight, Prevue Network, and Interactive TV Guide
Data Storage Devices	Examples are VCR-Plus and Sega Channel Game Adapter

Source: Dataquest (December 1995)

Figure 5-1
Interactive Television Systems



Source: Dataquest (December 1995)

Subscriber terminals are further divided into the following four subcategories by technology:

- Nonaddressable analog
- Addressable analog
- Advanced analog (includes addressability and upstream communications)
- Digital

A digital set-top box includes a digital video decoder for receiving digitally-encoded TV signals. The compression schemes are typically MPEG-2, but also include General Instrument's DigiCipher I and DigiCipher II. The difference between addressable analog boxes and advanced analog boxes is that advanced boxes also include an embedded modem for upstream communications. Embedded modems are the basic semiconductor components for receiving interactive services. Cable modems fall into a separate category, more closely related to PC modems than to set-top boxes. As subscriber terminals move from nonaddressable to addressable to advanced analog and finally to digital, almost every major component maker is eyeing this market as a major application area.

Markets for Subscriber Terminals

The following six network systems represent potential markets for subscriber terminals:

- Cable TV
- C-band satellite (also known as full-view satellite)
- Ku-band satellite (also known as DBS and DTH)
- Wireless cable (also known as MMDS)
- Cellular cable (also known as LMDS)
- Telco

Production and Market Forecast

Analog terminals will be buoyed temporarily by new sales in the wireless cable market. However, shipments of new digital terminals will overtake their analog predecessors by 1997. Now the cable industry is planning to introduce hybrid boxes capable of receiving both analog and digital signals. Because these boxes will include the expensive digital decoders and demodulators, we have included their projected sales in the digital terminals category.

Because of the controlled nature of the cable equipment business, analog converter boxes have maintained their selling price of about $105 for the last 10 years! As digital boxes become more prevalent, the average selling prices (ASPs) for analog boxes will finally begin to erode. There is a significant opportunity for system makers to reduce both the costs and the margins for DBS receivers over time. In fact, manufacturers will need to do just that in order to increase the size of their market from innovators to early adopters, and possibly to the mass market.

Tables 5-2 through 5-4 show Dataquest's forecast for worldwide analog set-top box production, the North American analog set-top box market, and North American analog set-top box production, respectively. Figures 5-2, 5-3, and 5-4 and Table 5-5 present the forecast for worldwide digital cable and satellite set-top box production, average selling price, and revenue. Tables 5-6 and 5-7 show the North American market and production forecast for digital set-top boxes.

Table 5-2
Worldwide Analog Cable/Satellite Set-Top Box Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	10,719	12,233	11,505	11,388	10,200	7,591	7,030	6,839	-9.9
Factory ASP ($)	103	113	114	99	87	78	75	71	-9.0
Factory Revenue ($M)	1,104	1,382	1,312	1,127	887	594	527	486	-18.0
Semiconductor Content ($)	42	46	47	41	38	35	32	30	-8.6
Semiconductor TAM ($M)	450.2	562.7	540.7	466.9	387.6	265.7	225.0	205.2	-17.6

Source: Dataquest (December 1995)

Table 5-3
North American Analog Cable/Satellite Set-Top Box Market Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	4,860	5,490	4,500	4,230	3,600	2,700	2,250	1,710	-17.6
Factory ASP ($)	103	113	114	99	87	78	75	71	-9.0
Factory Revenue ($M)	501	620	513	419	313	211	169	121	-25.0

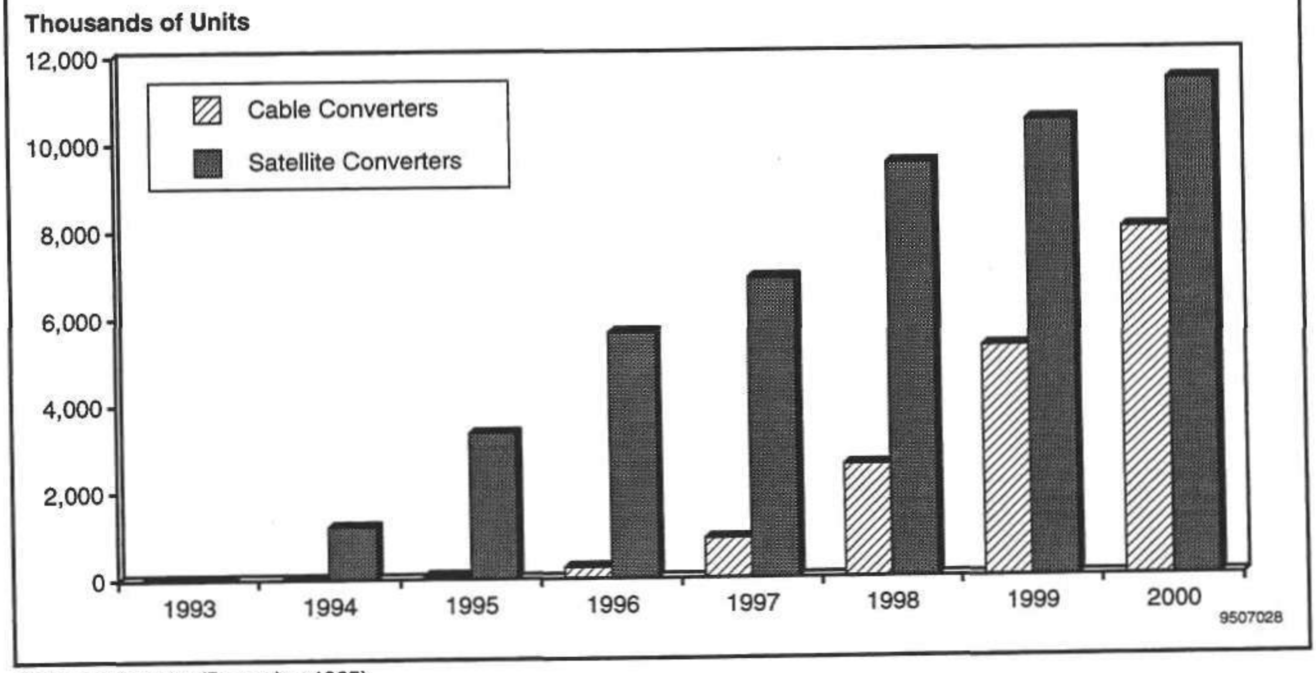
Source: Dataquest (December 1995)

Table 5-4
North American Analog Cable/Satellite Set-Top Box Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	5,400	6,100	5,000	4,700	4,000	3,000	2,500	1,900	-17.6
Factory ASP ($)	103	113	114	99	87	78	75	71	-9.0
Factory Revenue ($M)	556	689	570	465	348	235	188	135	-25.0
Semiconductor Content ($)	42	46	47	41	38	35	32	30	-8.6
Semiconductor TAM ($M)	226.8	280.6	235.0	192.7	152.0	105.0	80.0	57.0	-24.7

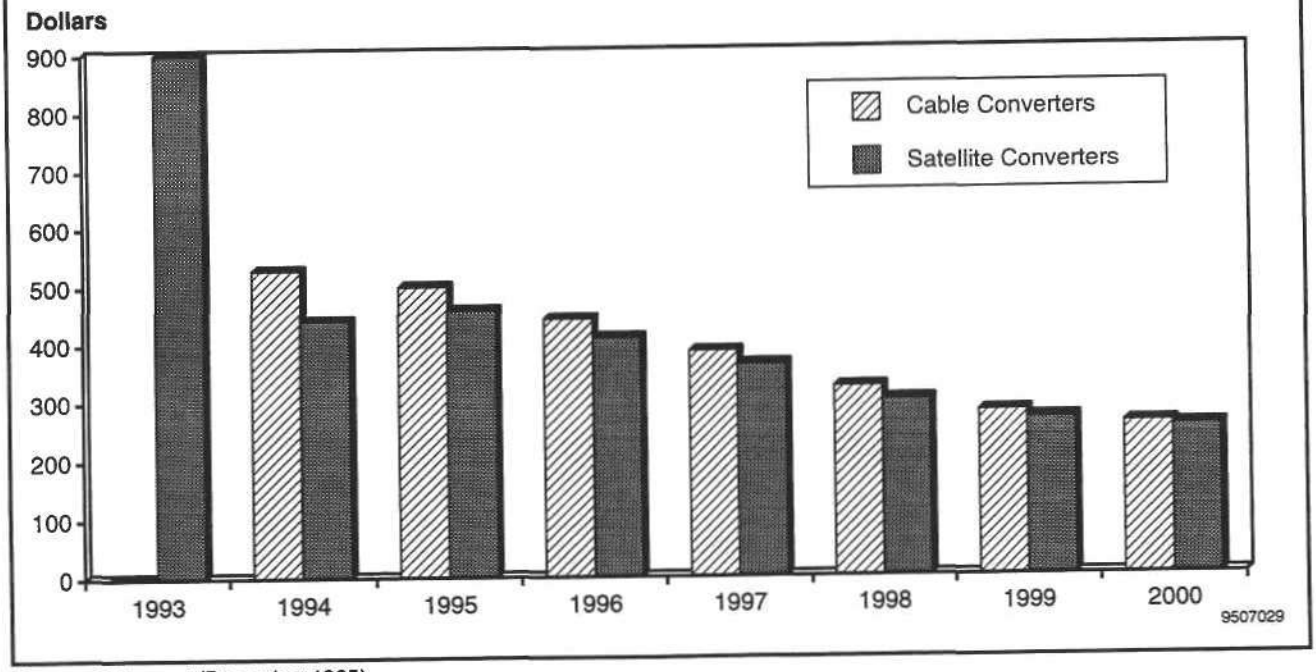
Source: Dataquest (December 1995)

Figure 5-2
Worldwide Digital Set-Top Box Production Forecast



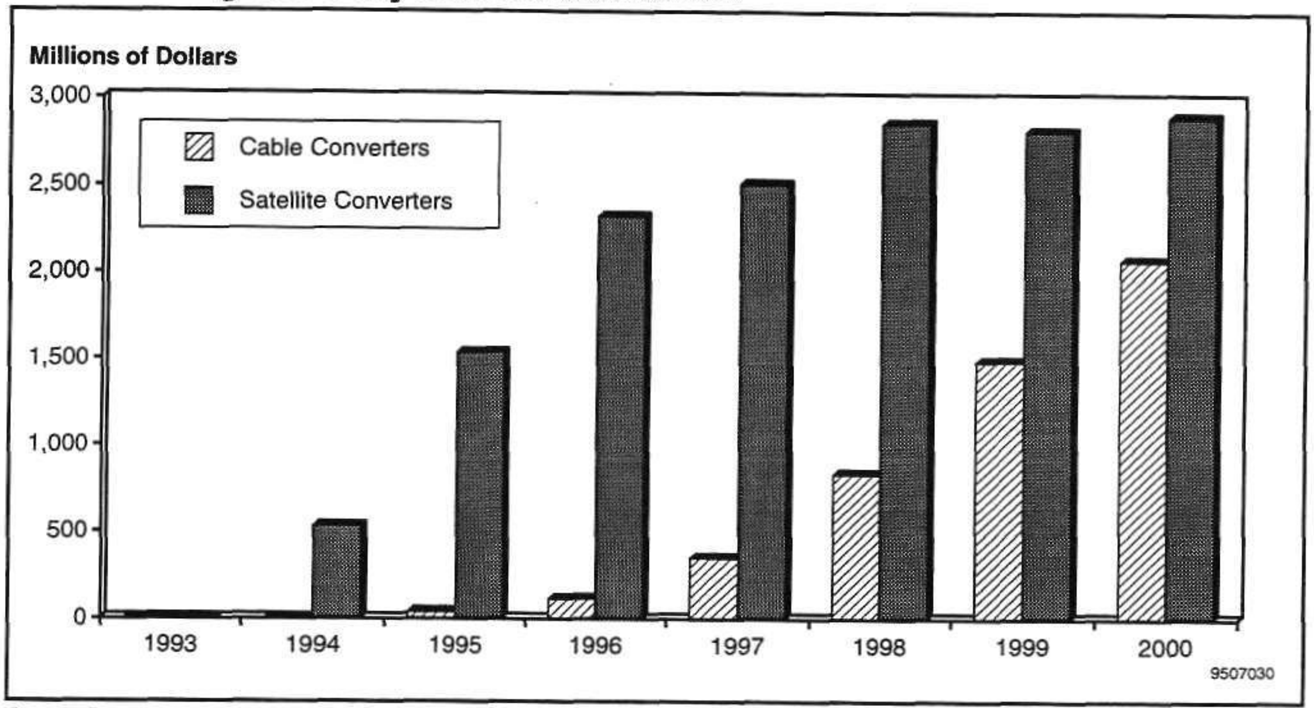
Source: Dataquest (December 1995)

Figure 5-3
Worldwide Digital Set-Top Box Average Selling Price Forecast



Source: Dataquest (December 1995)

Figure 5-4
Worldwide Digital Set-Top Box Revenue Forecast



Source: Dataquest (December 1995)

Table 5-5
Worldwide Digital Cable and Satellite Decoder Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Cable Converters									
Units (K)	0	7	77	260	907	2,580	5,300	8,000	153.1
Factory ASP ($)	0	528	499	442	386	323	280	259	-12.3
Factory Revenue ($M)	0	4	38	115	351	834	1,485	2,069	121.9
Semiconductor Content ($)	0	236	204	183	177	172	168	160	-4.7
Semiconductor TAM ($M)	0	2	16	48	160	444	889	1,282	141.1
Satellite Converters									
Units (K)	1	1,205	3,350	5,656	6,901	9,510	10,490	11,400	27.8
Factory ASP ($)	900	440	458	410	363	300	268	254	-11.1
Factory Revenue ($M)	1	530	1,533	2,318	2,508	2,855	2,811	2,894	13.6
Semiconductor Content ($)	400	223	210	196	187	179	172	165	-4.7
Semiconductor TAM ($M)	0	269	703	1,107	1,291	1,702	1,803	1,880	21.8

Source: Dataquest (December 1995)

Table 5-6
North American Digital Cable and Satellite Decoder Market Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Cable Converters									
Units (K)	0	5	42	54	96	225	1,350	3,150	136.8
Factory ASP ($)	0	436	432	390	345	280	250	240	-11.1
Factory Revenue ($M)	0	2	18	21	33	63	338	756	110.5
Satellite Converters									
Units (K)	0	1,071	2,565	3,600	3,780	4,950	5,400	5,940	18.3
Factory ASP ($)	0	436	432	390	345	280	250	240	-11.1
Factory Revenue ($M)	0	467	1,108	1,404	1,304	1,386	1,350	1,426	5.2

Source: Dataquest (December 1995)

Table 5-7
North American Digital Cable and Satellite Decoder Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Cable Converters									
Units (K)	0	5	47	60	107	250	1,500	3,500	136.8
Factory ASP ($)	0	436	432	390	345	280	250	240	-11.1
Factory Revenue ($M)	0	2	20	23	37	70	375	840	110.5
Semiconductor Content ($)	0	222	207	194	182	171	162	154	-5.7
Semiconductor TAM ($M)	0	1.1	9.7	11.6	19.5	42.8	243.0	539.0	123.2
Satellite Converters									
Units (K)	0	1,190	2,850	4,000	4,200	5,500	6,000	6,600	18.3
Factory ASP ($)	0	436	432	390	345	280	250	240	-11.1
Factory Revenue ($M)	0	519	1,231	1,560	1,449	1,540	1,500	1,584	5.2
Semiconductor Content ($)	0	222	207	194	182	171	162	154	-5.7
Semiconductor TAM ($M)	0	264.2	590.0	776.0	764.4	940.5	972.0	1,016.4	11.5

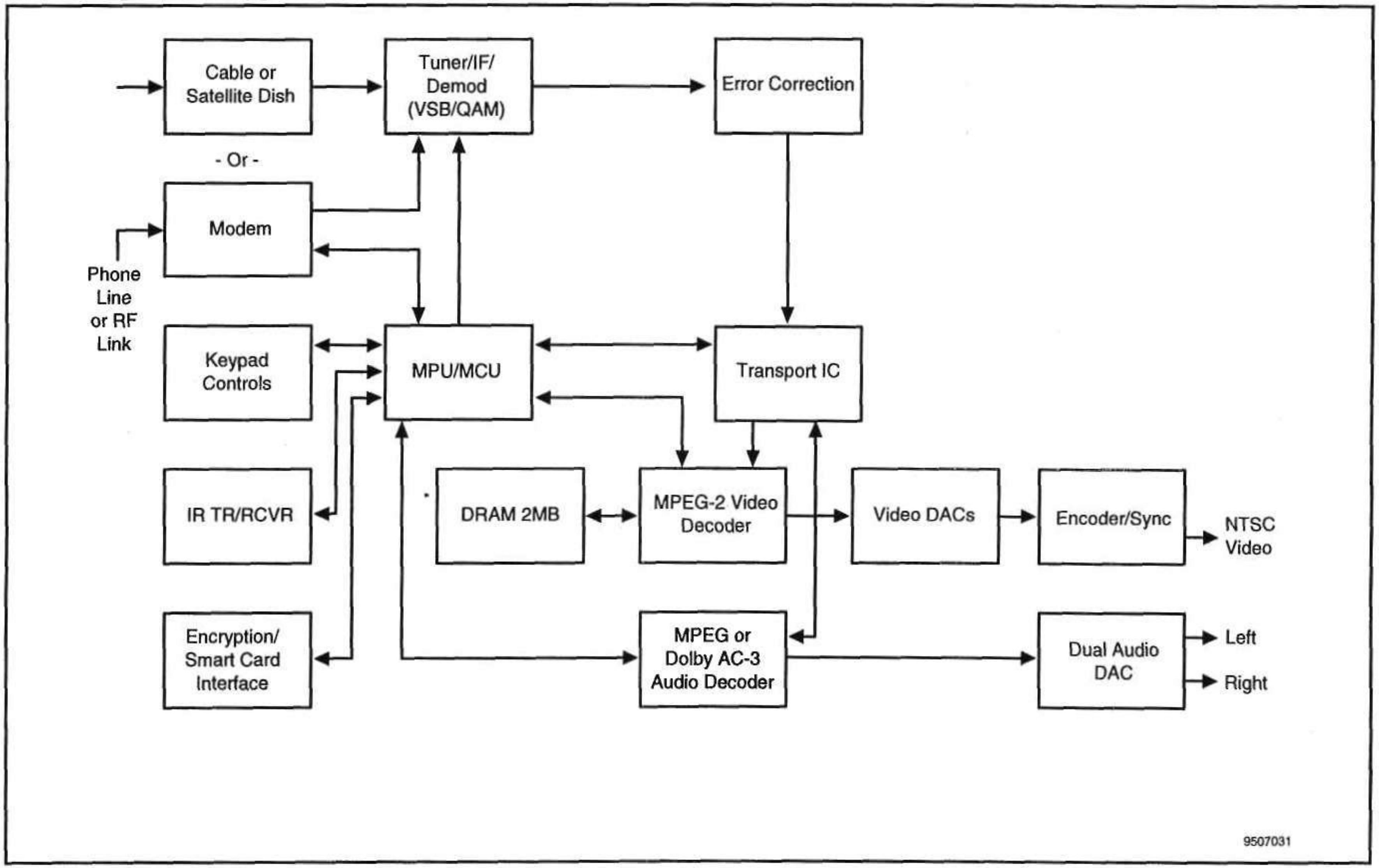
Source: Dataquest (December 1995)

Technology Requirements

Figure 5-5 presents a generic block diagram of the type of technology required in interactive terminals. A generic set-top box will require a variety of technologies ranging from RF to CMOS (see Table 5-8). Likewise, the opportunities will range from standard products to ASICs as the box OEMs differentiate through design and cost structure. There are many layers of software involved and companies like Microsoft are heavily involved in creating standard application program interfaces (API) to handle the various application programs managing the interactive services. The communication features are initially designed as modules that upgrade the basic terminal.

As shown in Table 5-9, the interactive terminal will require more features in the coming years including embedded two-way capability, greater

Figure 5-5
Block Diagram of a Typical CATV/DBS Set-Top Box



Source: Dataquest (December 1995)

Table 5-8
Semiconductor Opportunities in Interactive TV

Semiconductor Function	Technology
Broadband Up/Down Conversion	Bipolar/GaAs
IF Processing	Bipolar
Modulation/Demodulation (VSB, QAM)	CMOS, Bipolar
ATM/Sonet Physical	Opto, Bipolar, and BiCMOS
ATM/Network Protocol	CMOS
Transport Layer and Error Correction	CMOS
Video Standard Decode/Encode	Bipolar/CMOS
Video DAC	Bipolar
Video Conversion, Scaling	CMOS
Video Compression (MPEG-2, DigiCipher)	CMOS
Audio Conversion	Bipolar/CMOS
Audio Compression (AC-3, MPEG)	CMOS
DRAM	CMOS
VRAM/Field memory	CMOS
Fast DRAM (SDRAM, FRAM)	CMOS
SRAM	CMOS
MPU (32/64-Bit RISC)	CMOS
Encryption (Decryption) Functions	CMOS
Modem (up to V Fast)	CMOS
ASICs (for Above Functions)	CMOS/Bipolar

Source: Dataquest (December 1995)

Table 5-9
Interactive Television Technology Evolution

Category	1993	1995	1997
Transmission	Cable: analog; cable: digital test, 80 channels, FM subcarrier; fiber-optic/ADSL tests	Cable: analog/digital, 500 channels, IVDS, FM, VBI; Fiber-optic, ATM tests; QAM	Cable/DBS: digital/ two-way, IVDS, FM, VBI; fiber-optic, ATM; QAM
Processing	Addressing, pay-per-view; DBS down conversion; bipolar/CMOS ASIC	Digital video, audio; MPEG decompression, error correction; bipolar/ CMOS ASIC	Digital video, audio; MPEG decompression, error correction; bipolar/ CMOS ASIC
Memory	Minimal	2MB	2MB
Others	-	Modular design; security/ decryption; digital radio	Modular design; security/ decryption

Source: Dataquest (December 1995)

processing power, and supporting higher bandwidth transmission links. We expect the set-top box of 1995 to be capable of digital reception, decompression, and audio/video processing. The video decompression standard will be a version of MPEG-2, and audio decompression will be Dolby AC-3 or MPEG. Line transmission opportunities include 8-level vestigial side band (8 VSB) or higher or 64-level QAM or higher. Error correction will be needed to clean up the fast-moving bit stream, decryption for privacy, and a transport layer function for network overhead.

Approximately 2MB of DRAM or tailored field memory will be required for buffering. Many of the functions will be ASIC-based initially with the overall design controlled by the decoder box companies. Eventually, standard functions will dominate as cost reduction becomes paramount.

Manufacturers and Products

Thomson has emerged as the leading supplier of digital set-top boxes. Figure 5-6 presents a block diagram of Thomson's DirecTV Satellite decoder terminal. In 1994, Thomson Consumer Electronics (also known as Thomson Multimedia) shipped 591,000 DSS systems, of which 498,880 were receiving authorized programming from DirecTV or USSB by March 8, 1995. Table 5-10 displays the worldwide market share for leading manufacturers of digital cable and satellite decoder terminals in 1995.

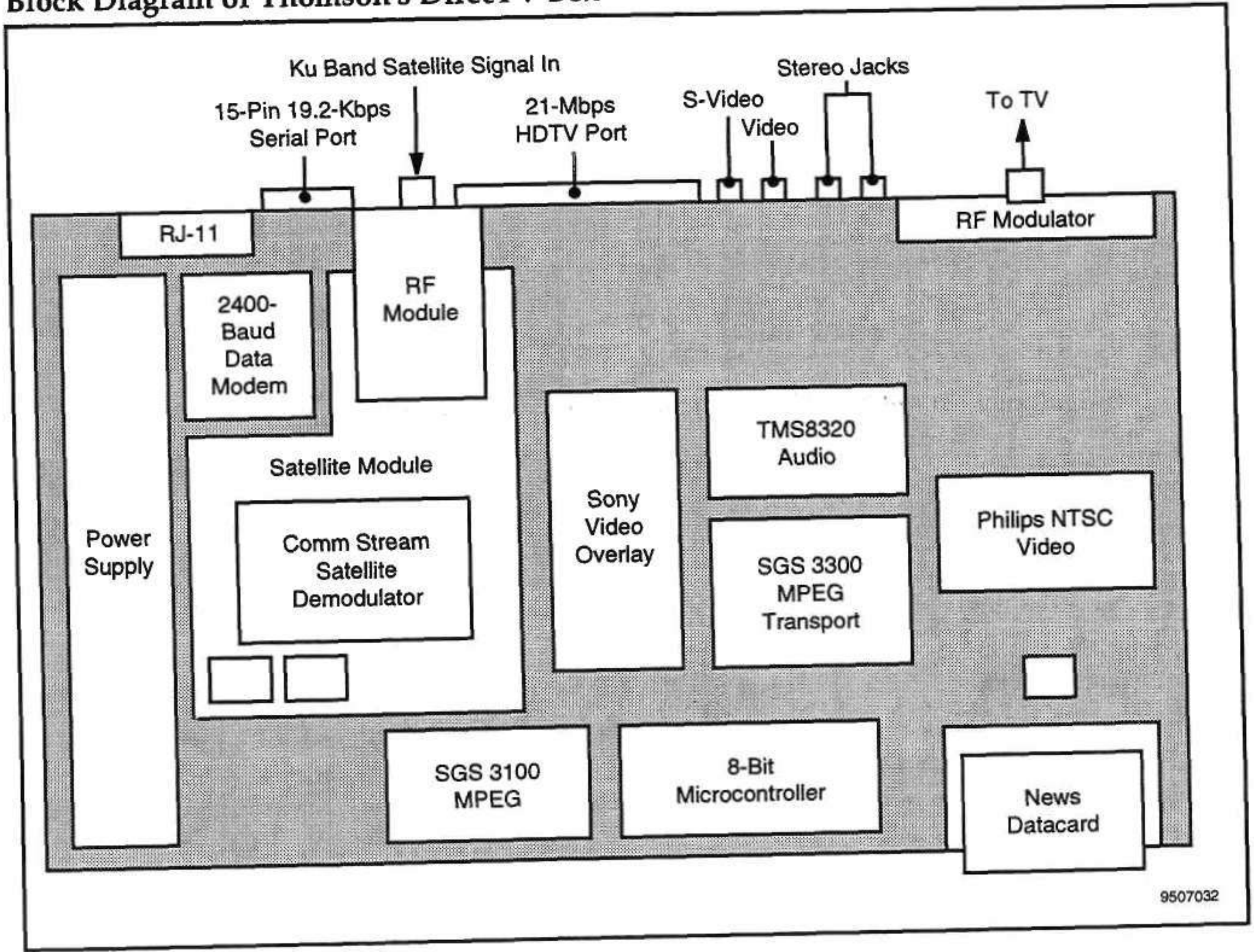
General Instrument has traditionally been the leader in subscriber terminals, producing 3.9 million analog boxes for the cable industry in 1994. Scientific-Atlanta held the No. 2 spot with 1.7 million analog boxes in 1994. In Europe, Pace Micro Technology of West Yorkshire, England, claims to be the leading supplier of analog set-top boxes. Pace supplies boxes for the cable, satellite, and wireless cable markets. The company has recently opened a U.S. office in Denver, Colorado.

We should note that changes occur in the cable equipment market very slowly. For instance, in 1982, GI shipped 2 million analog converter boxes. Eleven years later, in 1993, GI's shipments were up to 3 million units. The cable industry in the United States is slow to change because the nation is wired with a patchwork of 11,460 cable operators, each with a slightly different system.

However, with new network systems for delivering pay TV signals (DBS, wireless, telco), the market has opened up for suppliers from the computer, communications, and consumer electronics industries. For instance, Hewlett-Packard (HP) arrived on the cable scene in a big way in 1994, but soon found out that GI still controlled the head-end equipment and, ultimately, the way data could be transmitted and received.

Sony was the most significant new player to enter the market in 1995. Sony's RCA-DSS-compatible receivers succeeded in displacing HP from the No. 3 spot it held in 1994. Besides Thomson Consumer Electronics and Sony, six more manufacturers have been licensed to manufacture DSS boxes and are expected to begin shipping in 1996. DirecTV Inc., a unit of Hughes Electronics Corporation, is the trademark holder of DSS. Table 5-11 lists advanced subscriber terminals and their manufacturers.

Figure 5-6
Block Diagram of Thomson's DirecTV Box



Source: Dataquest (December 1995)

Table 5-10
Worldwide Digital Cable and Satellite Decoder Revenue Market Share, 1995 (Percentage)

Vendor	Revenue Market Share
Thomson	50.2
General Instrument	35.9
Sony	12.0
Pioneer	1.2
Apple	0.3
AT&T	0.2
Others	0.2
Total	100.0

Source: Dataquest (December 1995)

Table 5-11
Advanced Subscriber Terminal Manufacturers and Their Products
(Digital Boxes Unless Otherwise Noted)

Manufacturer	Product
Adaptive Micro-Ware Inc.	DAVID (with Mitsubishi and Stellar One)
Apple Computer Inc.	M4120 (first generation) intend to OEM
AT&T Network Systems	Digital Home Terminal
Compression Labs Inc.	Media Access and Magnitude
Divicom	Navigator 1000
EchoStar Communications	DISH DBS (1996)
General Instrument Corporation	CFT-2000 (analog), CFT-2200 DigiDock, CFT-2900 TCI, Primestar, DigiCipher I, and DigiCable
Hewlett-Packard Co.	Kayak
Hughes Network Systems Inc.	DirectPC, RCA-DSS compatible (1996)
IBM	Videoway Terminal (analog)
LG Electronics (Goldstar)	GIV-101
Mitsubishi Electronics America	STB-1000 (with Adaptive Micro-Ware and Stellar One)
Pace Micro Technology	DGT400
Philips Consumer Electronics	Media Access, Consumer IRDs, and Magnavox for EchoStar
Pioneer North America	BA-9000, BAV-1000 Command Station, BA-6700 for Quantum (these are all analog, digital is Canal Plus DBS in France)
Samsung Electronics America	(No details at press time)
Scientific-Atlanta Inc.	8600xD and 8600xDI (hybrid analog/digital boxes)
Sony Electronics Inc.	DSS SAS-BS1, SAS-BA1, and SAS-AD1
Stellar One Corporation	Stellar 1000 (with Adaptive Micro-Ware and Mitsubishi)
Tee-Comm Electronics Inc.	StarTrak Digital IRD
Thomson Consumer Electronics	RCA DSS-1 and now DSS-2
Toshiba America Corporation	(Components for FSN, RCA-DSS-compatible in 1996)
TV/COM International	(no details at press time)
Uniden	RCA-DSS-compatible (1996)
Zenith Electronics Corporation	Media Access

Source: Dataquest (December 1995)

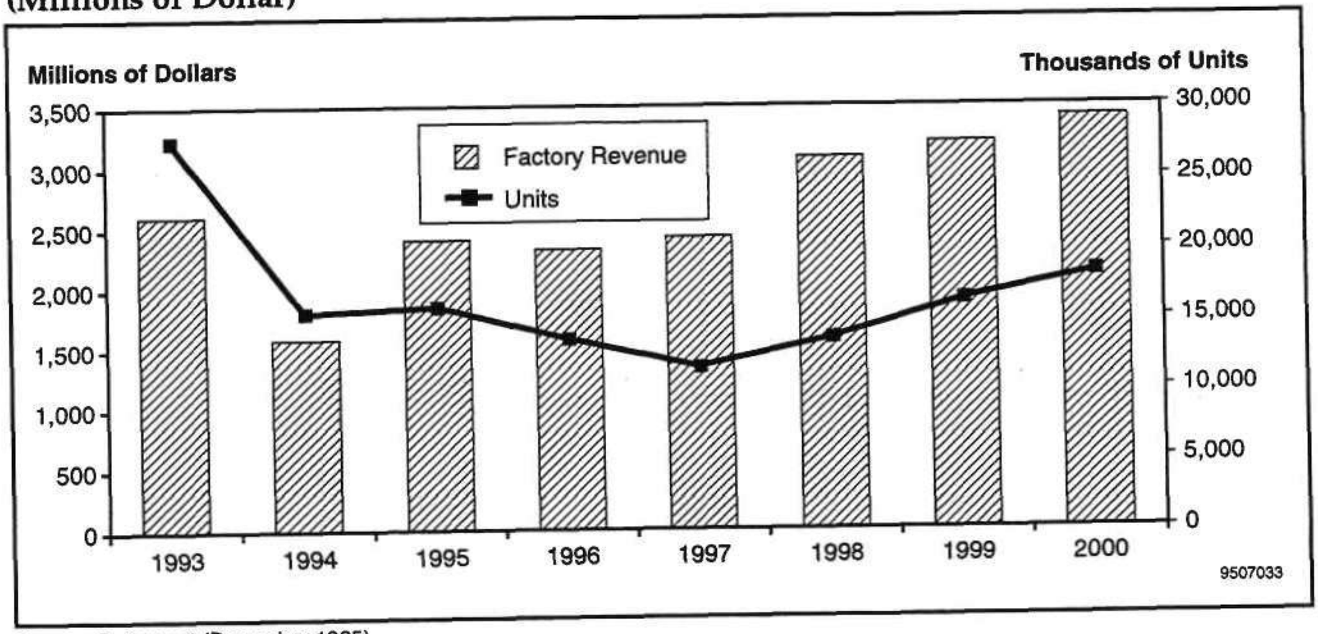
Interactive Video Games

Figures 5-7 and 5-8 and Tables 5-12 through 5-14 present the production forecast for handheld and console video games. Figure 5-9 and Table 5-15 show the production forecast for game cartridges.

Figures 5-10 and 5-11 show the distribution of regional production for video game controllers and game cartridges. Figure 5-12 presents the market share for video game controllers.

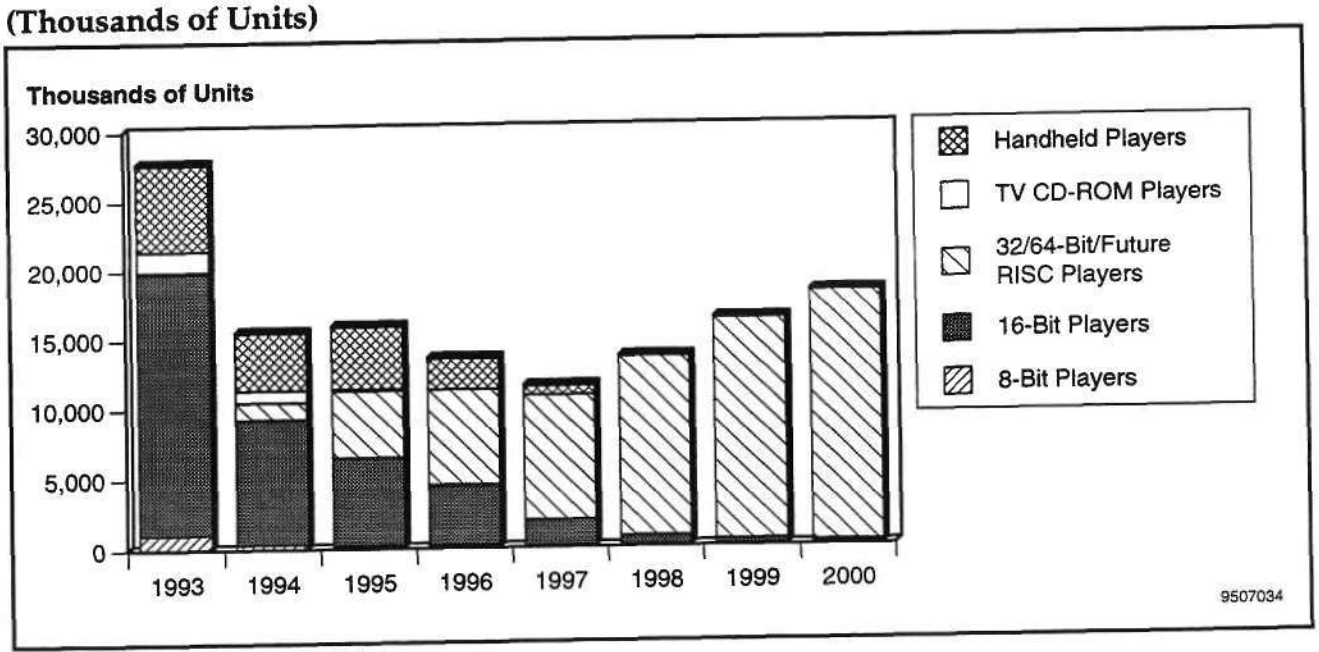
The major news in the video game market during 1995 was the introduction of 32/64-bit next-generation video game controllers by major players in the industry and the entry of Sony into the video game hardware market. Exciting new video game platforms such as Saturn, Playstation, Ultra-64, Virtual Boy, M2, and Jaguar captured the attention of the video game

Figure 5-7
Worldwide Video Game Controller Production Revenue and Unit Shipment Forecast (Millions of Dollar)



Source: Dataquest (December 1995)

Figure 5-8
Worldwide Video Game Controller Unit Shipment Forecast, by Type (Thousands of Units)



Source: Dataquest (December 1995)

Table 5-12
Worldwide Video Game Controller Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	27,641	15,472	15,859	13,532	11,500	13,572	16,266	18,197	2.8
Factory ASP ($)	94	102	152	172	211	227	197	187	4.3
Factory Revenue ($M)	2,605	1,584	2,404	2,323	2,422	3,075	3,196	3,405	7.2
Semiconductor Content ($)	34	45	87	105	136	150	131	124	7.3
Semiconductor TAM ($M)	945	698	1,384	1,420	1,560	2,030	2,128	2,253	10.2

Note: Includes handhelds
Source: Dataquest (December 1995)

Table 5-13
Worldwide Video Game Controller Unit Shipment Forecast, by Type (Thousands of Units)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
8-Bit Players	1,110	400	280	182	0	0	0	0	-100.0
16-Bit Players	18,710	8,860	6,202	4,341	1,954	781	469	328	-44.5
32/64-Bit/Future RISC Players	100	1,237	4,802	6,809	8,886	12,791	15,797	17,869	30.1
TV CD-ROM Players	1,525	860	120	0	0	0	0	0	-100.0
Handheld Players	6,196	4,115	4,455	2,200	660	0	0	0	-100.0
Total	27,641	15,472	15,859	13,532	11,500	13,572	16,266	18,197	2.8

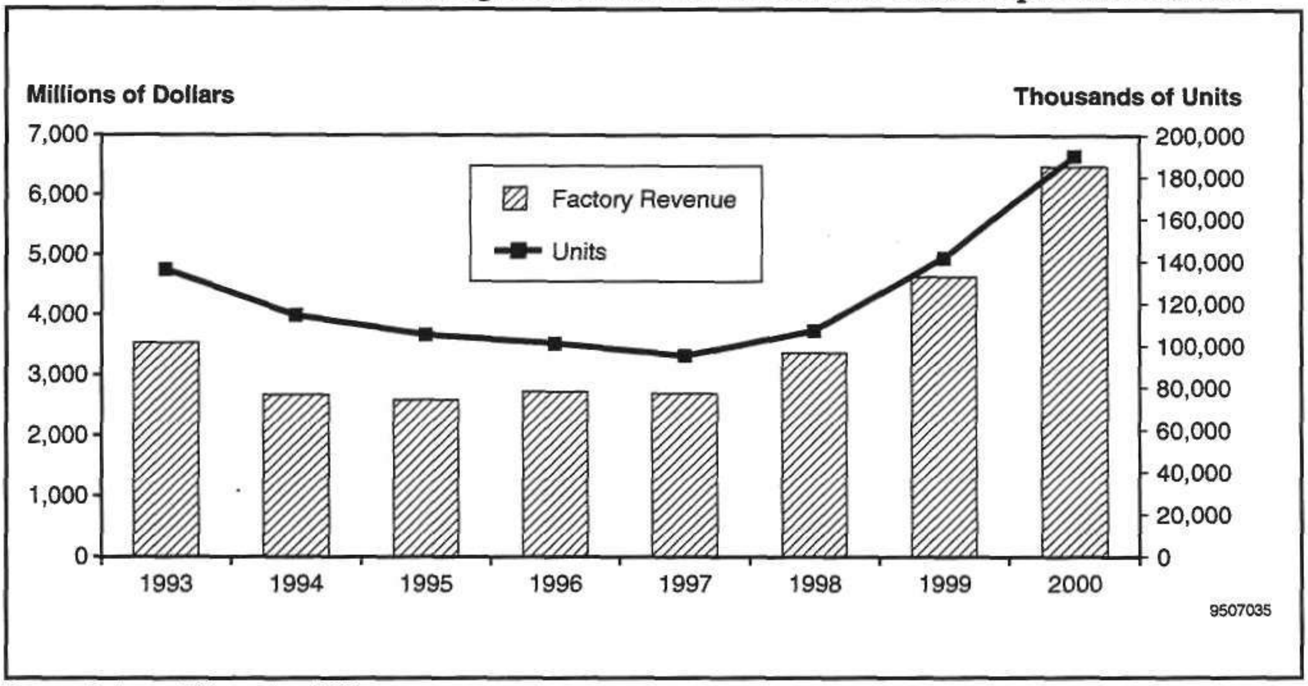
Source: Dataquest (December 1995)

Table 5-14
North American Video Game Controller Production Forecast

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	65	65	80	80	80	85	92	101	4.8
Factory ASP ($)	135	129	123	118	114	109	105	101	-3.8
Factory Revenue ($M)	9	8	10	9	9	9	13	10	0.8
Semiconductor Content ($)	42	40	38	37	35	34	33	33	-2.8
Semiconductor TAM ($M)	2.7	2.6	3.0	3.0	2.8	2.9	4.1	3.3	1.9

Note: Includes handhelds
Source: Dataquest (December 1995)

Figure 5-9
Worldwide Video Game Cartridge Production Revenue and Unit Shipment Forecast



Source: Dataquest (December 1995)

Table 5-15
Worldwide Video Game Cartridge Production Forecast

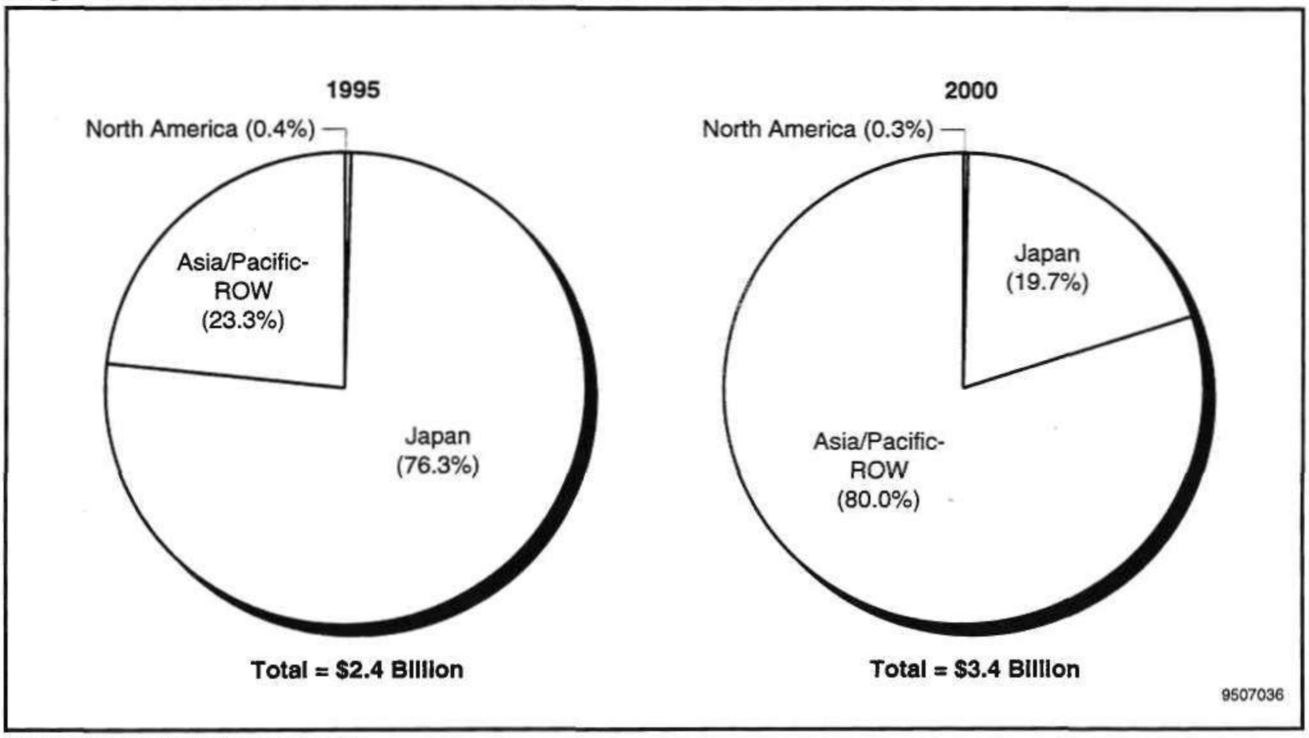
	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Units (K)	135,884	114,077	104,896	100,879	95,210	106,998	141,713	190,107	12.6
Factory ASP ($)	26	23	25	27	28	32	33	34	6.7
Factory Revenue ($M)	3,536	2,676	2,591	2,729	2,704	3,382	4,651	6,480	20.1
Semiconductor Content ($)	9	9	9	10	10	11	11	11	4.9
Semiconductor TAM ($M)	1,222.5	1,003.0	926.4	979.2	979.6	1,131.7	1,543.7	2,133.7	18.2

Source: Dataquest (December 1995)

industry. Following the 8- and 16-bit market cycles, these 32/64-bit controllers are expected to drive the next wave of video game sales and technology.

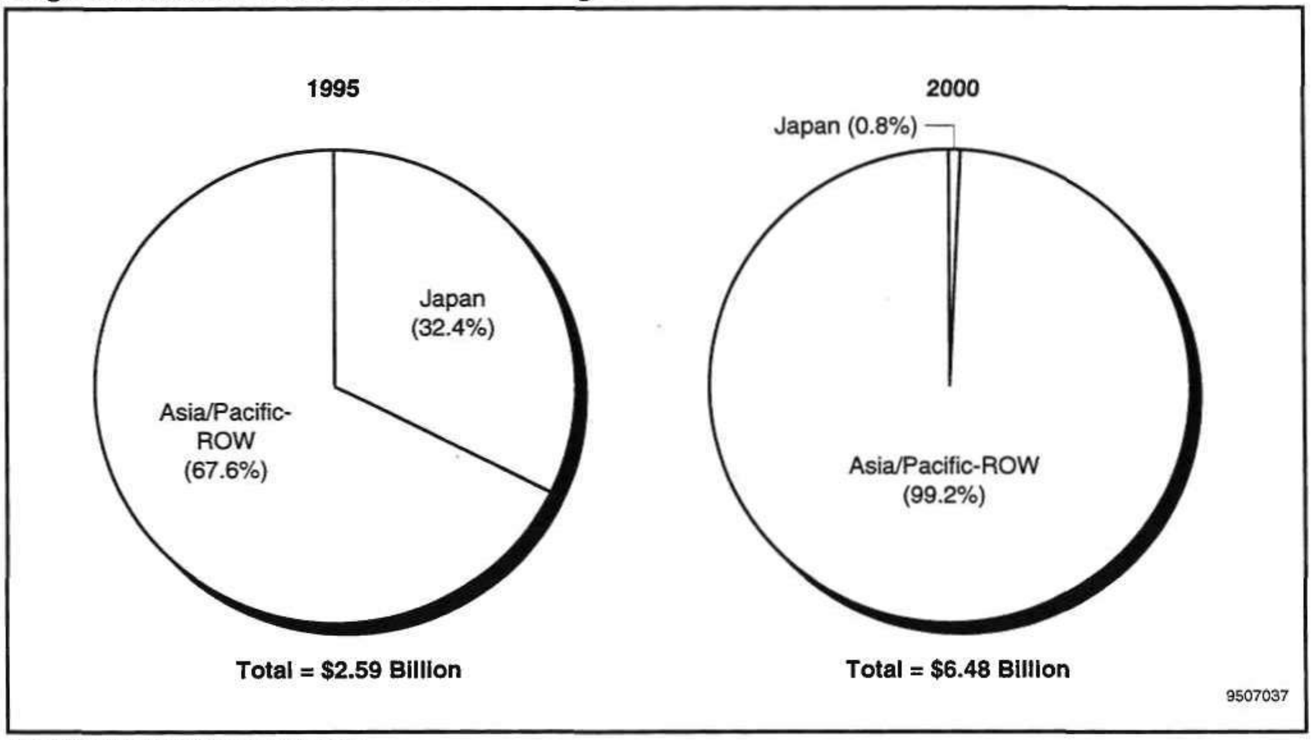
Dataquest predicts that worldwide shipments of these new video game controllers will climb to almost 18 million by the year 2000. With the semiconductor content in this new generation of controllers leaping to over 66 percent of manufacturing cost, the semiconductor market driven by these new video game controllers will reach $2.3 billion by the year 2000. This forecast is based on the average factory price of new video game controllers dropping below $200 by the year 2000. If prices decline more rapidly, the unit shipments and semiconductor market could grow even

Figure 5-10
Regional Share of Video Game Controller Production Revenue



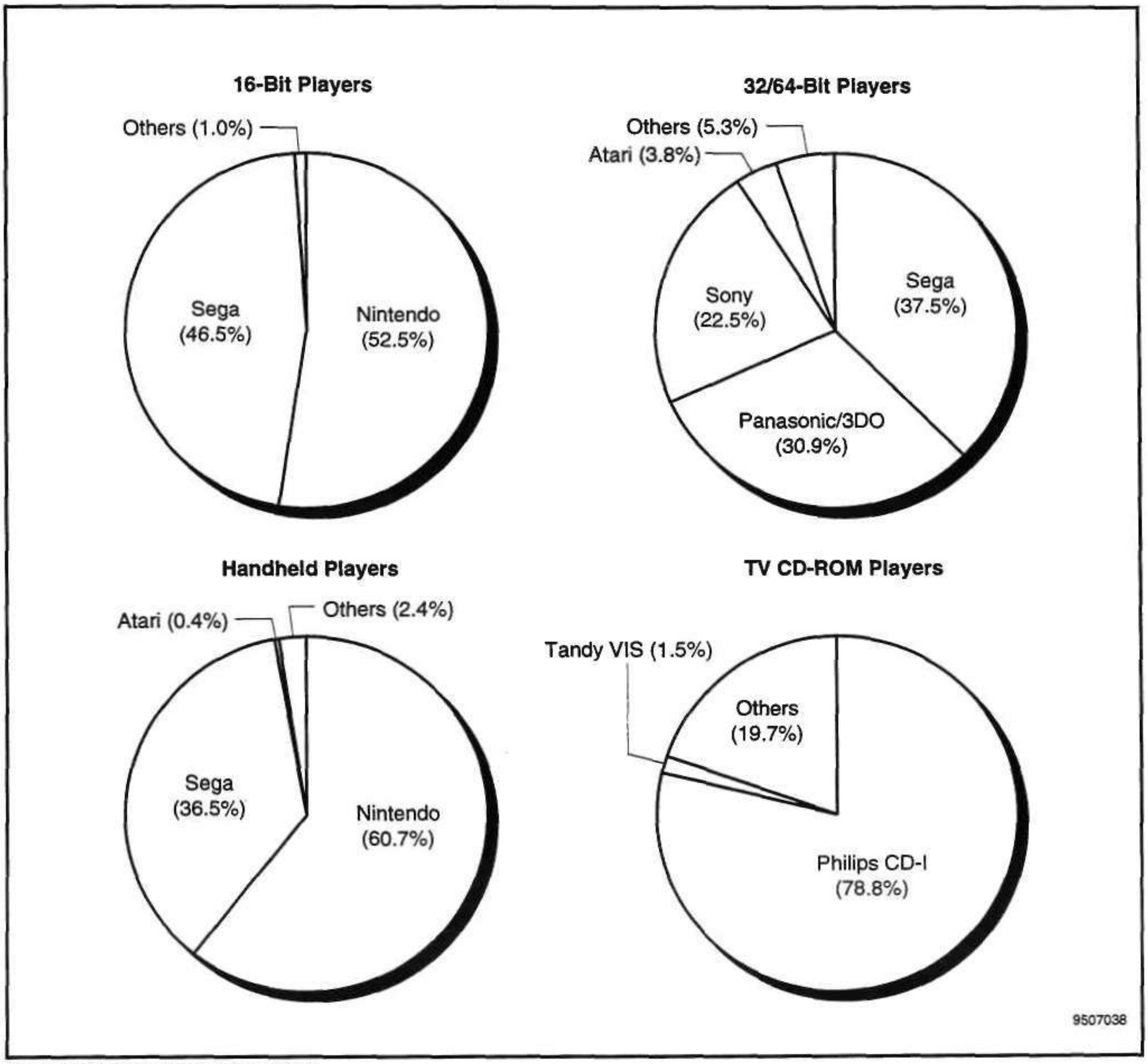
Source: Dataquest (December 1995)

Figure 5-11
Regional Share of Video Game Cartridge Production Revenue



Source: Dataquest (December 1995)

Figure 5-12
Worldwide Video Game Market Share, 1994



Source: Dataquest (December 1995)

larger. Some of the important market, technology, and production trends are as follows:

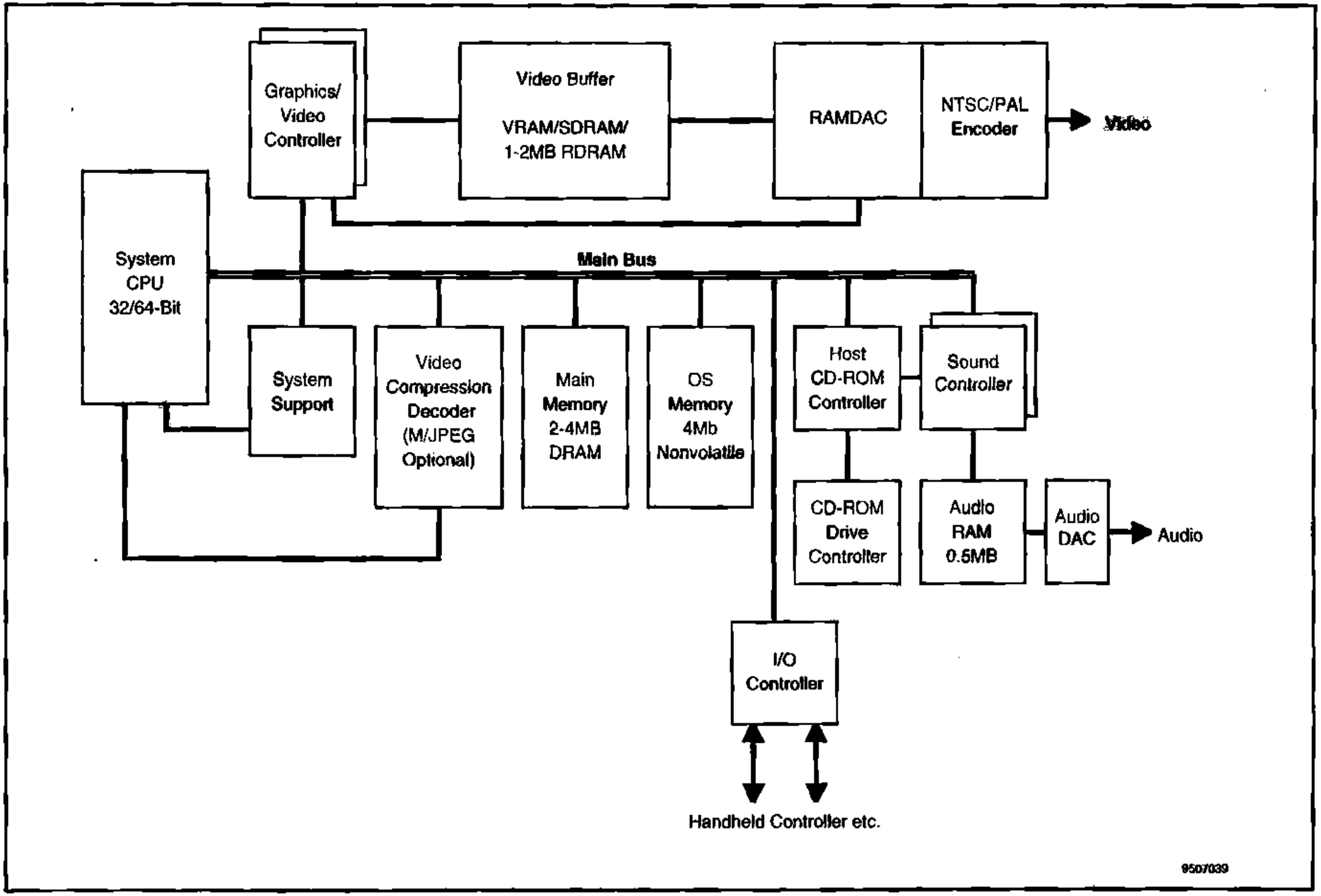
- The higher prices of the new 32-bit video game controllers reduced sales during 1995 and resulted in enhanced 16-bit games capturing the largest market share for software during the 1995 Christmas season.
- Sony entered the video game market with the introduction of its 32-bit Sony PlayStation for $299. This platform uses a CD-ROM drive instead of cartridges for the software. At the heart of the PlayStation is LSI Logic's custom 32-bit R3000 RISC processor.

- Sega launched two new platforms, the Sega Saturn and the Genesis Nomad. The Saturn was introduced in the United States at a price of $399 and also incorporates a CD-ROM drive instead of cartridges. The Saturn employs two 32-bit Hitachi SH2 processors in its design. It has been widely rumored that Sega is considering the PowerPC for future designs. After experiencing lackluster sales, Sega reduced the price to $299 to compete more effectively with the Sony PlayStation. The Genesis Nomad is Sega's first portable 16-bit video game system. It is compatible with the library of more than 600 Sega Genesis game cartridges.
- Nintendo delayed the introduction of its Ultra-64 platform until spring 1996 and focused its energy on the 16-bit market for another year. Initially, this delay was viewed as a serious setback for Nintendo that would make it difficult to recapture market share. However, with the lower-than-expected sales for 32-bit controllers during 1995, Nintendo could capture a significant advantage if its platform can demonstrate solid performance at the $249 price point. There have been some rumors that Nintendo would launch its Ultra-64 for $200. Part of the cost savings that would allow it to bring these controllers to the market at a lower price comes from its decision to stay with cartridges instead of CD-ROMs, which require the inclusion of a costly CD-ROM player in the controller. The Ultra-64 achieves a high level of integration in its design through use of a custom RISC processor developed by Silicon Graphics and Rambus DRAM. Nintendo is working on a new storage device for the Ultra 64 to overcome the limit on the amount of information that can be delivered in a cartridge. The device is expected to be some kind of magnetic recording disk, but it probably will not be revealed until late 1996.
- Nintendo did bring a new platform to the market during 1995, the Virtual Boy. The Virtual Boy game unit breaks the mold of the console-attached-to-TV standard. It is difficult to classify this product as either a handheld device or a console device because it delivers a very different gaming experience. The Virtual Boy provides visually immersive, three-dimensional gaming using a self-contained display that resembles a large pair of goggles. A 32-bit RISC processor running at 20 MHz and a dual-LED display create a smooth, three-dimensional display. The game platform was introduced in the United States in August 1995 at $180. The price was dropped to $160 three months later in reaction to consumer resistance to higher-priced games.
- Following the loss of support from AT&T, Toshiba, Creative Labs, and Sanyo for the 3DO platform, 3DO sold exclusive rights to control the use of its M2 64-bit platform to Matsushita Electric. 3DO effectively relinquished control over the technology's application in most markets in exchange for $100 million in licensing fees plus royalties from Matsushita. The 3DO M2 system employs the PowerPC in its design.
- The dramatic rise in the value of the yen has created a major challenge for Japanese manufacturers of video games. The strong yen has forced these companies to begin moving production of video game players offshore to meet critical price targets for increasing consumer demand.

Figure 5-13 presents a generic block diagram of a RISC video game controller. Key chip opportunities include:

- 32/64-bit RISC or CISC MPU

Figure 5-13
Generic Block Diagram of RISC Video Game Controller



Source: Dataquest (December 1995)

- 2MB to 4MB DRAM (VRAM for some designs)
- 1MB to 2MB VRAM, SDRAM, or RDRAM
- 32KB SRAM
- CMOS ASIC (100,000 to 200,000 gates) graphics/sound processing
- NTSC/PAL encode
- Sound DAC/amplification
- M/JPEG decompression (optional)
- CD-ROM drive controller

Cameras, Watches, and Clocks

Table 5-16 presents the North American production in these areas. Production for the most part has moved to Asia for all but the very high-end products.

Digital Cameras

The term "digital camera" is used to refer both to video cameras that are mounted on a PC for use in videoconferencing applications and to still cameras that record images on memory chips or a disk instead of film. The digital cameras discussed in this section use the latter definition. Digital cameras were originally targeted at vertical markets such as real estate, fashion, and law enforcement. However, to the pleasant surprise of manufacturers, consumers are purchasing digital cameras and driving a stronger-than-expected market. A number of new companies are jumping into this market. The merger of the camera and a computer represents the easiest way to get photographs into a PC. Images can be transferred to the hard drive of a computer, where they can be viewed, edited, or added to documents. Although the images created by digital cameras are inferior to the quality achieved by traditional film cameras, the image that can be captured in a PC through a digital camera is superior to the method of using a scanner to transfer a photo into a computer. The picture quality of the latest digital cameras is comparable to S-VHS or hi-8 video images.

Some of the digital camera models available in the market are Kodak's DC 40, Apple's QuickTake 100 and 150, Casio's QV-10, Logitech's FotoMan Pixtura, Ricoh's DC-1 and RDC-1, Toshiba's PROSHOT, Minolta's RD-175, Epson's Photo PC, and Chinon's ES-1000 and ES-3000. New product

Table 5-16
North American Revenue from Production of Cameras, Watches, and Clocks (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Cameras	24	25	27	28	29	29	30	30	2.4
Watches	110	115	120	127	131	136	142	148	4.2
Clocks	60	62	66	69	72	75	78	81	4.3
Total	194	202	213	224	232	241	251	259	4.0

Source: Dataquest (December 1995)

announcements are expected from Panasonic, Polaroid, and Canon in the coming months. Prices for digital cameras range from $500 for cameras such as the Epson Photo PC and the Chinon ES-1000 to $1,800 for the advanced Ricoh RDC-1. Even with these high prices, industry observers expect market sales to be four times higher in 1996 than in the previous two years combined. Recent announcements from major manufacturers would support this prediction.

- Chinon has been a major manufacturer of digital cameras, producing digital still cameras for U.S. makers on an OEM basis since 1992. The company manufactures cameras for Apple, Kodak, and Logitech. In December it announced two new cameras under its own name. It also announced that it would triple its monthly production capacity from an estimated 20,000 units per month in December 1995.
- Casio started producing 3,000 cameras per month in March 1995 and boosted its monthly output to 10,000 units per month in September as its camera became one of the most popular models on the market. It also announced their plan to invest ¥300 million to expand production capacity to 30,000 units per month by the end of 1995.

One of the most impressive digital cameras to come to the market in 1995 was the Ricoh RDC-1, which received *Byte Magazine*'s Best of COMDEX/Fall '95 Award. The RDC-1 was designed for multimedia applications in business and government. It can record a maximum of 492 still images, four motion scenes with sound (five seconds each) or about 100 minutes of sound on a 24MB PC card. Images can be transferred directly to a PC or transmitted via a modem. The camera can also be connected directly to a television or an optional 2.5-inch LCD monitor. The camera will begin selling in the United States in April 1996.

Chapter 6
Appliances and Other Consumer Equipment

Figures 6-1 through 6-3 and Tables 6-1 through 6-2 present production and market forecast for appliance and other consumer electronics.

Highlights in the markets for appliances and other consumer equipment are as follows:

- Generally appliances are following replacement market economics in the developed countries. Because of prohibitive transportation costs, most appliances are produced in the end-use market.
- New models are incorporating an increasing amount of user features based on MCU (4-bit, mostly) control.
- Motor-driven appliances such as refrigerators, washers, and dryers are gradually moving to solid-state controls for direct-drive motors.
- The "green" movement is forcing more appliance power conservation with solid-state controls as a way of accomplishing design objectives.

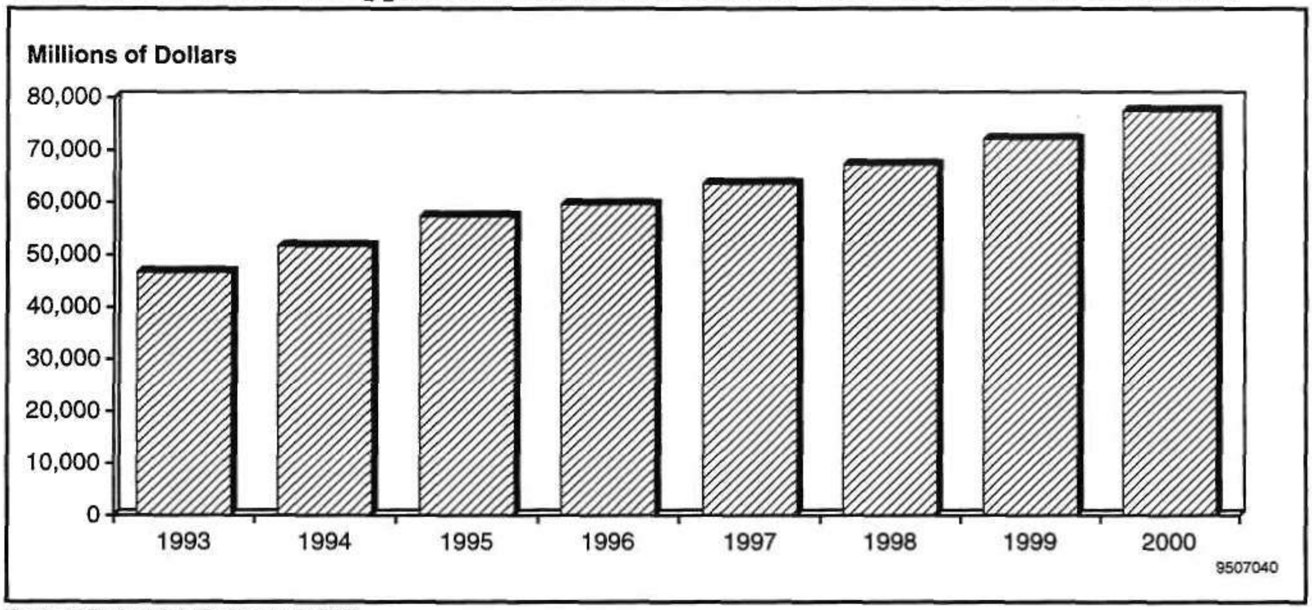
Microwave Ovens

Tables 6-3 and 6-4 detail the market for microwave ovens.

Refrigerators

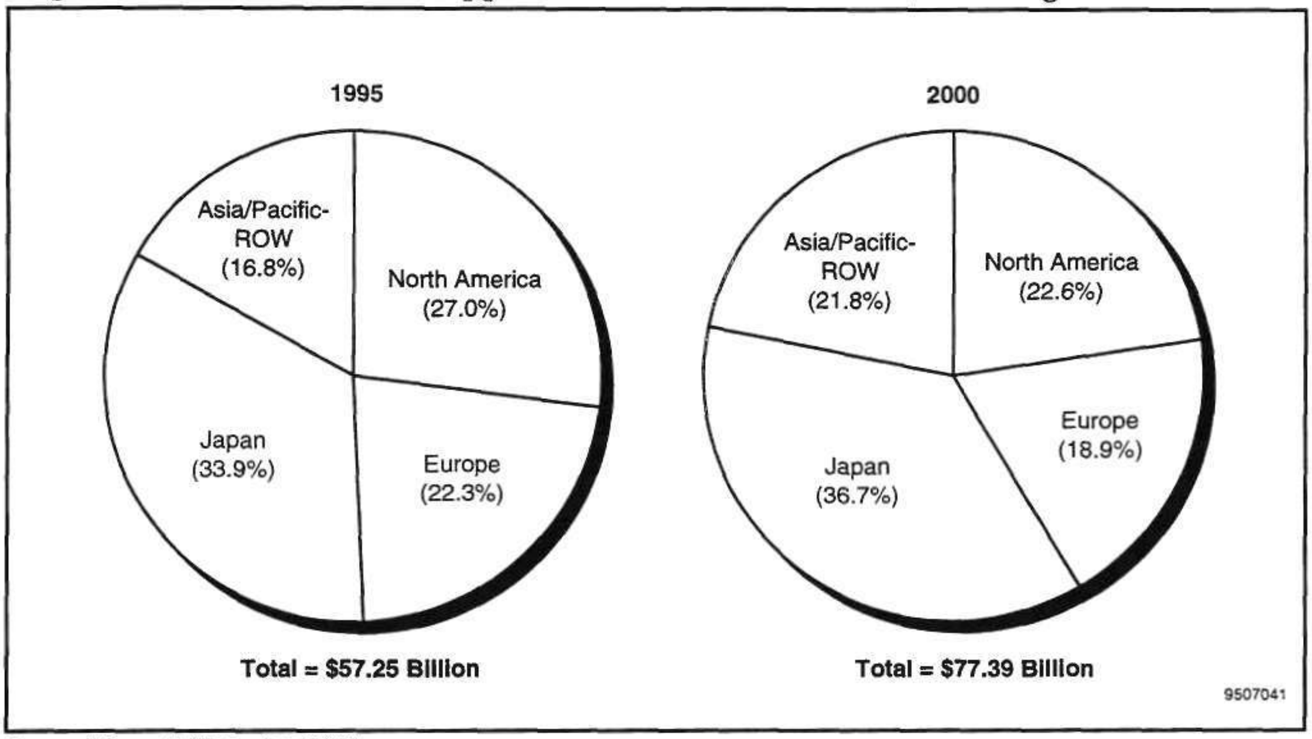
Tables 6-5 and 6-6 detail the market for refrigerators.

Figure 6-1
Worldwide Electronic Appliance Production Revenue Forecast (Millions of Dollars)



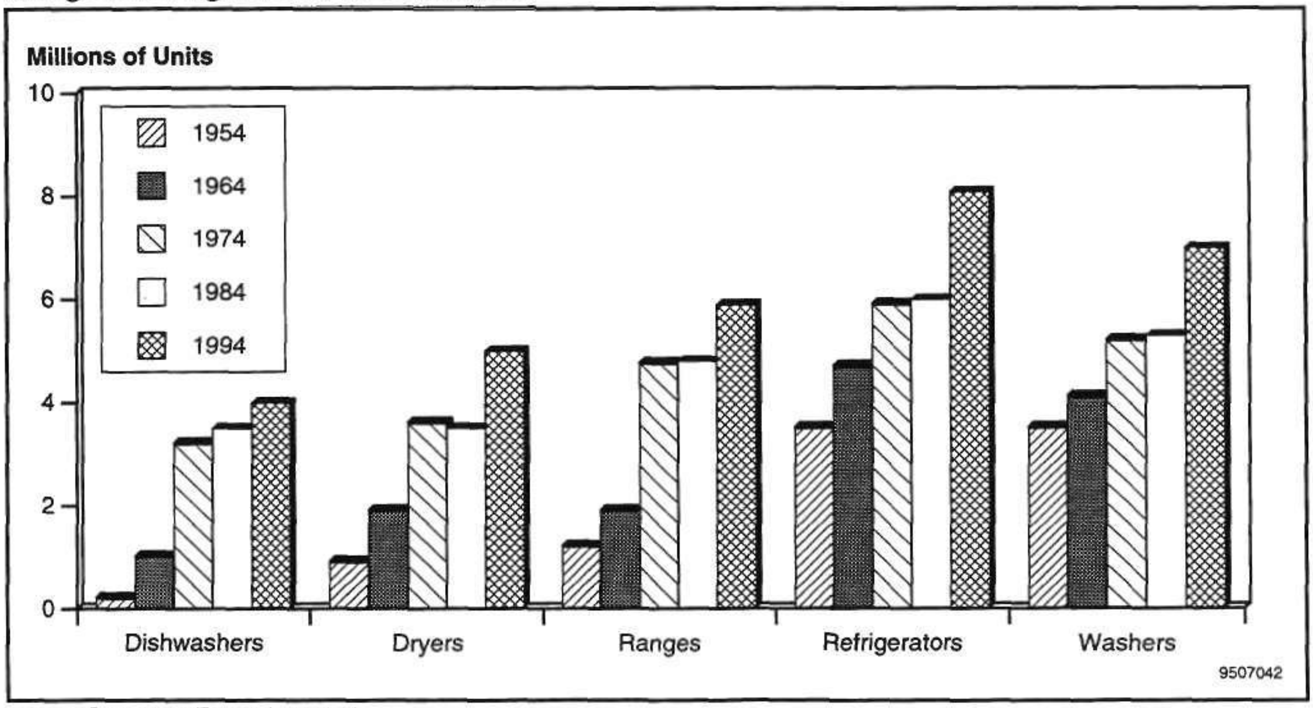
Source: Dataquest (December 1995)

Figure 6-2
Regional Share of Electronic Appliance Production Revenue (Percentage)



Source: Dataquest (December 1995)

Figure 6-3
U.S. Major Appliance Unit Shipments, 1954 to 1994 (Includes Dishwashers, Dryers, Ranges, Refrigerators, and Washers)



Source: Dataquest (December 1995)

Table 6-1
North American Appliance Production Revenue Forecast (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Range and Oven (Gas and Electric)	1,154	1,239	1,286	1,324	1,372	1,400	1,466	1,515	3.3
Microwave Oven	574	627	657	688	713	734	764	795	3.9
Clothes Washer and Dryer	3,518	3,724	3,879	3,842	3,997	4,036	4,233	4,343	2.3
Dishwasher	1,168	1,284	1,341	1,376	1,434	1,439	1,538	1,595	3.5
Refrigerator	5,228	5,606	5,792	5,693	5,872	6,018	6,357	6,519	2.4
Room Air Conditioner	2,027	2,463	2,515	2,428	2,528	2,559	2,689	2,735	1.7
Total	13,669	14,942	15,470	15,351	15,917	16,186	17,047	15,987	0.7

Source: Dataquest (December 1995)

Table 6-2
North American Appliance Market Revenue Forecast (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Range and Oven (Gas and Electric)	7,390	7,843	7,636	7,700	7,816	7,972	8,091	8,172	1.4
Microwave Oven	8,945	9,844	9,697	9,862	10,059	10,260	10,465	10,674	1.9
Clothes Washer	7,472	7,739	7,484	7,613	7,803	8,014	8,214	8,379	2.3
Clothes Dryer	5,581	5,873	5,623	5,768	5,941	6,132	6,316	6,473	2.9
Dishwasher	4,509	5,038	4,847	4,956	5,129	5,334	5,521	5,703	3.3
Refrigerator	8,920	9,517	9,384	9,486	9,676	9,918	10,116	10,319	1.9
Freezer	1,767	1,860	1,843	1,867	1,904	1,952	1,991	2,030	2.0
Room Air Conditioner	3,384	4,532	4,697	4,389	4,301	4,344	4,388	4,432	-1.2
Total	47,968	52,246	51,211	51,641	52,629	53,925	55,102	56,183	1.9

Source: Dataquest (December 1995)

Dishwashers

Tables 6-7 and 6-8 detail the market for dishwashers.

Washers

Tables 6-9 and 6-10 detail the market for washers.

Dryers

Tables 6-11 and 6-12 detail the market for dryers.

Air Conditioners

Tables 6-13 and 6-14 details the market for air conditioners.

Table 6-3
U.S. Microwave Oven Brand Share Leaders, First Quarter 1994 through Fourth Quarter 1994 (Percentage)

	Unit Market Share	Revenue Market Share
Sharp	22.9	22.2
General Electric	15.5	20.6
Panasonic	10.4	8.9
Sears/Kenmore	9.9	9.7
Tappan	6.3	5.8
Whirlpool	4.8	6.7
Goldstar	4.8	3.6
Magic Chef	4.6	2.9
Emerson	4.1	2.5
Samsung	3.7	2.4
Others	13.0	14.7
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-4
U.S. Microwave Oven Brand Share Leaders, Third Quarter 1994 through Second Quarter 1995 (Percentage)

	Unit Market Share	Revenue Market Share
Sharp	23.8	23.8
General Electric	14.0	17.9
Sears/Kenmore	9.8	9.5
Panasonic	9.5	8.5
Tappan	6.0	5.6
Whirlpool	5.4	7.4
Magic Chef	5.3	3.6
Emerson	4.7	2.6
Goldstar	4.5	3.5
Samsung	3.9	2.8
Others	13.1	14.8
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-5
U.S. Refrigerator Brand Share Leaders, First Quarter 1994 through Fourth Quarter 1994 (Percentage)

	Unit Market Share	Revenue Market Share
Sears/Kenmore	19.4	20.2
General Electric	18.0	20.1
Whirlpool	13.5	14.0
Amana	13.3	14.5
Hotpoint	6.0	4.8
Frigidaire	5.6	4.9
Admiral	3.1	2.6
KitchenAid	3.0	3.8
Maytag	2.8	3.4
Magic Chef	2.7	2.1
Others	12.6	9.6
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-6
U.S. Refrigerator Brand Share Leaders, Third Quarter 1994 through Second Quarter 1995 (Percentage)

Brand	Unit Market Share	Revenue Market Share
Sears/Kenmore	19.2	20.2
General Electric	18.9	20.6
Whirlpool	12.8	13.1
Amana	12.1	13.6
Frigidaire	6.3	5.4
Hotpoint	5.6	4.6
Maytag	3.9	4.5
KitchenAid	3.1	3.7
Admiral	2.9	2.7
Magic Chef	2.5	2.0
Others	12.7	9.6
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-7
U.S. Dishwasher Brand Share Leaders, First Quarter 1994 through Fourth Quarter 1994 (Percentage)

	Unit Market Share	Revenue Market Share
Sears/Kenmore	20.6	19.9
Maytag	19.5	21.4
General Electric	18.8	18.3
Whirlpool	17.1	16.2
KitchenAid	8.6	11.3
Hotpoint	3.4	2.5
Frigidaire	2.9	2.5
Magic Chef	1.4	1.1
Tappan	1.3	0.9
White/Westinghouse	1.1	0.8
Others	5.3	5.1
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-8
U.S. Dishwasher Brand Share Leaders, Third Quarter 1994 through Second Quarter 1995 (Percentage)

	Unit Market Share	Revenue Market Share
Sears/Kenmore	21.8	21.3
Maytag	19.4	21.2
General Electric	18.0	18.1
Whirlpool	15.1	14.3
KitchenAid	9.8	12.3
Hotpoint	3.4	2.4
Frigidaire	2.9	2.6
Tappan	1.7	1.3
Magic Chef	1.5	1.3
White/Westinghouse	1.4	1.0
Others	5.0	4.2
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-9
U.S. Clothes Washer Brand Share Leaders, First Quarter 1994 through First Quarter 1994 (Percentage)

	Unit Market Share	Revenue Market Share
Sears/Kenmore	26.6	26.8
Whirlpool	20.4	20.2
Maytag	15.7	18.4
General Electric	11.6	10.7
Hotpoint	4.1	3.4
Amana	3.9	3.9
Frigidaire	2.8	2.7
White/Westinghouse	2.7	2.7
Roper	2.3	1.8
KitchenAid	1.8	1.9
Others	8.1	7.5
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-10
U.S. Clothes Washer Brand Share Leaders, Third Quarter 1994 through Second Quarter 1995 (Percentage)

	Unit Market Share	Revenue Market Share
Sears/Kenmore	28.7	28.7
Whirlpool	20.1	20.0
Maytag	15.7	18.3
General Electric	9.3	8.6
Amana	4.3	4.4
Hotpoint	3.5	2.9
Roper	3.1	2.4
White/Westinghouse	2.9	2.7
Frigidaire	2.4	2.3
KitchenAid	1.9	2.1
Others	8.1	7.6
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-11
U.S. Clothes Dryer Brand Share Leaders, First Quarter 1994 through Fourth Quarter 1994 (Percentage)

	Unit Market Share	Revenue Market Share
Sears/Kenmore	27.7	27.6
Whirlpool	19.0	19.4
Maytag	14.5	17.5
General Electric	14.4	13.2
Hotpoint	4.0	3.5
Amana	3.0	2.9
White/Westinghouse	3.1	2.8
Roper	2.5	2.1
Frigidaire	2.3	2.1
Speed Queen	1.8	1.9
Others	7.5	7.0
Total	99.8	100.0

Source: The Scout Report®/The Polk Company

Table 6-12
U.S. Clothes Dryer Brand Share Leaders, Third Quarter 1994 through Second Quarter 1995 (Percentage)

	Unit Market Share	Revenue Market Share
Sears/Kenmore	29.0	28.9
Whirlpool	19.6	20.3
Maytag	13.9	16.7
General Electric	13.2	12.0
Hotpoint	3.5	2.9
Amana	3.0	2.9
Roper	2.6	2.2
Frigidaire	2.6	2.2
White/Westinghouse	2.6	2.1
Speed Queen	1.4	1.5
Others	8.6	8.3
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-13
U.S. Room Air Conditioner Brand Share Leaders, First Quarter 1994 through Fourth Quarter 1994 (Percentage)

	Unit Market Share	Revenue Market Share
Sears/Kenmore	16.4	17.2
Fedders	14.1	12.0
Whirlpool	11.4	11.5
General Electric	10.3	9.8
Amana	5.9	6.2
Carrier	5.8	6.0
White/Westinghouse	5.5	4.9
Emerson	4.5	4.8
Friedrich	4.1	5.7
Frigidaire	4.0	4.6
Others	18.0	17.3
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Table 6-14
U.S. Room Air Conditioner Brand Share Leaders, Third Quarter 1994 through Second Quarter 1995 (Percentage)

	Unit Market Share	Revenue Market Share
Sears/Kenmore	18.9	19.1
Fedders	16.6	14.9
Whirlpool	10.7	10.8
General Electric	9.4	9.1
Carrier	6.4	7.5
Amana	6.1	6.1
Frigidaire	5.4	5.9
White/Westinghouse	4.7	3.7
Emerson	4.6	4.8
Friedrich	4.3	5.9
Others	12.9	12.2
Total	100.0	100.0

Source: The Scout Report®/The Polk Company

Ranges

Tables 6-15 and 6-16 detail the market for ranges.

Table 6-15
U.S. Electric Range Market Share Leaders, First Quarter 1994 through Fourth Quarter 1994 (Percentage)

	Unit Market Share
General Electric	39.0
Electrolux (Frigidaire)	19.0
Whirlpool	19.0
Maytag (Magic Chef, Hardwick, Jenn Air)	13.0
Raytheon (Caloric)	6.0
Brown	2.0
Peerless Premier	1.0
Others	1.0
Total	100.0

Source: Appliance Magazine

Table 6-16
U.S. Gas Range Brand Share Leaders, First Quarter 1994 through Fourth Quarter 1994 (Percentage)

	Unit Market Share
General Electric (Roper)	25.0
Electrolux (Frigidaire)	24.0
Maytag (Magic Chef, Hardwick, Jenn Air)	24.0
Raytheon (Caloric)	20.0
Brown	3.0
Peerless Premier	3.0
Others	1.0
Total	100.0

Source: Appliance Magazine

Other Consumer Equipment

Tables 6-17 and 6-18 detail the market for other consumer equipment.

Top OEMs in home security systems are as follows:

- Honeywell
- Black & Decker
- Sony
- Audiovox
- Yale

Table 6-17
Worldwide Revenue from Production of Other Consumer Equipment (Millions of Dollars)

Year	Revenue
1993	12,310
1994	13,623
1995	16,262
1996	17,215
1997	18,518
1998	19,598
1999	20,543
2000	22,313
1995-2000 CAGR (%)	6.5

Source: Dataquest (December 1995)

Table 6-18
North American Revenue from Production of Other Consumer Equipment (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Automatic Garage Door Opener	352	411	435	464	485	510	537	562	5.3
Others	944	983	1,026	1,075	1,107	1,145	1,186	1,226	3.6
Total	1,296	1,394	1,461	1,539	1,592	1,655	1,723	1,788	4.1

Source: Dataquest (December 1995)

Chapter 7
Emerging Opportunities

"Smart Home" Electronics

Although home bus technology to date has been an elusive market, it is worth keeping tabs on. These house LANs create a communications pathway among the home's appliances, HVAC systems, computing and cable equipment, and outside agencies such as the power company so that energy use can be optimized and outside communications can be automatic.

Leading bus contenders in the United States include:

- CEBus—An EIA-supported protocol that has been designated as interim standard IS-60 and is in the progress of balloting.
- LonWorks—A proprietary approach advocated by Echelon Corporation

One CEBus offering is from Intellon Corporation, which has a power line radio-frequency modem IC using spread spectrum technology capable of 10-Kbps data rates. Intellon recently tested its technology on the TCI and Microsoft set-top box platform. Echelon network controllers are made by Motorola and Toshiba.

In May 1995 a major feud erupted between CEBus proponents and LonWorks supporters. The fight resulted from the EIA's proposal to the FCC that it adopt AVBus as a standard for the control channel between set-top boxes and cable-ready TVs and VCRs. AVBus is a subset of the CEBus protocol. Echelon protested that this would grant CEBus an unfair advantage in competition for the home automation market. It believes that adoption of this standard in set-top boxes would limit access to the home by other standards because of the higher cost incurred by the need to implement a protocol converter. The CEO of Echelon claimed adoption of CEBus by the FCC for set-top boxes would be "almost like the FCC picking a winning PC operating system in 1980" before DOS, Macintosh, and Windows were invented. Claims and counterclaims are also being made about patent rights and whether one protocol or another is an "open standard."

Both standards are developing expanded trials of their systems while they seek to enlist the support of more manufacturers. For example, 50,000 homes were scheduled to have LonWorks devices installed in 1995. Intellon announced plans to participate in joint trials with Tele-Communications Inc. (TCI) and Microsoft using CEBus technology. Costs are also being reduced for implementing this technology in consumer products such as refrigerators, hot water heaters, and air conditioners. Motorola and Toshiba are now quoting prices between $2 and $3 for "Neuron" controller chips, compared to $15 a few years ago.

New Influential Regions in the World

It is important to keep an eye on several developing regions around the world as household disposable income rises, creating a new generation of consumers. About two-thirds of the world's population uses relatively few consumer electronic items, and a huge market awaits patient consumer electronics and appliance companies (and their suppliers).

Expect basic goods such as refrigerators, cookware (rice cookers, among others), personal/portable stereos, and color TVs to be in demand first. Markets such as China, India, Indonesia, Malaysia, Brazil, and Mexico are indicating huge potential. In most cases, these markets are best served by joint venture with local companies.

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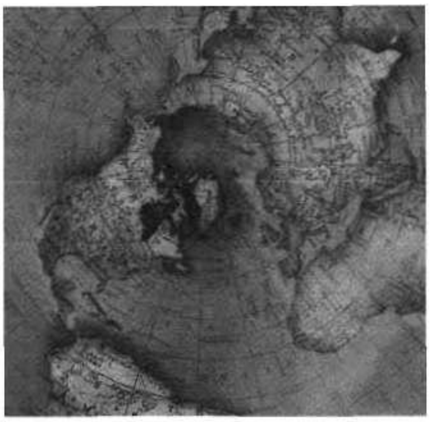

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Competitive Trends: 1995 Consumer Electronics Semiconductor Market

Competitive Trends

Program: Consumer Multimedia Semiconductors and Applications Worldwide
Product Code: MSAM-WW-CT-9601
Publication Date: August 5, 1996
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Chapter 1
Introduction and Definitions

Introduction

This report summarizes Dataquest's first comprehensive study of the semiconductor companies supplying the market for consumer electronics products. Rankings, market share, and revenue data for semiconductor suppliers will be presented in tables covering key areas in the market for consumer electronics semiconductors. Chapter 2 provides revenue data on areas including:

- Total shipments of semiconductors for consumer applications
- Shipments of MOS digital integrated circuits for consumer applications
- Shipments of analog audio and video ICs
- Shipments of discrete components and optoelectronics for consumer applications

Chapter 3 presents company rankings in semiconductors for the emerging video compression market and provides revenue and unit shipment figures for:

- Shipments of all MPEG-1 semiconductors for consumer applications
- Shipments of all MPEG-2 semiconductors for consumer applications
- Shipments of all standalone MPEG semiconductors for consumer applications
- Shipments of all embedded MPEG semiconductors for consumer applications

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Methodology

The information in this report was derived using two methods. The first method used a written company survey conducted in April and May 1996. The second method used estimates made by Dataquest's semiconductor product and regional analysts. A team of worldwide Dataquest analysts reviewed the preliminary results and made some modifications of the information based on their professional judgment and insight. Dataquest believes that the companies and products surveyed and analyzed in this report account for about 90 percent or more of worldwide shipments of semiconductors used in consumer electronics applications.

Segmentation

This section outlines the market segments that are specific to this document. It also provides a list of definitions of the markets and products covered in this document.

Dataquest's objective is to provide data along lines of segmentation that are logical, appropriate to the industry in question, and immediately useful to clients. For market share purposes, Dataquest defines the semiconductor market according to the following functional segmentation scheme:

- Total semiconductors: hybrids, total monolithic ICs, total discretes, and total optical semiconductors
  - Digital bipolar ICs: bipolar digital memory ICs and bipolar digital logic ICs
  - MOS digital ICs: MOS digital memory ICs, MOS digital microcomponent ICs, and MOS digital logic ICs
    - MOS digital MPUs: 8-bit and 16-bit CISC MPUs, 32-bit and greater CISC MPUs, and 32-bit and greater RISC MPUs
    - MOS digital microcontrollers (MCUs): 4-bit MCUs, 8-bit MCUs, and 16-bit and greater MCUs
    - MOS digital microperipherals (MPRs): system core logic chipsets, graphics and imaging controllers, communications controllers, mass storage controllers, and audio/other controllers
    - Programmable digital signal processors (DSPs)
    - MOS digital logic ASICs/ASSPs: traditional digital gate arrays, embedded gate arrays, MOS digital programmable logic devices, MOS digital cell-based ICs, and MOS digital full-custom ICs
    - Other MOS digital logic ICs: standard logic, LCD drivers, and other MOS digital logic ICs
  - Analog ICs: video analog ICs, audio analog ICs, and other analog ICs
    - Video analog ICs
    - Audio analog ICs
    - Other analog ICs
  - Total discrete semiconductors: transistors, diodes, thyristors, and other discretes
  - Total optical semiconductors: total LED lamps/displays, optocouplers, charge-coupled devices (CCDs), laser diodes, photosensors, and other optical semiconductors

Definitions

This report begins with a table describing total semiconductor shipments into consumer products and then continues through the subcategories that compose the whole. The following list provides definitions used for the data presented in this report.

Product Definitions

Total Semiconductor Consumer End Use (Hybrid IC + Total Monolithic Integrated Circuit + Total Discrete + Total Optical Semiconductor): Total semiconductor is defined as any active semiconductor product that contains semiconducting material (such as silicon, germanium, or gallium arsenide, but excluding ceramics) and reacts dynamically to an input signal, either by modifying its shape or adding energy to it. This definition excludes standalone passive components, such as capacitors, resistors, inductors, oscillators, crystals, transformers, and relays.

Consumer electronics end use is defined as all semiconductors used in consumer electronics applications. Consumer electronics applications consist of audio, video, personal electronics, appliances, and other consumer equipment. Audio equipment includes stereos and compact disc players. Video equipment encompasses devices such as VCRs, TVs, and camcorders. The personal electronics category is composed of set-top boxes, electronic games and toys (with cartridges), cameras, and watches and clocks. Appliances include air conditioners, microwave ovens, and refrigerators. Other consumer electronics equipment consists of devices not classified elsewhere, such as garage door openers. Products not counted as consumer electronics equipment include home PCs, printers and fax equipment, corded and cordless telephones, answering machines, and cellular telephones. Dataquest categorizes this equipment in the data processing and communications segments.

Total IC Consumer End Use (Bipolar Digital IC + MOS Digital IC + Analog IC): An IC is defined as a large number of passive and/or active discrete semiconductor circuits integrated into a single package.

Bipolar Digital IC (Bipolar Digital Memory IC + Bipolar Digital Logic IC): A bipolar digital IC is a monolithic semiconductor product in which 100 percent of the die area performs digital functions, and, concurrently, 100 percent of the die area is manufactured using bipolar semiconductor technology. A digital function is one in which data is carried as numerical values, usually in a binary code.

MOS Digital IC (MOS Digital Memory IC + MOS Digital Microcomponent IC + MOS Digital Logic IC): Defined as a monolithic semiconductor product in which 100 percent of the die area performs digital functions and, concurrently, any portion of the die area that is manufactured using metal-oxide semiconductor (MOS) technology. A digital function is one in which data is carried as numerical values, usually in a binary code. This category includes mixed-technology manufacturing, such as BiMOS and BiCMOS, where there is some MOS technology employed.

MOS Memory IC (DRAM + SRAM + EPROM + EEPROM + Flash Memory + Mask ROM + Other MOS Digital Memory): Defined as a MOS IC in which data is stored and electronically retrieved.

MOS Microcomponent IC (MOS Digital Microprocessor + MOS Digital Microcontroller + MOS Digital Microperipheral + Programmable Digital Signal Processor): Defined as a MOS IC that contains a data processing unit or serves as an interface to such a unit.

Microprocessor (8-bit and 16-bit CISC MPU + 32-bit and greater CISC MPU + 32-bit and greater RISC MPU): A microprocessor is an IC that includes an instruction decoder, an arithmetic logic unit (ALU), registers, and additional logic. It may contain an instruction cache and/or data cache. An MPU's functions are determined by fetching and executing instructions and manipulating data held in external memory or an internal cache. The MPU category includes MPUs incorporating or originating from an ASIC design.

Microcontroller (4-bit MCU + 8-bit MCU + 16-bit and greater MCU): Defined as an IC that is similar to an MPU, with the primary exception being that it is designed to operate from on-chip program and data memory (not including cache memories). MCU devices must be available with on-chip program and/or data store. As an option, some MCU devices can be purchased without on-chip memory. The MCU category includes MCUs incorporating, or originating from, an ASIC design.

Digital Signal Processor: A DSP is an IC that includes a high-speed arithmetic unit (typically a multiply-accumulate unit) used for performing complex mathematical operations, such as Fourier transforms. Like an MPU or an MCU, a pDSP is programmable in that it fetches and executes preprogrammed instructions. These instructions are oriented toward signal-processing algorithms. Integrating a pDSP on the same chip as an MPU or MCU does not alter the MPU or MCU categorization of that device.

Microperipheral: Defined as an IC that serves as a logical support function to an MPU in a system. This definition includes MPRs comprising more than one device, such as PC or core logic chipsets. The MPR category includes MPRs incorporating or originating from an ASIC design.

MOS Logic IC (MOS Logic + MOS ASIC/ASSP + Other MOS Logic): Defined as a MOS IC in which more than 50 percent of the die area performs logic functions and excludes MOS microcomponent ICs.

MOS ASIC/ASSP (Traditional Digital Gate Array + Embedded Gate Array + MOS Digital Programmable Logic Device + MOS Digital Cell-Based IC + MOS Digital Full-Custom IC): A MOS ASIC/ASSP is defined as a single-user logic IC (ASIC) or multiple-user logic IC (ASSP) that is manufactured using vendor-supplied tools and/or libraries. This does not include ASICs of ASSPs incorporating microprocessor cells or microcontroller cells, as these should be reported in the microprocessor IC or microcontroller IC category, respectively.

Other MOS Logic IC: Defined as all other MOS logic ICs not accounted for in the preceding categories. This includes MOS commodity family logic with 150 or more gates and MOS general-purpose logic not belonging to any families.

Analog IC (Analog Video IC + Analog Audio IC + Other Analog IC): Defined as a semiconductor product that deals with electrical signal processing, power control, or electrical drive capability. It is one in which some of the inputs or outputs can be defined in terms of continuously or linearly variable voltages, currents, or frequencies. This includes only monolithic analog ICs manufactured using bipolar, MOS, or BiCMOS technologies. A monolithic IC is a single die contained in a single package.

Analog Audio IC: An analog audio IC is an analog IC implemented for audio applications, including radio and speech synthesis and recognition.

Analog Video IC: This is defined as an analog IC implemented for video applications including video encoding and decoding.

Other Analog IC: This is defined as an analog IC used in consumer applications other than processing video or audio.

Total Discrete (Transistor + Diode + Thyristor + Other Discrete): A discrete semiconductor is defined as a single semiconductor component such as a transistor, diode, or thyristor. Although multiple devices may be present in a package, they are still considered discretes if they have no internal functional interconnection and are applied in the same manner as other discrete devices.

Total Optoelectronics (Total LED Lamp/Display + Optocoupler + Charge-Coupled Device + Laser Diode + Photosensor + Other Optical Semiconductor): Defined as a semiconductor product in which photons induce the flow of electrons or vice versa. Other functions may also be integrated onto the product. This category does not include LCD, incandescent displays, fluorescent displays, cathode ray tubes (CRTs), or plasma displays.

MPEG IC: This is an IC implemented for the purpose of encoding and/or decoding data conforming with the MPEG-1 or MPEG-2 specifications for digital video and audio compression.

MPEG-1 IC: This is an IC implemented for the purpose of encoding and/or decoding data conforming with the MPEG-1 specification for digital video and audio compression.

MPEG-2 IC: This is an IC implemented for the purpose of encoding and/or decoding data conforming with the MPEG-2 specification for digital video and audio compression.

Standalone MPEG IC: This is an IC exclusively dedicated to performing MPEG encoding or decoding.

Embedded MPEG IC: This is an ASIC or ASSP that implements MPEG encoding or decoding as part of a larger audio or video processing function.

Chapter 2

1995 Consumer Semiconductor Market Share

The consumer market represents a vast opportunity for manufacturers of many different types of semiconductors. As shown in Table 2-1, revenue from sales of semiconductors into the consumer market totaled more than $24 billion in 1995.

Reflecting the fact that the Asian market is the world's biggest region for consumer electronics equipment production, Japan-based and Asia/Pacific-based companies dominate the top ranks of semiconductor suppliers into that area. Four of the top five suppliers and eight of the top 10 suppliers of semiconductors for consumer electronics applications are Japanese companies. Table 2-1 and Figure 2-1 present the top 10 vendors of semiconductors for use in consumer electronics.

Table 2-1
Top 10 Vendors of Semiconductors for Use in Consumer Electronics, Worldwide Revenue (Millions of U.S. Dollars)

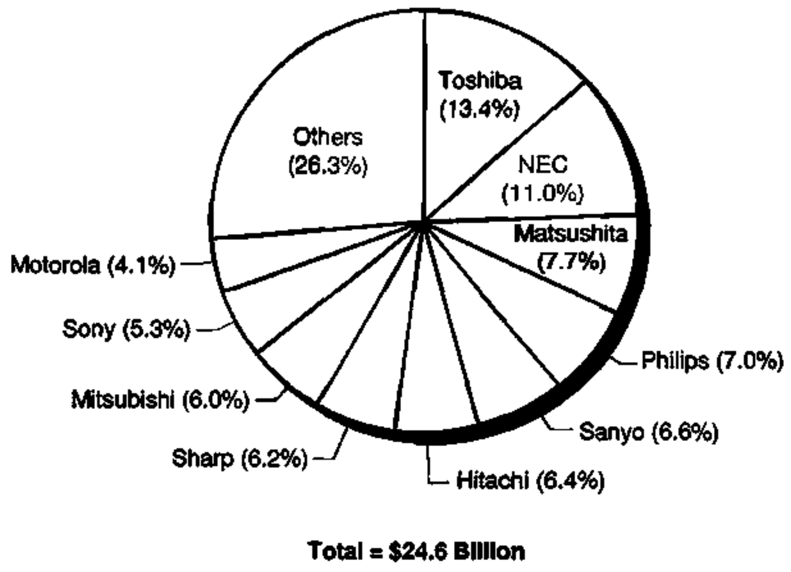
1995 Rank	Company	1995 Revenue	1995 Market Share (%)
1	Toshiba	3,286	13.4
2	NEC	2,710	11.0
3	Matsushita	1,905	7.7
4	Philips	1,724	7.0
5	Sanyo	1,613	6.6
6	Hitachi	1,587	6.4
7	Sharp	1,529	6.2
8	Mitsubishi	1,479	6.0
9	Sony	1,309	5.3
10	Motorola	1,019	4.1
	All Others	6,452	26.2
	Total Market	24,613	100.0

Source: Dataquest (July 1996)

The following describes the top 10 companies in the consumer electronics semiconductor market. The companies listed are leaders in the segments constituting the consumer semiconductor market. It is noteworthy that these companies account for almost 75 percent of all semiconductor revenue in the area of consumer electronics. Although it is not one of the top 10 consumer semiconductor suppliers, Texas Instruments is the leading seller of DSPs for consumer applications. Tables 2-2 through 2-18 present the top semiconductor vendors for various categories of semiconductors used in consumer electronics.

- Toshiba was the leading vendor of semiconductors for consumer equipment in 1995. It offers a substantial line of ICs targeted at the consumer market and has a long history of marketing efforts directed at consumer electronics. Toshiba continues to pursue aggressive sales promotion activities in this area.

Figure 2-1
Top 10 Vendors of Semiconductors for Use in Consumer Electronics



Source: Dataquest (July 1996)

- Although NEC garnered more revenue from its overall semiconductor business than Toshiba in 1995, it takes second place to Toshiba in the consumer electronics market. NEC possesses major strengths in designing and manufacturing digital ICs and memory. A particular strength for NEC is in digital logic ICs for consumer electronics equipment.
- Although Matsushita was not ranked as one of the top 10 overall semiconductor manufacturers in 1995, the company held the No. 3 position in the consumer chip market, reflecting its strength in this area. Matsushita's consumer product groups, which include Panasonic, National, and Technics, offer a range of consumer electronics products, including audio and video equipment. Matsushita operates as both a captive manufacturer, supplying parts to its own consumer line, and as a merchant market seller. Strong product areas for Matsushita include MCUs, analog ICs, and optoelectronics, such as charge-coupled devices for consumer equipment.
- Netherlands-based Philips is the world's fourth-largest vendor of semiconductors for consumer electronics products and is the only non-Japanese company among the top five players in that market. In addition to competing in the merchant market, Philips supplies semiconductors to its parent company, which is one of the world's top sellers of consumer equipment. Philips is strongest in consumer analog semiconductors, where it leads in video and holds a strong position in audio analog ICs. It is also one of the top suppliers of MOS logic ICs and discrete components.

- The world's fifth-largest vendor of consumer semiconductors is Sanyo, a company that is very strong in the Asia/Pacific and Japanese semiconductor markets. The company focused its consumer semiconductor efforts on Asia before the other Japanese manufacturers did. Sanyo is particularly good at selling semiconductors to niche markets. The company shines in the market for consumer MOS logic and in analog audio and video ICs.
- Hitachi achieved the sixth position in consumer semiconductor sales in 1995 primarily because of strong sales of its SH-2 microprocessor and SH-1 microcontroller. Although the SH-2 can be used in a variety of consumer products, the microprocessor owes its success largely to the Sega Saturn home video game console, which was extremely popular in 1995. Each Saturn includes two Hitachi SH-2 microprocessors and one SH-1 microcontroller.
- Sharp, the seventh-largest manufacturer of semiconductors for the consumer market, is strong in the MOS memory market. The company is the leading supplier of mask ROM, which is used extensively in cartridges for home video game consoles. Another area where Sharp leads in is optoelectronics, where it holds the No. 1 position in the consumer electronics market. Sharp also maintains a large business selling MOS ASICs and other types of MOS logic.
- Mitsubishi, which is the No. 8 supplier of consumer semiconductors, is part of one of the world's largest manufacturing companies and a major supplier of consumer products ranging from big-screen televisions to air conditioners. The company is particularly strong in sales of microcontrollers for consumer products.
- Sony is the ninth-largest producer of semiconductors in the consumer electronics market. In addition to selling semiconductors, Sony is one of the world's leading manufacturers of consumer electronics equipment. Sony is a leader in nearly every segment of the consumer audio market, as well as being a major player in video and other products. In semiconductors, Sony is strong in optoelectronics and analog audio, reflecting its leadership in compact disc players and stereo equipment. Sony also is a major supplier of analog video ICs.
- Ranked at No. 10, Motorola is the only North American supplier among the top 10 consumer semiconductor sellers. Motorola is the leading supplier of microprocessors for consumer applications and maintains a strong position in sales of microcontrollers, particularly 8-bit devices to that market.
- Texas Instruments is the top seller of DSPs for consumer applications. The world's No. 1 producer of DSPs, TI has a broad line of devices for applications ranging from wireless communications to hard disk drives. In the consumer market, TI produces DSPs for products such as sophisticated stereos, compact disc players, and set-top boxes.

Table 2-2
Top 10 Vendors of All ICs for Use in Consumer Electronics, Worldwide Revenue (Millions of U.S. Dollars)

1995 Rank	Company	1995 Revenue	1995 Market Share (%)
1	Toshiba	2,618	13.5
2	NEC	2,246	11.6
3	Hitachi	1,395	7.2
4	Sharp	1,267	6.5
5	Philips	1,250	6.5
6	Matsushita	1,202	6.2
7	Sanyo	1,196	6.2
8	Mitsubishi	1,130	5.8
9	Sony	984	5.1
10	Motorola	825	4.3
	All Others	5,262	27.2
	Total Market	19,375	100.0

Source: Dataquest (July 1996)

Table 2-3
Top Five Vendors of Bipolar Digital ICs for Use in Consumer Electronics, Worldwide Revenue (Millions of U.S. Dollars)

1995 Rank	Company	1995 Revenue	1995 Market Share (%)
1	Hitachi	68	30.0
2	Motorola	37	16.3
3	Toshiba	32	14.1
4	NEC	24	10.6
5	Texas Instruments	13	5.7
	All Others	53	23.3
	Total Market	227	100.0

Source: Dataquest (July 1996)

Table 2-4
Top 10 Vendors of MOS Digital ICs for Use in Consumer Electronics, Worldwide Revenue (Millions of U.S. Dollars)

1995 Rank	Company	1995 Revenue	1995 Market Share (%)
1	Toshiba	2,017	14.8
2	NEC	1,875	13.7
3	Sharp	1,011	7.4
4	Hitachi	961	7.0
5	Mitsubishi	819	6.0
6	Matsushita	742	5.4
7	Motorola	653	4.8
8	Samsung	645	4.7
9	Sanyo	451	3.3
10	Hyundai	414	3.0
	All Others	4,054	29.7
	Total Market	13,642	100.0

Source: Dataquest (July 1996)

Table 2-5
Top 10 Vendors of MOS Memory for Use in Consumer Electronics, Worldwide Revenue (Millions of U.S. Dollars)

1995 Rank	Company	1995 Revenue	1995 Market Share (%)
1	Toshiba	611	14.3
2	Samsung	601	14.0
3	Sharp	468	10.9
4	NEC	431	10.1
5	Hyundai	412	9.6
6	Hitachi	268	6.3
7	LG Semicon	264	6.2
8	Siemens	164	3.8
9	Texas Instruments	153	3.6
10	United Microelectronics	148	3.5
	All Others	767	17.9
	Total Market	4,287	100.0

Source: Dataquest (July 1996)

Table 2-6
Top 10 Vendors of MOS Microcomponents for Use in Consumer Electronics, Worldwide Revenue (Millions of U.S. Dollars)

1995 Rank	Company	1995 Revenue	1995 Market Share (%)
1	NEC	921	19.5
2	Toshiba	808	17.1
3	Mitsubishi	564	11.9
4	Hitachi	482	10.2
5	Motorola	360	7.6
6	Matsushita	293	6.2
7	Sharp	172	3.6
8	Sanyo	151	3.2
9	Sony	139	2.9
10	Texas Instruments	126	2.7
	All Others	716	15.1
	Total Market	4,732	100.0

Source: Dataquest (July 1996)

Table 2-7
Top Five Vendors of Microprocessors for Use in Consumer Electronics, Worldwide Revenue (Millions of U.S. Dollars)

1995 Rank	Company	1995 Revenue	1995 Market Share (%)
1	Motorola	54	20.8
2	NEC	38	14.7
3	Toshiba	32	12.4
4	Intel	29	11.2
5	Hitachi	20	7.7
	All Others	86	33.2
	Total Market	259	100.0

Source: Dataquest (July 1996)

Table 2-8
Top 10 Vendors of Microcontrollers for Use in Consumer Electronics, Worldwide Revenue (Millions of U.S. Dollars)

1995 Rank	Company	1995 Revenue	1995 Market Share (%)
1	NEC	799	20.6
2	Toshiba	655	16.9
3	Mitsubishi	548	14.2
4	Hitachi	409	10.6
5	Matsushita	285	7.4
6	Motorola	232	6.0
7	Sharp	157	4.1
8	Sanyo	142	3.7
9	Sony	128	3.3
10	Oki	85	2.2
	All Others	432	11.2
	Total Market	3,872	100.0

Source: Dataquest (July 1996)

Table 2-9
Top Six Vendors of Microperipherals for Use in Consumer Electronics, Worldwide Revenue (Millions of U.S. Dollars)

1995 Rank	Company	1995 Revenue	1995 Market Share (%)
1	Toshiba	114	24.6
2	NEC	74	15.9
3	Motorola	55	11.9
4	United Microelectronics	40	8.6
5	Hitachi	39	8.4
6	Texas Instruments	32	6.9
	All Others	110	23.7
	Total Market	464	100.0

Source: Dataquest (July 1996)

Table 2-10
Top Six Vendors of Digital Signal Processors for Use in Consumer Electronics, Worldwide Revenue (Millions of U.S. Dollars)

1995 Rank	Company	1995 Revenue	1995 Market Share (%)
1	Texas Instruments	52	38.0
2	Motorola	19	13.9
3	Hitachi	14	10.2
4	Zilog	12	8.8
5	NEC	10	7.3
6	Sanyo	9	6.6
	All Others	21	15.2
	Total Market	137	100.0

Source: Dataquest (July 1996)

Table 2-11
Top 10 Vendors of MOS Logic for Use in Consumer Electronics, Worldwide Revenue (Millions of U.S. Dollars)

1995 Rank	Company	1995 Revenue	1995 Market Share (%)
1	Toshiba	598	12.9
2	NEC	523	11.3
3	Matsushita	384	8.3
4	Sharp	371	8.0
5	Sanyo	288	6.2
6	LSI Logic	279	6.0
7	Philips	275	5.9
8	Yamaha	249	5.4
9	Sony	217	4.7
10	Hitachi	211	4.6
	All Others	1,228	26.6
	Total Market	4,623	100.0

Source: Dataquest (July 1996)

Table 2-12
Top 10 Vendors of MOS ASICs/ASSPs for Use in Consumer Electronics, Worldwide Revenue (Millions of U.S. Dollars)

1995 Rank	Company	1995 Revenue	1995 Market Share (%)
1	Toshiba	409	13.2
2	NEC	399	12.8
3	Matsushita	369	11.9
4	LSI Logic	279	9.0
5	Sharp	200	6.4
6	Yamaha	180	5.8
7	Motorola	154	5.0
8	SGS-Thomson	124	4.0
9	Hitachi	98	3.2
10	Fujitsu	95	3.1
	All Others	803	25.8
	Total Market	3,110	100.0

Source: Dataquest (July 1996)

Table 2-13
Top 10 Vendors of Analog ICs for Use in Consumer Electronics, Worldwide Revenue (Millions of U.S. Dollars)

1995 Rank	Company	1995 Revenue	1995 Market Share (%)
1	Philips	900	16.3
2	Sanyo	745	13.5
3	Sony	577	10.5
4	Toshiba	569	10.3
5	Matsushita	449	8.2
6	Hitachi	366	6.6
7	NEC	347	6.3
8	Mitsubishi	302	5.5
9	Sharp	256	4.6
10	Texas Instruments	165	3.0
	All Others	830	15.1
	Total Market	5,506	100.0

Source: Dataquest (July 1996)

Table 2-14
Top 10 Vendors of Analog Audio ICs for Use in Consumer Electronics, Worldwide Revenue (Millions of U.S. Dollars)

1995 Rank	Company	1995 Revenue	1995 Market Share (%)
1	Sanyo	324	18.1
2	Sony	231	12.9
3	Toshiba	199	11.1
4	Matsushita	191	10.7
5	Hitachi	155	8.7
6	Mitsubishi	115	6.4
7	Philips	101	5.6
8	Sharp	100	5.6
9	NEC	74	4.1
10	Texas Instruments	62	3.5
	All Others	236	13.2
	Total Market	1,788	100.0

Source: Dataquest (July 1996)

Table 2-15
Top 10 Vendors of Analog Video ICs for Use in Consumer Electronics, Worldwide Revenue (Millions of U.S. Dollars)

1995 Rank	Company	1995 Revenue	1995 Market Share (%)
1	Sanyo	309	16.0
2	Philips	300	15.6
3	Sony	244	12.7
4	Toshiba	228	11.8
5	Matsushita	170	8.8
6	NEC	99	5.1
7	Hitachi	98	5.1
8	Samsung	76	3.9
9	Mitsubishi	72	3.7
10	Sharp	71	3.7
	All Others	259	13.4
	Total Market	1,926	100.0

Source: Dataquest (July 1996)

Table 2-16
Top 10 Vendors of Other Analog ICs for Use in Consumer Electronics, Worldwide Revenue (Millions of U.S. Dollars)

1995 Rank	Company	1995 Revenue	1995 Market Share (%)
1	Philips	499	27.8
2	NEC	174	9.7
3	Toshiba	142	7.9
4	Mitsubishi	115	6.4
5	Hitachi	113	6.3
6	Sanyo	112	6.3
7	Sony	102	5.7
8	Matsushita	88	4.9
9	Sharp	85	4.7
10	Siemens	77	4.3
	All Others	285	15.9
	Total Market	1,792	100.0

Source: Dataquest (July 1996)

Table 2-17
Top 10 Vendors of Discrete Components for Use in Consumer Electronics, Worldwide Revenue (Millions of U.S. Dollars)

1995 Rank	Company	1995 Revenue	1995 Market Share (%)
1	Matsushita	485	13.0
2	Toshiba	479	12.9
3	Philips	474	12.7
4	NEC	384	10.3
5	Sanyo	315	8.5
6	Mitsubishi	272	7.3
7	Motorola	188	5.0
8	Hitachi	162	4.4
9	Samsung	111	3.0
10	Sony	75	2.0
	All Others	778	20.9
	Total Market	3,723	100.0

Source: Dataquest (July 1996)

Table 2-18
Top 10 Vendors of Optoelectronics for Use in Consumer Electronics, Worldwide Revenue (Millions of U.S. Dollars)

1995 Rank	Company	1995 Revenue	1995 Market Share (%)
1	Sharp	262	17.3
2	Sony	250	16.5
3	Matsushita	218	14.4
4	Toshiba	189	12.5
5	Sanyo	102	6.7
6	NEC	80	5.3
7	Mitsubishi	77	5.1
8	Hewlett-Packard	61	4.0
9	TEMIC	39	2.6
10	Siemens	37	2.4
	All Others	200	13.2
	Total Market	1,515	100.0

Source: Dataquest (July 1996)

Chapter 3

MPEG ICs

This chapter presents rankings for companies selling chips that can perform decompression of MPEG digital video and audio. During 1995, video and audio MPEG functions typically were performed by separate chips. During 1996, both audio and video decompression were being integrated into a single chip. The market shares in this report do not separate the audio and video functions. Table 3-1 and Figure 3-1 present the top sellers of both audio and video MPEG decoding chips.

SGS-Thomson is the world's leading vendor of MPEG decompression chips, a position it achieved based on its strong business selling decoders for digital Direct Broadcast Satellite (DBS) systems. It scored an early design-win for its MPEG-2 decoding chips when Thomson Multimedia began producing set-top boxes for Hughes Electronics' wildly successful DirecTV DBS television system.

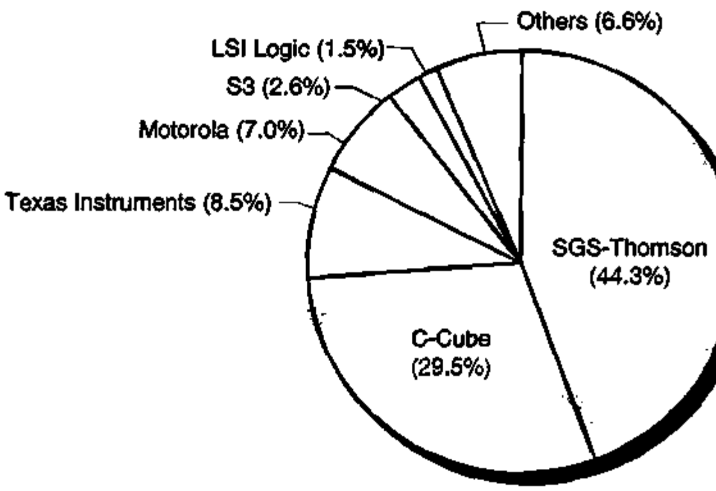
C-Cube, a company that is dedicated to digital video compression technology, dominates the market for MPEG-1 decoders. The company has found strong demand for its MPEG-1 decoders in Japan and Asia/Pacific, where they are used in VideoCD video playback systems. Although revenue for its MPEG-2 encoder chips is not counted in this ranking, C-Cube is leveraging its strengths in this area into future MPEG-2 decoder products. Tables 3-2 and 3-3 list the market shares for vendors of MPEG-1 and MPEG-2 chips. Tables 3-4 and 3-5 present the market shares for MPEG chip vendors segmented by standalone MPEG decoders and embedded MPEG decoders.

Table 3-1
Top Six Vendors of MPEG Decoder ICs for Use in Consumer Electronics, Worldwide Revenue and Shipments

1995 Rank	Company	1995 Revenue ($M)	1995 Shipments (K Units)	1995 Market Share (%)
1	SGS-Thomson	120	4,200	44.3
2	C-Cube	80	2,600	29.5
3	Texas Instruments	23	955	8.5
4	Motorola	19	600	7.0
5	S3	7	350	2.6
6	LSI Logic	4	182	1.5
	All Others	18	730	6.6
	Total Market	271	9,617	100.0

Source: Dataquest (July 1996)

Figure 3-1
Top Six Vendors of MPEG ICs for Use in Consumer Electronics, Worldwide Revenue



Source: Dataquest (July 1996)

Table 3-2
Top Five Vendors of MPEG-1 Decoder ICs for Use in Consumer Electronics, Worldwide Revenue and Shipments

1995 Rank	Company	1995 Revenue ($M)	1995 Shipments (K Units)	1995 Market Share (%)
1	C-Cube	74	2,400	48.7
2	SGS-Thomson	35	1,400	23.0
3	Motorola	19	600	12.5
4	Texas Instruments	10	500	6.6
5	S3	7	350	4.6
	All Others	7	280	4.6
	Total Market	152	5,530	100.0

Source: Dataquest (July 1996)

Table 3-3
Top Five Vendors of MPEG-2 Decoder ICs for Use in Consumer Electronics, Worldwide Revenue and Shipments

1995 Rank	Company	1995 Revenue ($M)	1995 Shipments (K Units)	1995 Market Share (%)
1	SGS-Thomson	85	2,800	71.4
2	Texas Instruments	13	455	10.9
3	C-Cube	6	200	5.0
4	LSI Logic	4	182	3.4
5	Oak Technology	2	100	1.7
	All Others	9	350	7.6
	Total Market	119	4,087	100.0

Source: Dataquest (July 1996)

Table 3-4
Top Five Vendors of Standalone MPEG Decoder ICs for Use in Consumer Electronics, Worldwide Revenue and Shipments

1995 Rank	Company	1995 Revenue ($M)	1995 Shipments (K Units)	1995 Market Share (%)
1	SGS-Thomson	103	3,360	66.5
2	Motorola	19	600	12.3
3	Texas Instruments	13	669	8.4
4	S3	7	350	4.5
5	Oak Technology	2	100	1.3
	All Others	11	385	7.1
	Total Market	155	5,464	100.0

Source: Dataquest (July 1996)

Table 3-5
Top Four Vendors of ICs with Embedded MPEG Decoder Functions for Use in Consumer Electronics, Worldwide Revenue and Shipments

1995 Rank	Company	1995 Revenue ($M)	1995 Shipments (K Units)	1995 Market Share (%)
1	C-Cube	80	2,600	69.0
2	SGS-Thomson	17	840	14.7
3	Texas Instruments	10	286	8.6
4	LSI Logic	4	182	3.4
	All Others	5	245	4.3
	Total Market	116	4,153	100.0

Source: Dataquest (July 1996)

Chapter 4
Market Participation

Table 4-1 is a matrix illustrating which companies are involved in the various product segments constituting the consumer electronics semiconductor market. Each x signifies that a company garnered revenue from a particular product type in 1995.

Table 4-2 is a matrix illustrating which companies offer various types of MPEG semiconductors. Each x signifies that a company garnered revenue from a particular product type in 1995.

Table 4-1
Matrix of Company Participation in Various Consumer Electronics Semiconductor Product Segments

	Bipolar Digital	MOS Memory	Micro-processors	Micro-controllers	Micro-peripherals	Digital Signal Processors	MOS ASICs/ ASSPs	Analog Audio ICs	Analog Video ICs	Other Analog ICs	Discrete Components	Opto-electronics
Americas Companies												
Advanced Micro Devices	X	X	X	X	X	X	X					
Analog Devices						X		X	X	X		
AT&T							X	X	X	X		
Brooktree								X	X	X		
C-Cube							X					
Dallas Semiconductor		X		X								
General Instrument											X	
Hewlett-Packard	X	X	X	X	X	X	X	X	X	X	X	X
IBM	X	X	X	X	X	X	X					
Intel	X	X	X	X	X	X						
Linear Technology								X	X			
LSI Logic							X					
Microchip Technology		X		X	X							
Motorola	X	X	X	X	X	X	X	X	X	X	X	X
Symbios							X					
National Semiconductor		X	X	X	X	X	X	X	X	X	X	
Oak Technology					X							
S3							X					
Texas Instruments	X	X	X	X	X	X	X	X	X	X	X	X
VLSI Technology	X	X	X	X	X	X	X	X	X	X	X	X
Zilog			X	X	X	X						
Japanese Companies												
Fujitsu	X	X	X	X	X	X	X	X	X	X	X	X
Hitachi	X	X	X	X	X	X	X	X	X	X	X	X
Matsushita	X	X	X	X	X	X	X	X	X	X	X	X
Mitsubishi	X	X	X	X	X	X	X	X	X	X	X	X
NEC	X	X	X	X	X	X	X	X	X	X	X	X
Oki	X	X	X	X	X	X	X	X	X	X	X	X

(Continued)

Table 4-1 (Continued)
Matrix of Company Participation in Various Consumer Electronics Semiconductor Product Segments

	Bipolar Digital	MOS Memory	Micro-processors	Micro-controllers	Micro-peripherals	Digital Signal Processors	MOS ASICs/ ASSPs	Analog Audio ICs	Analog Video ICs	Other Analog ICs	Discrete Components	Opto-electronics
Ricoh							X					
Sanyo	X	X	X	X	X	X	X	X	X	X	X	X
Seiko Epson	X	X	X	X	X	X	X	X	X	X	X	X
Sharp	X	X	X	X	X	X	X	X	X	X	X	X
Sony	X	X	X	X	X	X	X	X	X	X	X	X
Toshiba	X	X	X	X	X	X	X	X	X	X	X	X
Yamaha	X	X	X	X	X	X	X	X	X	X	X	X
European Companies												
GEC Plessey	X					X	X		X			X
Philips				X			X	X	X	X	X	
SGS-Thomson	X	X	X	X	X	X	X	X	X	X	X	
Siemens	X	X	X	X	X	X	X	X	X	X	X	X
TEMIC				X			X		X			X
Asia/Pacific Companies												
Daewoo	X	X	X	X	X	X	X	X	X	X	X	X
Hyundai	X	X	X	X	X	X	X	X	X	X	X	X
LG Semicon	X	X	X	X	X	X	X	X	X	X	X	X
Samsung	X	X	X	X	X	X	X	X	X	X	X	X
United Microelectronics	X	X	X	X	X							

Source: Dataquest (July 1996)

Table 4-2
Matrix of Company Participation in Various MPEG Product Segments

	MPEG-1 ICs	MPEG-2 ICs	Standalone MPEG ICs	ICs with Embedded MPEG Functions
C-Cube	X	X		X
IBM	X	X	X	
LSI Logic		X		X
Motorola	X		X	
Oak Technology		X	X	
S3	X		X	
Texas Instruments	X	X	X	X
VLSI Technology	X	X	X	X
Fujitsu		X	X	
Hitachi	X		X	
Sony	X	X	X	X
Philips	X	X	X	X
SGS-Thomson	X	X	X	X
Hyundai		X	X	

Source: Dataquest (July 1996)

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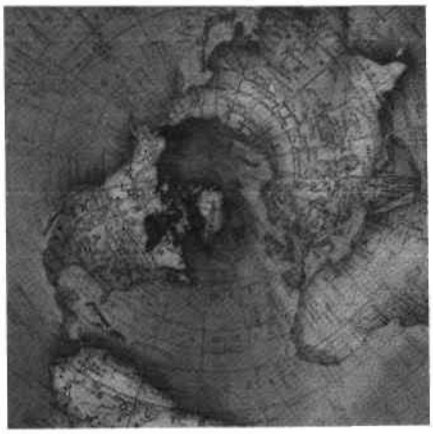

Dataquest

DVD: The Hot New Digital Video Destination for Semiconductors

Focus Report

Program: Consumer Multimedia Semiconductors and Applications Worldwide
Product Code: MSAM-WW-FR-9602
Publication Date: July 8, 1996
Filing: Reports

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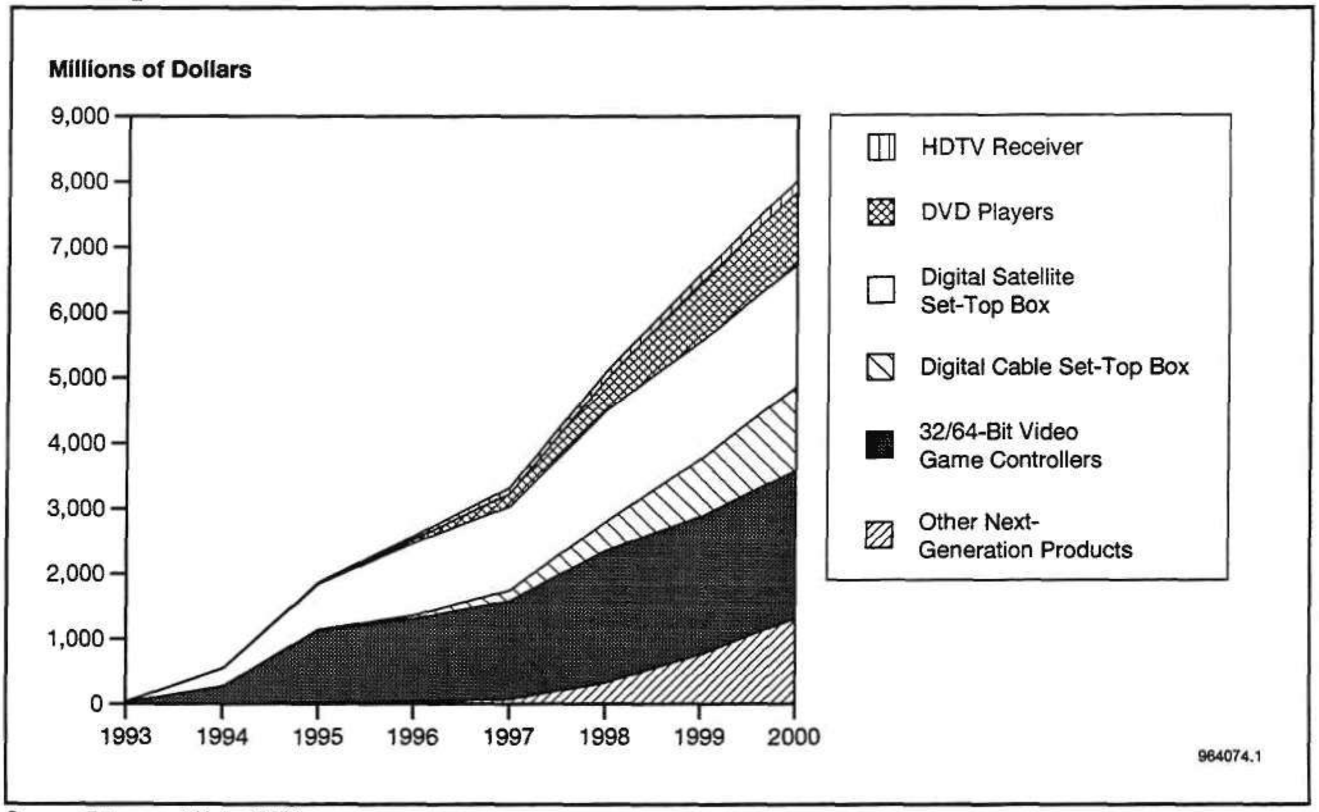
Chapter 1
The DVD Opportunity

Introduction

Digital technologies and advanced semiconductors are reshaping the consumer electronics world. The introduction of exciting new products such as DVD-Video players and direct broadcast satellite (DBS) set-top boxes creates new destinations for chips such as microprocessors (MPUs), digital signal processors (DSPs), application-specific ICs (ASICs), application-specific standard products (ASSPs), and memory. Although these markets are still in their infancy, they are forecast to experience rapid growth, as shown in Figure 1-1. This report will explore the key issues that semiconductor manufacturers should be aware of as they prepare to compete in the dynamic DVD arena.

This report is one in a series of reports that will be published in the Consumer Multimedia Semiconductor Application Markets (MSAM) progam providing detailed analysis and forecasts of the emerging digital consumer electronics markets. The next report in this series will cover digital set-top boxes. Dataquest is also engaged in active research on leading-edge electronic equipment through its Teardown Analysis program. Dataquest plans to publish a detailed teardown analysis of a selected DVD player after the players reach the market.

Figure 1-1
The Chip Market for Next-Generation Consumer Electronics



Source: Dataquest (July 1996)

Forecast Summary: High Growth

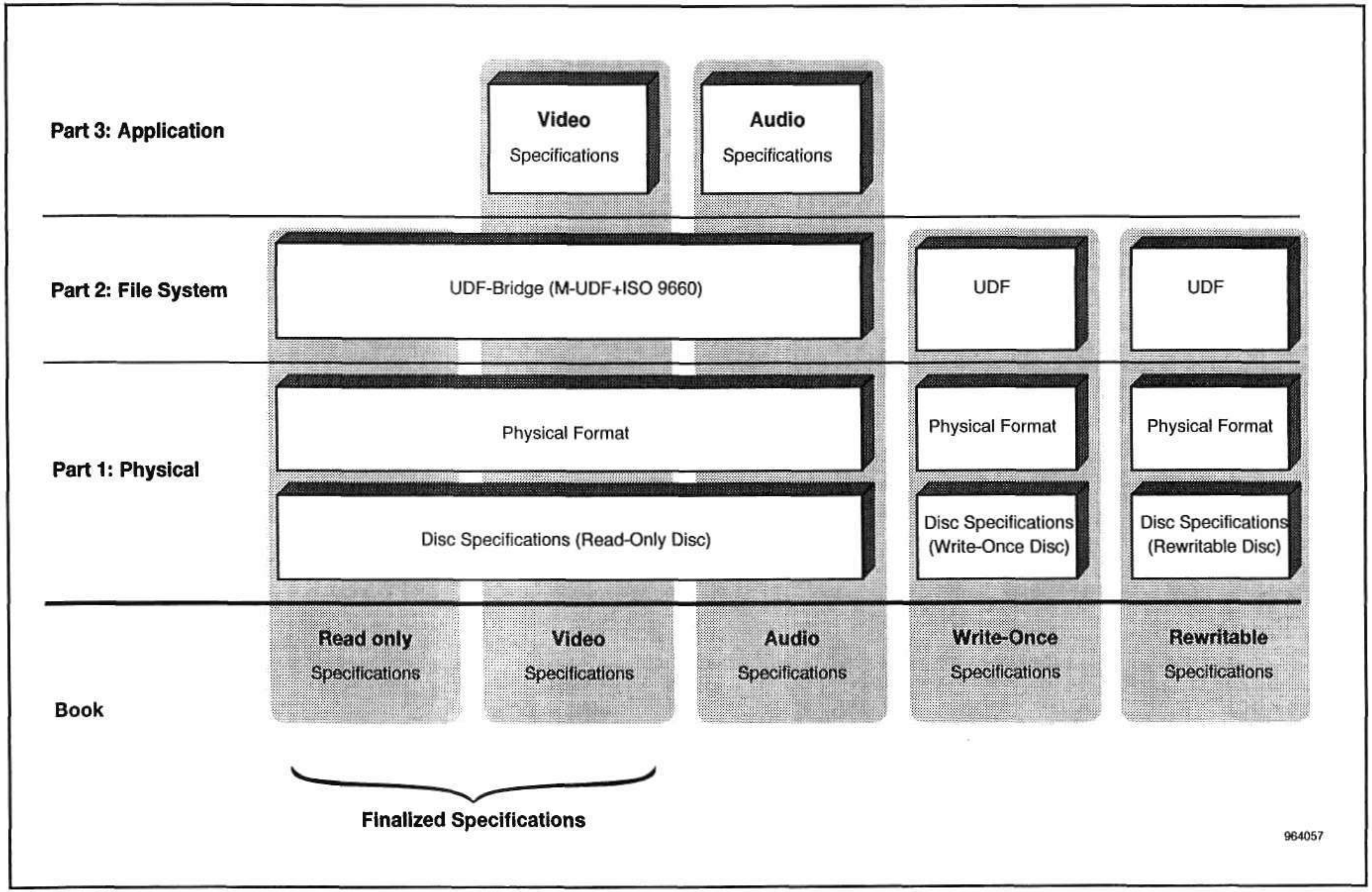
Standing on the shoulders of major technological advances in areas such as video and audio compression, laser diode physics, and optical storage technology, DVD is poised to boost both the consumer electronics and personal computer markets to new heights. The exciting capabilities promised by DVD have captured the imagination and investment budgets of companies from at least seven major industries. The major players in the development of DVD continue to struggle with balancing the cooperative and competitive forces that have swirled around this promising product for over two years. While all of the players recognize that a coordinated, cooperative effort is essential for the creation of a successful market, their zeal to capitalize on one of the most exciting products of the 1990s has brought DVD to the brink of digital video disaster on a number of occasions.

Dataquest is optimistic that the remaining hurdles on the path to the successful launch and growth of the DVD market will be overcome. Although it does not match the hyped expectations of some DVD proponents, Dataquest's forecast for the growth of the DVD market would make this one of the most successful products ever introduced in the consumer electronics and PC markets. After assessing the many factors that will influence the success of the DVD market, Dataquest projects that market shipments of DVD-Video players and DVD optical drives will top 33 million by the year 2000. More than 2.3 million DVD systems are expected to ship between the first product introductions in August and September 1996 and the end of 1997. The semiconductor opportunity generated by the DVD market is forecast to exceed $3.6 billion by the year 2000. This report will outline the market opportunity presented by DVD and review some of the major hurdles that remain on the path to market. Detailed information and forecasts on DVD production, the DVD semiconductor market, and chip companies expected to enter the market will be provided. Information on some of the early semiconductor product announcements will also be presented.

DVD: What Is It? Where Is It Going? Who Will Take It There?

Perhaps the easiest way to think of DVD is as a CD drive on steroids. With higher storage capacity, faster data transfer rates, interactive capabilities, and applications across computer, video, and audio markets, DVD has moved the capabilities of optical storage forward by an order of magnitude, and DVD supporters are already beginning to "feel the burn." In its incarnation as a video player, it offers the ability to view full-length movies in multiple aspect ratios, languages, and Motion Picture Association of America(MPAA) ratings (R, PG-13, PG, G), all stored on a single CD-ROM-size disc. As a PC peripheral, DVD offers new levels of interactivity for next-generation software titles and the storage capacity to handle more content than developers currently know what to do with. In reality, DVD is actually five separate standards, as shown in Figure 1-2. The physical specifications and file system for the first three standards are the same so that a common platform can be created for multiple applications in the video, audio, computer, and next-generation consumer electronics markets.

Figure 1-2
The Five DVD Standards



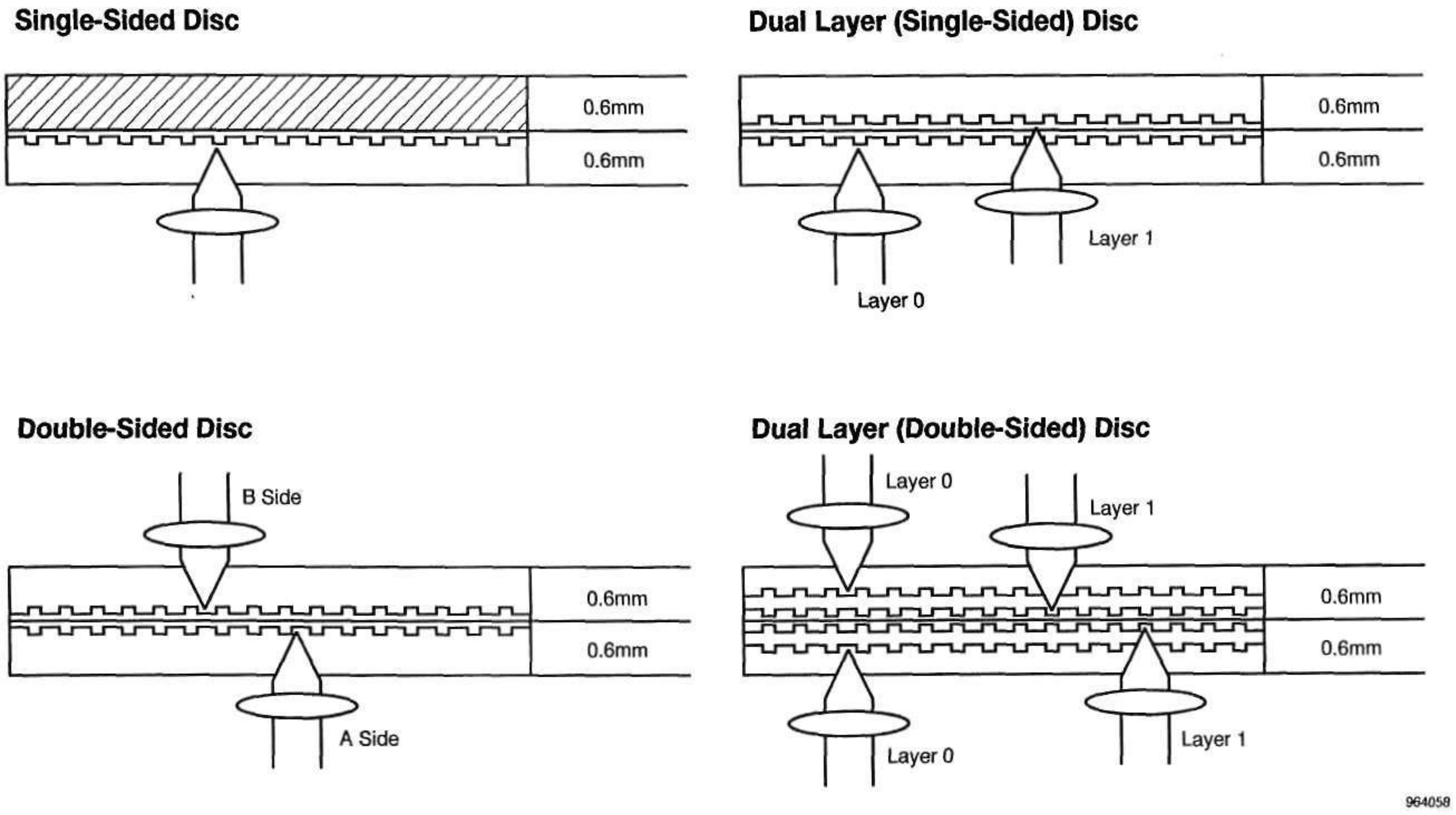
Source: Toshiba

Books A, B, and C in the standard are "read-only memory standards" (ROM), while Book D will specify a "write once, read many" (WORM) standard, and Book E will offer the ability to read, write, and erase. Because of its ability to read and write, it is often called DVD-RAM, referring to a random access memory capability. Book A, also known as DVD-ROM, and Book B, called, DVD-Video or DVD-Movie, are close to final and should enable the launch of products based on these standards at the end of 1996. Manufacturers would say that the standards are final. They are close, but there are some details that remain to be decided that will be described later in this report. The DVD-Audio standard, or Book C, is in the early stages of discussion, and some preliminary proposals have been presented for this standard. Although hardware manufacturers are eager to move to market as quickly as possible, the music industry is intent on protecting its interests and has signaled its intention to set a slower pace of development. The DVD-WORM and DVD-RAM standards will be established over the coming one to two years. In the meantime, the promoters of DVD have their hands full trying to bring the first DVD products to market.

Figure 1-3 presents a basic structure of the four different types of DVD discs that can be produced. The single-sided disc offers 4.7GB of storage capacity and will allow the storage of a 130-minute movie. The initial DVD discs will be 12cm in diameter, the same size as a CD-ROM disc. An 8cm disc has also been defined but delivery of content in this format has taken a back seat to the 12cm disc. The dual-layer, double-sided, and dual-layer/ double-sided discs offer increased levels of storage, as shown in Table 1-1. This table shows the major differences between CD and DVD technology. Table 1-2 presents a comparison between DVD and Video CD technology, which has been very popular in Japan and Asia/Pacific. Almost 2 million Video CD players were shipped in 1995, and Sony plans to ship 4 million portable players in 1996.

The title of "convergence product" has been bestowed upon DVD because of the common platform it will create for multiple applications across computer and consumer devices. Some of the major products in which DVD will find application are illustrated in Figure 1-4. While obvious uses are found in TV, PC, and high-end audio systems, the set-top box, network computer, and video game console will also be impacted by DVD. Manufacturers of set-top boxes already have plans to leverage the common MPEG-2 chipset into a hybrid device that may provide the ability to record content sent over satellite or cable in the future. When the Bandai Pippen was introduced at the E3 1996 show, the manufacturer was already talking about the eventual replacement of the CD-ROM drive with a DVD drive in the next version. Even video game consoles will upgrade to DVD eventually. The incorporation of DVD in this platform will be delayed for a few years because of the unique business model employed by video game companies. They are just beginning to create an installed base of new 32-bit and 64-bit game consoles, and they will need to derive software profits from this base before they move to upgrade it again. Figure 1-5 presents a time line of when Dataquest expects hardware and software DVD products to reach the market.

Figure 1-3
DVD Disc Types and Structures



Source: Toshiba

Table 1-1
A Comparison of DVD and CD Disc Specifications

	CD	DVD
Disc Diameter	120mm	120mm
Disc Thickness	1.2mm	1.2mm
Laser Wavelength	780nm (infrared)	650 and 635nm (red)
Numerical Aperture	0.45	0.60
Track Pitch	1.6um	0.74um
Shortest Pit/Land Length	0.83um	Single layer: 0.40um Dual layer: 0.44um
Reference Scanning Velocity	1.2 m/sec CLV	4.0 m/sec CLV
Data Layers	1	1, 2, or 4; single layer, dual layer, double-sided, dual layer/ double-sided
Data Capacity	Approximately 680MB	Single layer: 4.7GB Dual layer: 8.5GB Double-sided: 9.4GB Dual layer/ double-sided: 17GB
Reference User Data Rate	Mode 1: 153.6 KB/sec Mode 2: 176.4 KB/sec	1.108 MB/sec nominal

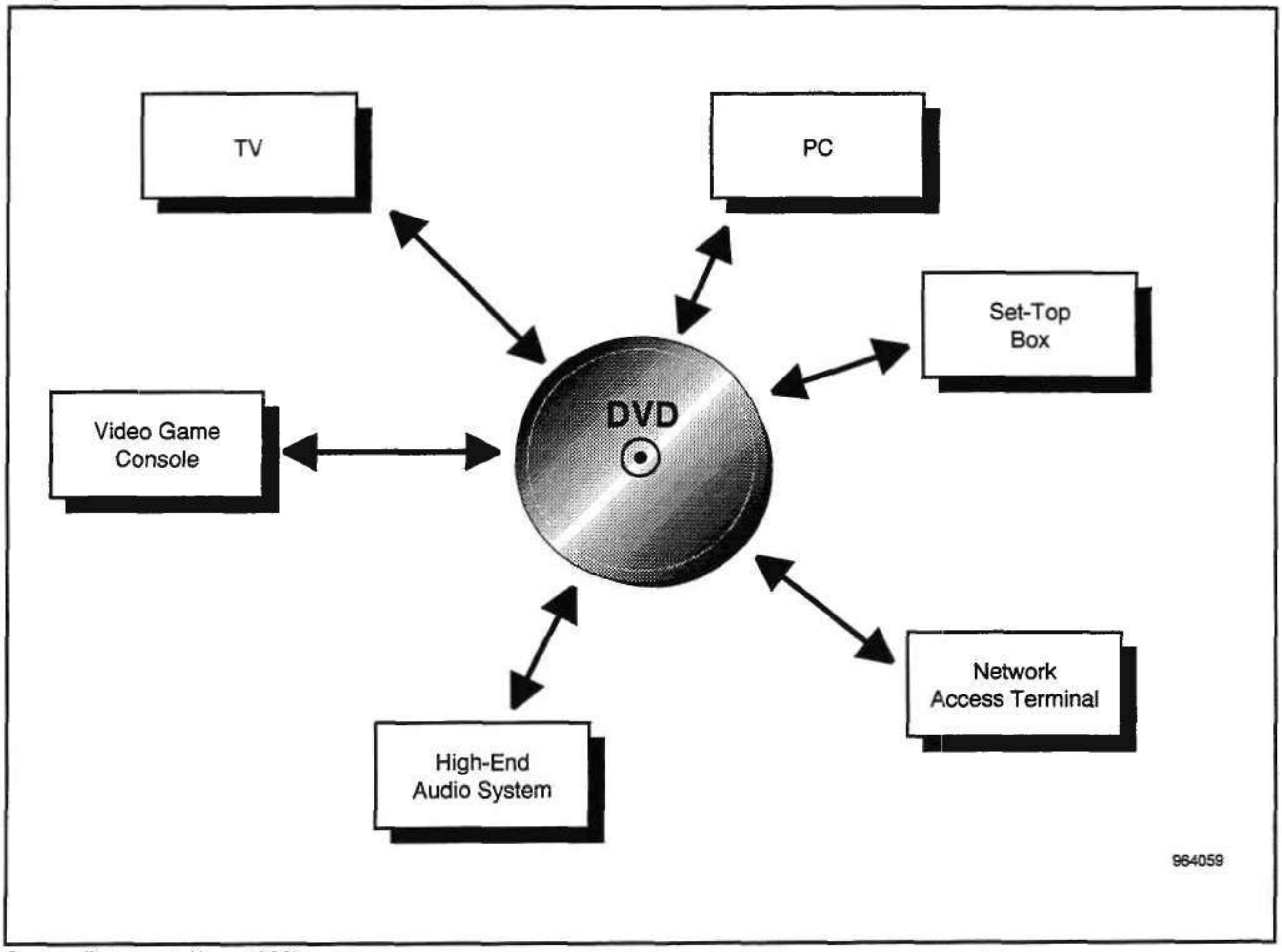
CLV = Constant linear velocity
Source: Dataquest (June 1996)

Table 1-2
A Comparison of DVD-Video and Video CD Specifications

	Video CD	DVD-Video
Video Data Rate	1.44 Mbps (video, audio)	1 to 10 Mbps variable (video, audio, subtitles)
Video Compression	MPEG-1	MPEG-2
Sound Tracks	2-channel MPEG	2-channel linear PCM; 2/5.1-channel AC-3 or MPEG; optional: up to eight streams of data available
Subtitles	Open caption only	Up to 32 languages

CLV = Constant linear velocity
Source: Dataquest (June 1996)

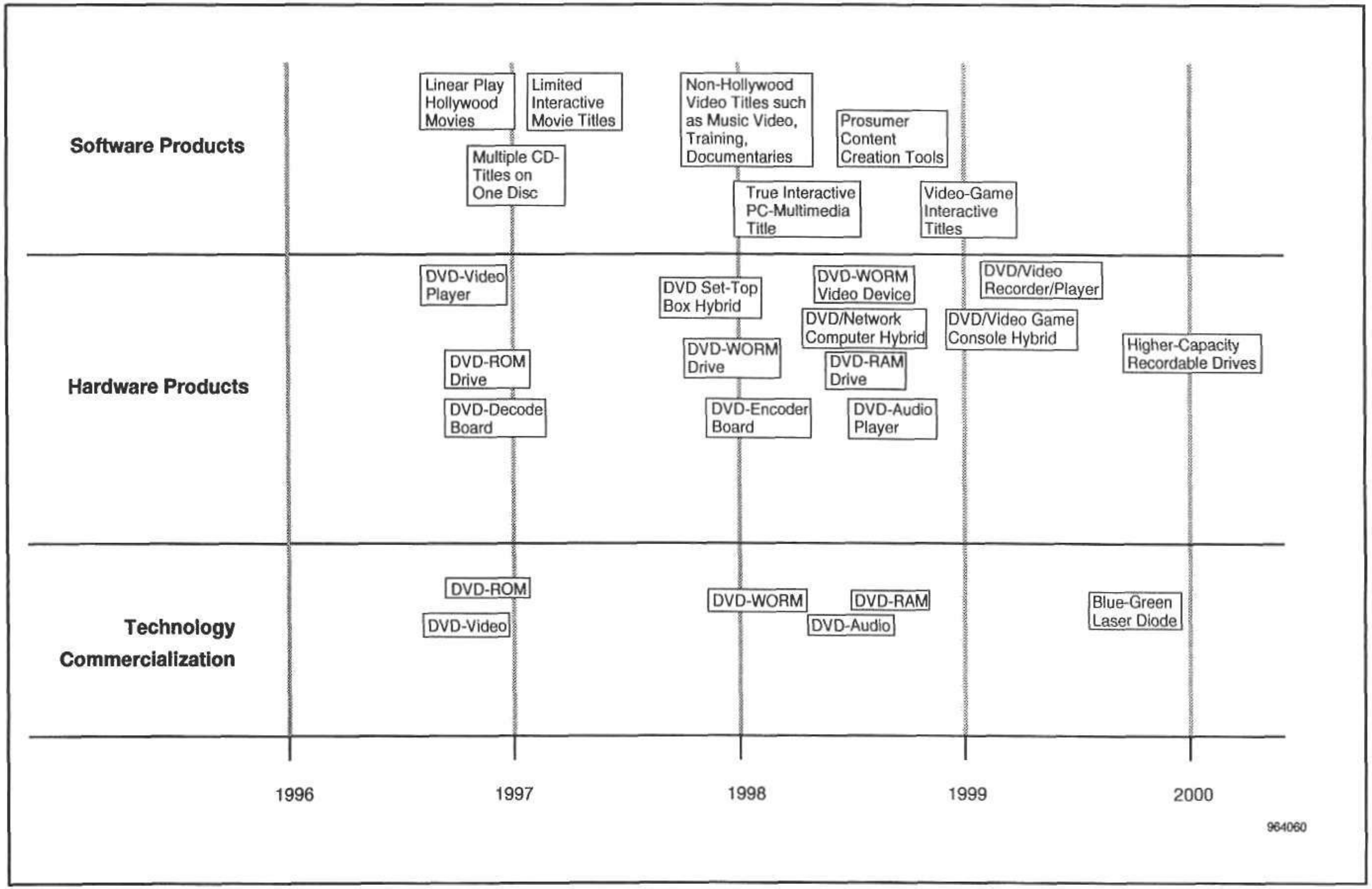
Figure 1-4
Digital Video Direction: Convergence



Source: Dataquest (June 1996)

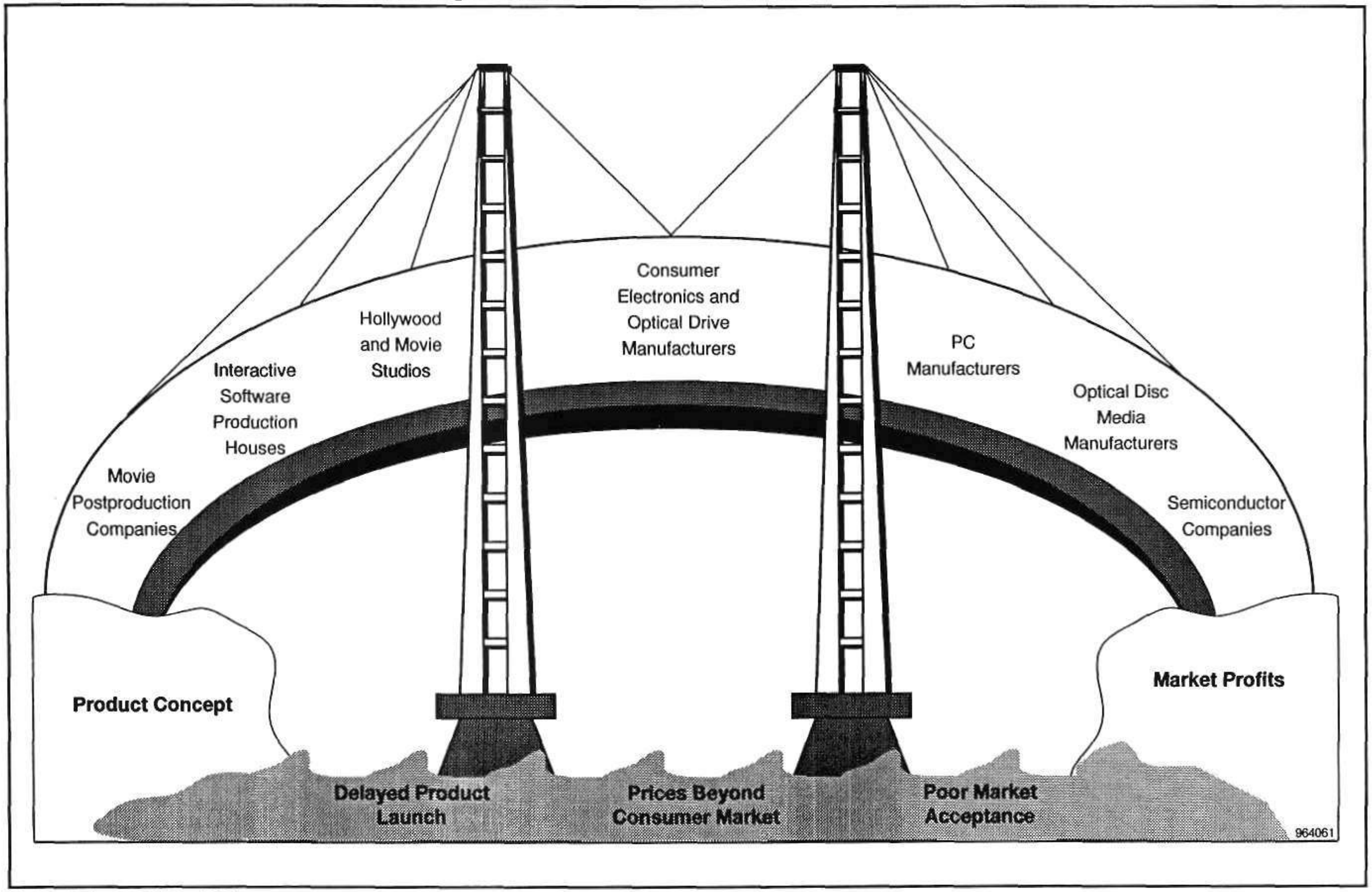
The success of DVD in the market is highly dependent on the ability of seven major industries to cooperate in translating this product concept into a market reality. If the major companies in any one of the industries shown in Figure 1-6 decide that they are not benefiting sufficiently from DVD and decide to withdraw support, or if they fail to develop the necessary support infrastructure in a timely fashion, the near-term success of DVD would be seriously harmed. The next section describes some of the contention that currently exists among these industries. If disputes involving issues such as royalties and copyrights are not resolved soon, the launch of this market could be delayed. However, Dataquest is optimistic that present difficulties can be overcome and that the long-term prospects for DVD are very bright.

Figure 1-5
A DVD Time Line



Source: Dataquest (June 1996)

Figure 1-6
Support of Multiple, Key Industries Required for DVD Market Success



Source: Dataquest (June 1996)

Chapter 2
DVD Challenges: Past and Future

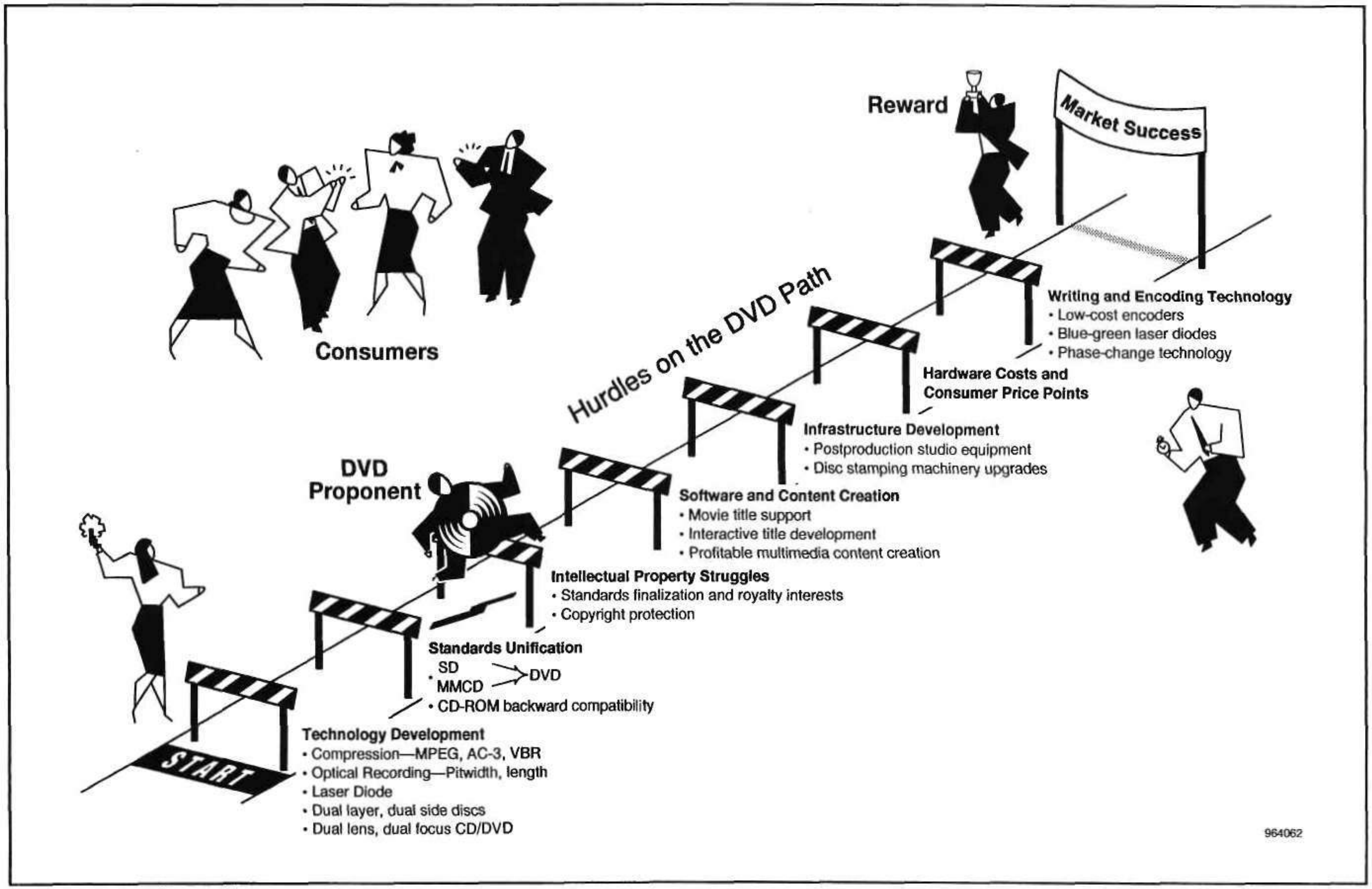
As they race to the market, DVD proponents will have to avoid being tripped up by some of the major hurdles shown in Figure 2-1. They have already overcome significant technological and standards hurdles, but they still do not have a clear sprint to the finish line. It is to be hoped that the potential rewards will provide the necessary momentum to allow the emerging DVD market to reach its full potential. An outline of the past and future challenges facing DVD is presented below.

Technology Development

The following major technological developments provide the foundation for DVD:

- Video and audio compression make it possible for high-quality video and surround-sound 3-D audio to be played back from the DVD disc. In particular, MPEG-2, which also provides the backbone for direct broadcast satellite (DBS) set-top boxes, is used for compressing the video. It is also used for audio compression in regions that use the PAL TV standard. Dolby Labs and Zoran must be given credit for the development of the AC-3 audio compression standard, which is used in DVD players in countries that comply with the NTSC TV standard. The AC-3 5.1 standard allows a complete home-theater sound system to be delivered by DVD. Linear PCM compression is also used as an alternative audio compression standard.
- The variable bit rate (VBR) encoding scheme is what makes it possible to store a full-length movie on a single DVD disc. As shown in Figure 2-2, if a 130-minute movie were compressed at a constant 3.5 Mbps, it would require about 8GB of storage. Because a single-layer DVD disc only provides 4.7GB of storage, VBR encoding must be employed. The basic VBR concept is that scenes with a lot of action that cause the image to change significantly are allocated more storage space, while slower-changing images can be stored with less space.
- The file structure that was developed for DVD enables multiple attractive benefits, from the ability to store a movie in multiple languages to the ability to control the content that is played back. As shown in Figure 2-3, future video producers will even have the ability to store multiple camera angles so a viewer can see the action from a variety of perspectives. The interactive features of DVD will be valuable in video game applications. The structure also allows a user to jump among multiple scenes with no pause in the video. This is accomplished by storing enough content at the branch points on the disc so that the DVD player can play out the lead-in to the next scene from its buffer while it finds the next video sequence.

Figure 2-1
Hurdles on the DVD Path



Source: Dataquest (June 1996)

- One of the critical elements in a DVD player is the red laser diode. This is a shorter-wavelength diode (635/650nm) than the infrared diode used for CD players. At the end of 1995, concerns were raised that there may not be an adequate supply of red laser diodes to meet demand because of difficulties in moving out of the lab to volume production quantities. Also, there were concerns about the life of the red laser diode being long enough. A 10,000-hour life is considered the minimum requirement for this component. While manufacturers appear to have made progress in preparing for volume production, the cost of an optical pickup unit that incorporates the red laser diode will be very high, \$35 to \$50, initially. Major suppliers of this component are Toshiba, Philips, Sony, Sharp, Sony, and Sanyo. Sony has stated that it will be prepared to supply red laser diodes in volume for \$10 at the end of 1996.
- One of the key requirements of the DVD standard is that the players be backward-compatible with CD discs. Because of the different structures of DVD and CD discs, this created a costly problem for DVD manufacturers. The differences in pit sizes and depth on the disc create the necessity for changing the focus between DVD and CD discs. Figure 2-4 shows the two most popular methods that have been developed for solving this problem, the dual focus and the dual lens optical pickup. A scheme using LCDs and polarized gratings has also been developed. Again, the necessity to build in backward compatibility adds a significant cost to a DVD player. Early rumors raised the possibility that the first DVD players would not be compatible with CD discs because of the cost of implementation.

Standards Unification

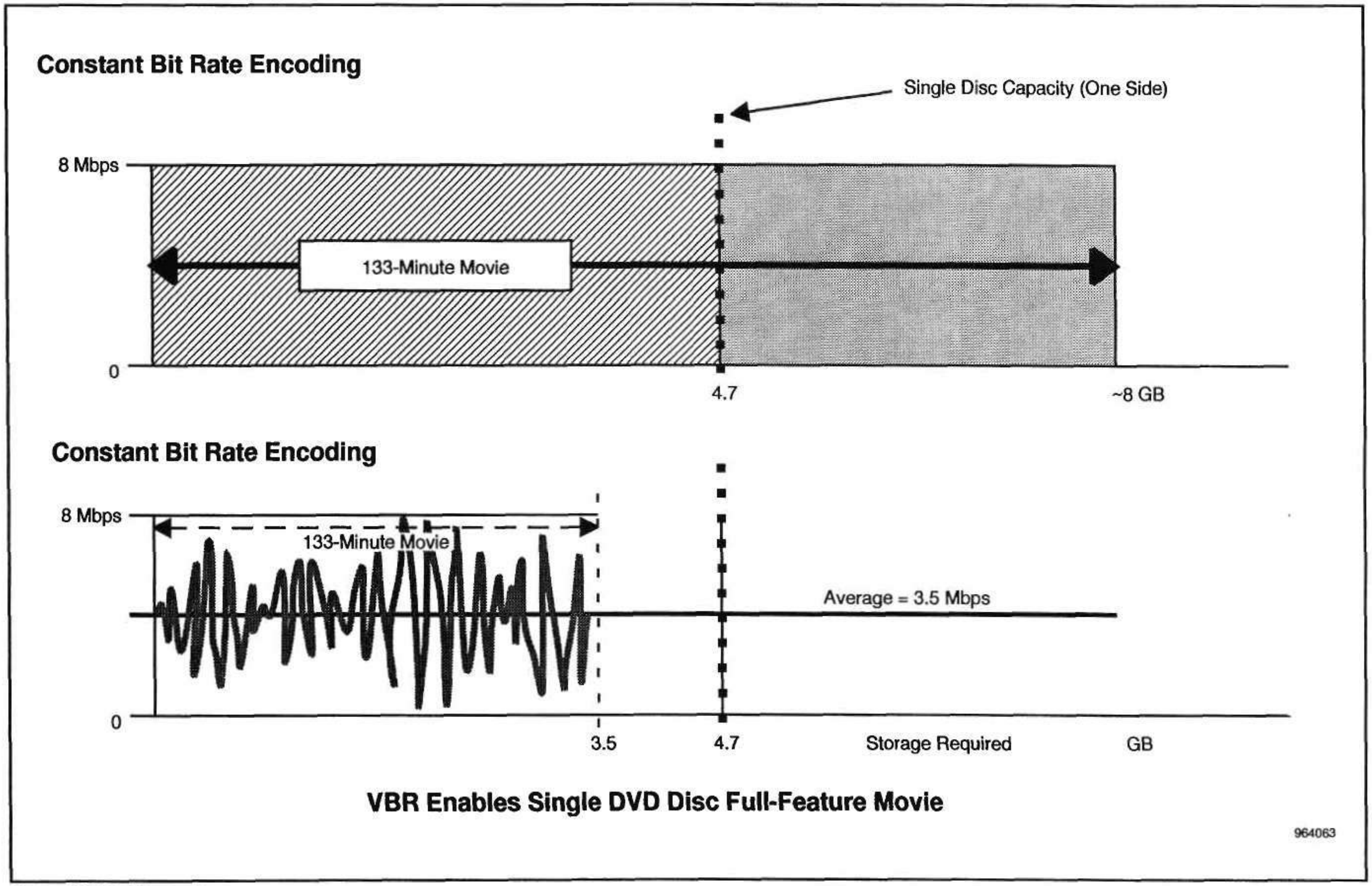
Standards, copyright, and royalty issues have been at center stage in the DVD story.

- It should be remembered that both Sony and Toshiba were demonstrating DVD technology as far back as the 1995 Winter Consumer Electronics Show (CES). Throughout 1995, the industry watched closely as intense competition was played out between two formats, Super Density (SD) and Multimedia CD (MMCD). Nobody wanted to see a repeat of the format wars that hindered the early growth of other consumer electronics markets, and the two camps were finally pushed into negotiation on a common standard. The announcement of an agreement on a unified DVD specification allowed manufacturers to begin rolling out their products with confidence at the 1996 Winter CES.

Intellectual Property Struggles

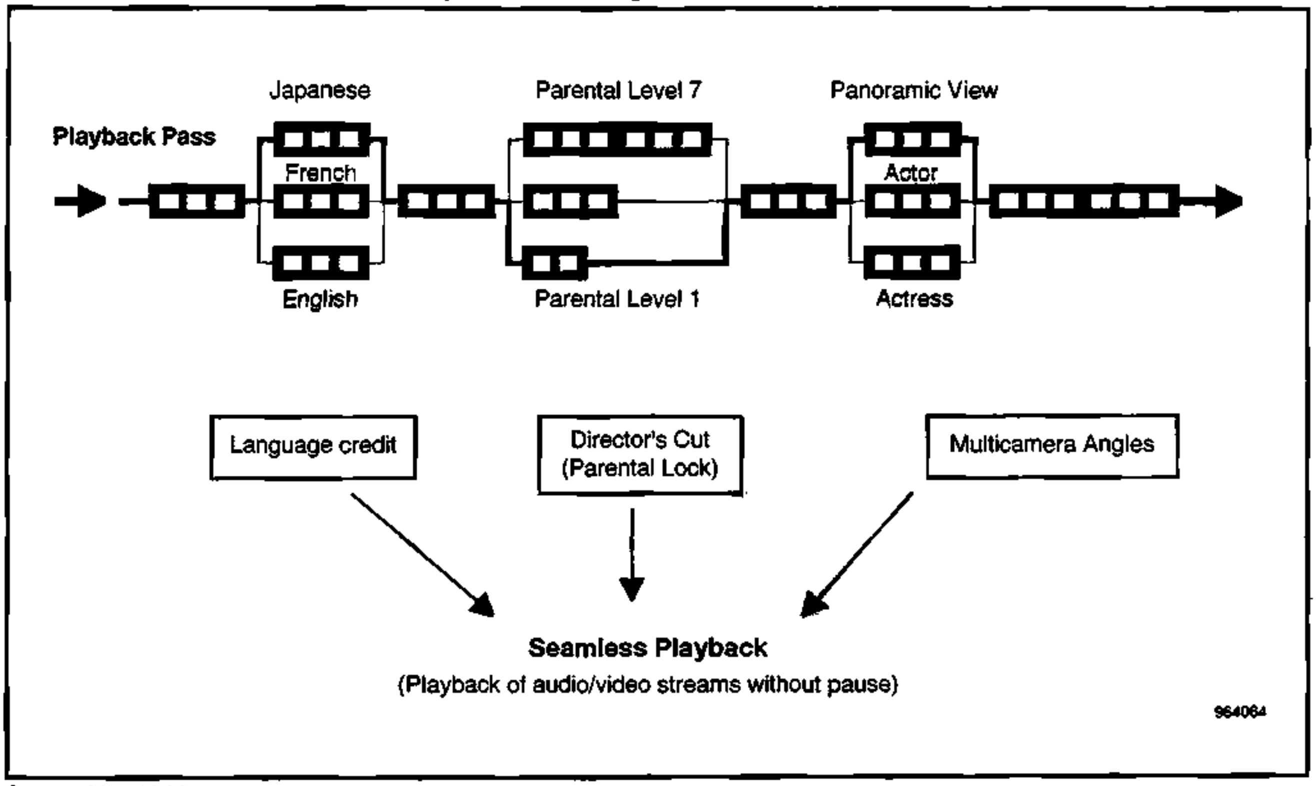
- Although a common standard has been agreed on, the details of the actual specifications are still being worked out. Two similar forces are at work to hold up the creation of a final specification for DVD, royalty interests and copyright protection. Creation of a final specification is not being held up by technical considerations; the real battle is over how the royalty revenue will be split among the different technology contributors. The battle over this issue has resulted in unfulfilled promises every month since January that an agreement would be reached within that month and a final specification would be published.

Figure 2-2
The Key to Movie Storage on a Single Disc: Variable Bit Rate Encoding



Source: C-Cube Microsystems

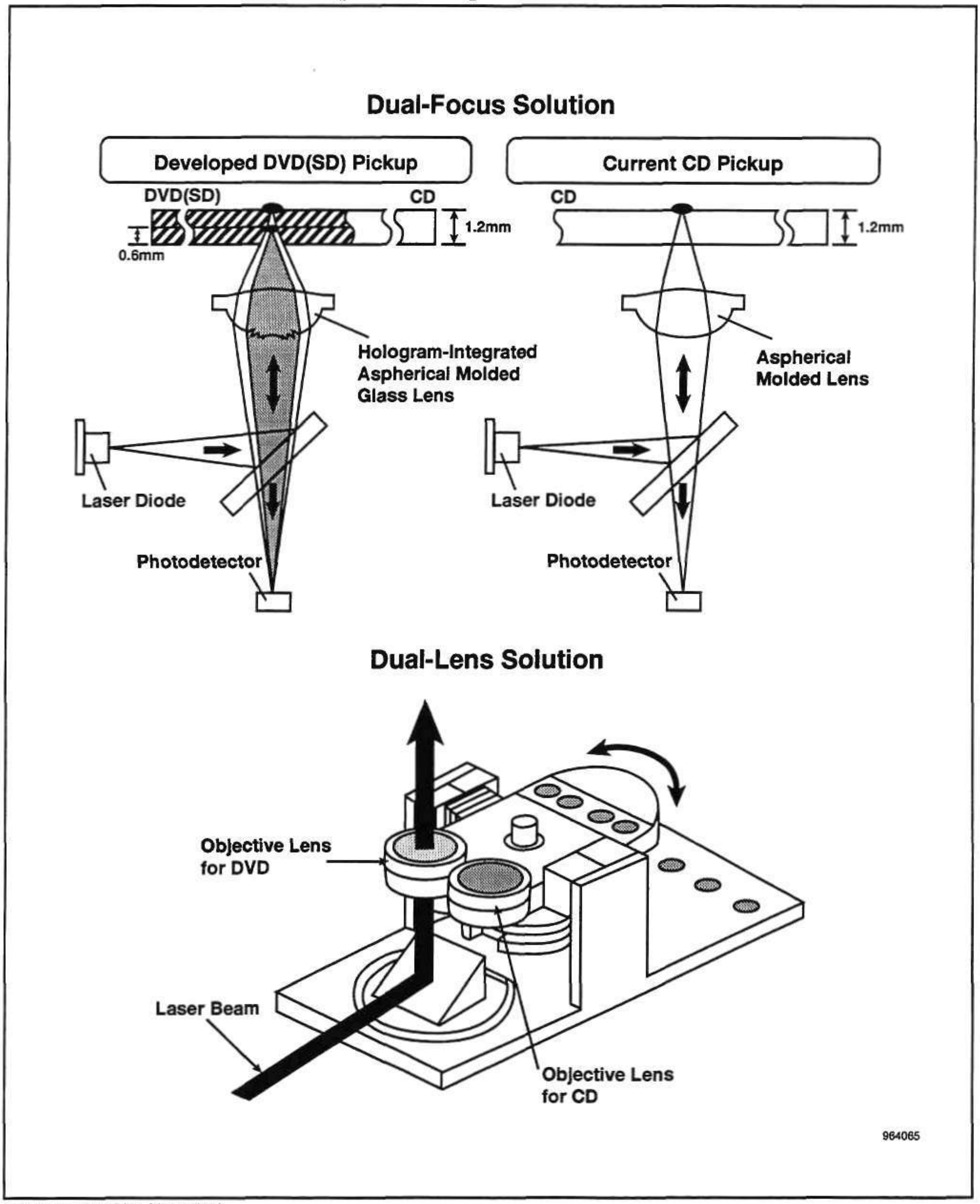
Figure 2-3
The Seamless, Interactive Playback Concept



Source: Mitsubishi

- The most recent fight over DVD revenue was launched when the Consumer Electronics Manufacturers Association (CEMA) and the MPAA proposed legislation that would require anticopying protection to be implemented through hardware. This proposal was met with immediate objections from the PC industry, which opposed the additional costs this would create and insisted that this type of scheme was incompatible with the entire PC storage concept. While the PC community, represented by Information Technology Industry Council (ITI), vowed to fight the legislation, a number of Hollywood studios announced they would not release their movies on the DVD format unless their demands were met. The two sides were preparing to negotiate in June to break the deadlock as retailers warned that any significant delays would push the possibility of a market launch beyond 1996. There is hope that some type of software encryption solution will create ground for agreement. However, this issue holds the greatest potential for delaying the launch of DVD.

Figure 2-4
Alternative DVD/CD-ROM Optical Pickup Solutions



Source: Matsushita, Mitsubishi

Software and Content Creation

Software and compelling content will be critical to both the near-term and long-term success of DVD.

- Since January 1996, the supporters of DVD have announced that anywhere between 250 and 400 movie titles would be launched when DVD-Video players went on the market at the end of August or beginning of September. Availability of these titles is critical for early sales of DVD-Video players. However, concerns continue to surface that the fight over copyright protection and the significant effort currently required to convert a title to DVD format may result in very few titles being ready for market launch.
- In the PC world, the creation of software content for DVD is facing a chicken-and-egg dilemma. Software developers have not begun work on DVD titles, and most do not plan to do so until there is an installed base of DVD-ROM drives sufficient to create a market for their products. Very few CD-ROM titles were profitable in 1995, and content developers are cautious about investing effort in a market that does not exist yet. The large installed base of CD-ROM drives in PCs presents a much more attractive opportunity for software developers, and it will require significant effort to redirect this energy to the DVD platform. This creates a problem for PC manufacturers working to deliver new PCs that incorporate a DVD-ROM drive. Without compelling DVD titles, the consumer has no incentive to pay extra money for a DVD-ROM drive. Even after interactive software companies begin working on new titles that take advantage of the capabilities of DVD, it will take 12 to 18 months for them to bring a product to market. Until then, most DVD titles will probably be nothing more than repackaged CD-ROM titles. This will leave PC manufacturers with the task of convincing consumers that it is really fun to watch movies on a PC.

Infrastructure Development

Two of the important support industries for DVD are the postproduction houses and the disc manufacturers.

- There are currently a limited number of postproduction studios with the equipment necessary to convert a movie to the DVD format. However, a number of companies have ordered the expensive equipment required for DVD encoding. Three companies are cooperating to develop and market professional-use tools for DVD content and authoring systems, Sonic Solutions, Daikin Industries, and Toshiba Corporation. Companies that currently have the equipment to convert movies to the DVD format or that have ordered the equipment are as follows:
    - California Video Center (CVC), which is backed by Toshiba/ Time-Warner
    - Laser Pacific Media Corporation
    - Crest National
    - Patapsco Design
    - Sunset Post

- Thomson Electronics
- Warner Advanced Media Operations and Warner Brothers

- It has been estimated that by the end of 1996 there will be 600 CD manufacturing plants worldwide. Half of these plants will come into operation in 1996. The cost of converting their CD stamping equipment to produce DVD discs has created another potential barrier. The cost to convert an existing CD machine has been estimated at $600,000 to $750,000. The cost of a new DVD plant could be between $10 million and $15 million. These steep costs have created a question about the ability to generate a profit in this business. Manufacturers such as Matsushita have jumped in to try to create a solution by building DVD manufacturing plants and selling them to companies willing to operate them.

Hardware Costs and Consumer Price Points

As always, one of the critical elements for a successful consumer product is hitting the right price point.

- DVD manufacturers had originally targeted a price of $499 for the first DVD-Video players. However, the steep costs of manufacturing these players pushed Toshiba to announce two products at $599 and $699 for delivery in September 1996. Thomson Consumer Electronics has continually stated its intention of meeting the $499 price goal, but it appears that it may be subsidizing its early players to capture market share. Thomson will rely on Matsushita for production of its early models until it can establish its own DVD production capacity. Long experience has shown that price plays a key role in a consumer's purchase decision. Manufacturers will be under strong pressures to reduce the costs of their DVD players in order to stimulate the market. It is widely expected that most companies will be subsidizing the cost of their early DVD models in order to create attractive consumer price points that will drive market growth.

Writing and Encoding Technology

Although today's DVD products are read-only devices, the long-term growth path will rely on the development of writing and erasing technologies.

- Writable DVD drives are expected to employ phase-change (PD) optical disc technology. With this technology, spots on the recording layer of a disc are changed from an amorphous to a crystalline state using the heat from a laser diode. A high temperature is used to erase, a lower one to record, and very low power is used for reading. Toshiba has backed this technology because of its low dependence on wavelength, anticipating the use of blue or green laser diodes in the future. However, some companies, including Sony, are supporting the use of magneto-optical technology (MO) for writing to DVD discs. They believe that MO is better suited than phase-change to assure signal read-time margins using signal-processing technologies such as partial response maximum likelihood (PRML). Issues such as these will come to the forefront as specifications for the DVD-WORM and DVD-RAM drives are examined.

- The storage capacity of future DVD drives will be increased through the use of shorter-length blue/green diodes. In May 1996, Philips Research's Photonics Research Lab and 3M demonstrated a 520nm blue/green laser diode based on zinc selenide that can be used for DVD applications. They claim that this laser would increase DVD disc storage by 60 percent. Currently, this laser diode only has a life of four hours, but scientists believe they can develop a commercial product by the turn of the century. A competitive solution is being developed by Nichia Chemical Industries, which has produced a purplish-blue laser using gallium nitride that operates at 410nm. Philips has decided to work with both gallium nitride and zinc selenide because it is not possible to predict which solution will become feasible first.

- Development of low-cost MPEG-2 and AC-3 encoder chips will be necessary for creation of a DVD-Video recorder. Currently, MPEG-2 encoder chipsets for DVD are very expensive, between $1,500 and $2,500, and are used in high-end professional production equipment. An encoder product targeted at the mass consumer market will require that these costs be reduced to around $50. C-Cube Microsystems has been the pioneering semiconductor player in the MPEG-2 encoder market. In 1996, IBM and LSI Logic announced their entry into the market, and Mitsubishi Research is working with Futuretel to develop an encoder chipset. All these companies will face the task of developing a low-cost encoding solution for the DVD market. A DVD-Video player with recording capability will present a true upgrade opportunity from the VCR and open up additional growth opportunities for this segment of the DVD market.

Chapter 3

Market and Production Forecast

The exciting opportunity presented by DVD technology has attracted a host of manufacturers to the market. The product plans announced by manufacturers that have declared their entry into the DVD arena are summarized in Table 3-1.

During DVD's long, slow march to the market, the DVD publicity machine has done a very effective job of raising consumer awareness of this new product. A recent survey by *Video Business* magazine found that 45 percent of the survey respondents had heard of DVD. There were high awareness levels among the likely early adopter group of males between the ages of 18 and 45. Based on an analysis of consumer market behavior and expected price trends, Dataquest has developed the market forecast for DVD-Video players, DVD optical storage drives, and DVD PC decode/encode add-in boards shown in Figure 3-1 and Table 3-2. This market forecast demonstrates Dataquest's optimism regarding the future of DVD. Our projections show the combined annual market shipments of DVD-Video players and DVD drives growing to over 33 million by the year 2000, making it one of the most successful products introduced in the 1990s. The combined market shipments of all DVD products including decode/encode add-in boards would drive factory revenue over $10 billion by the year 2000.

Certainly, there are factors that could drive the market above or below this forecast. If manufacturers are able to drive prices below Dataquest's expectations, this would stimulate higher growth. On the other hand, if the creative community fails to develop software products in a timely fashion that exploit the advanced capabilities of DVD, it will be hard to push the installed base of CD-ROM users and VCR owners to a more expensive platform. All the hurdles discussed earlier in this report could impact the growth of the DVD market.

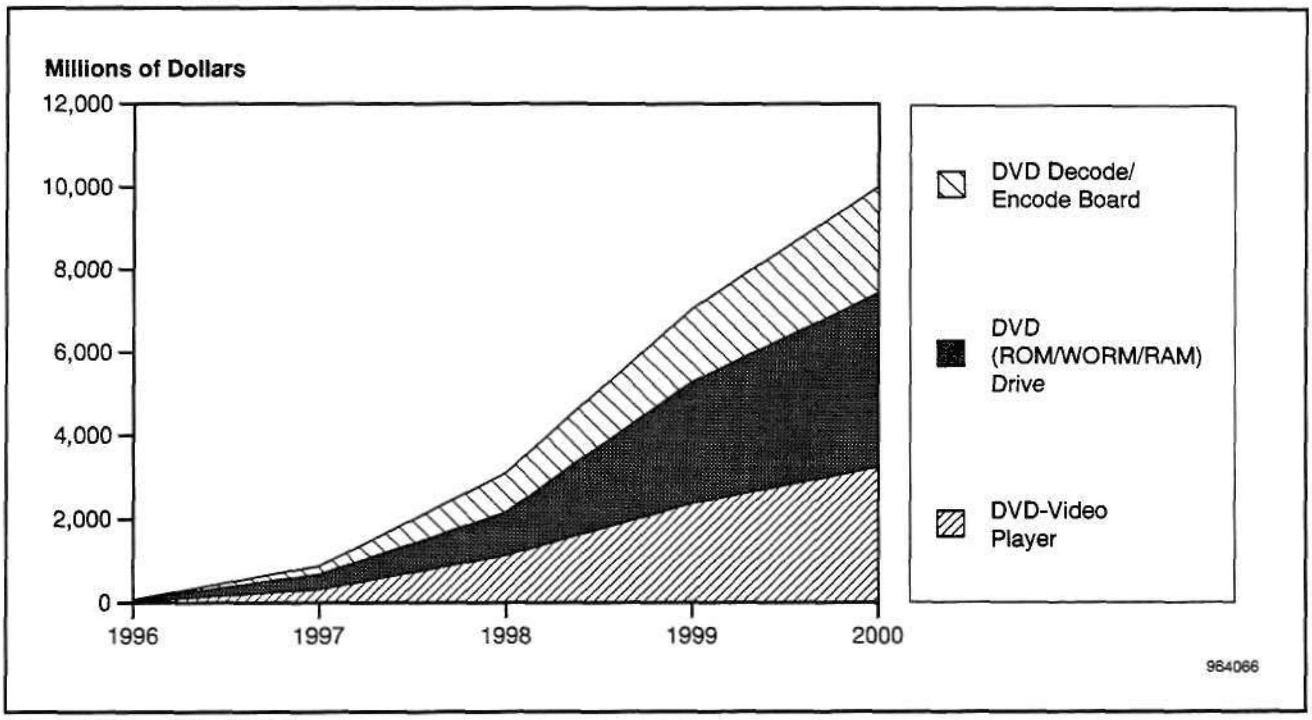
Based on the predicted market growth, Figure 3-2 and Tables 3-3, 3-4, and 3-5 present Dataquest's DVD production forecast. It should be noted that the enthusiasm and competitive drive of DVD manufacturers could lead to supply exceeding demand for DVD in the near term and cause some temporary jolts and lurches in the market. It seems that every manufacturer is planning to capture over 50 percent of the market, and with 16 players expected to compete in the market over the next two years, there could be some casualties. An examination of the forecast will also reveal that Dataquest expects products based on the DVD-WORM technology to find transitional and niche markets. Although some manufacturers have announced plans to produce DVD-WORM products, many others are planning to jump directly to DVD-RAM technology. With very little to differentiate DVD-WORM from DVD-RAM in terms of cost, the DVD-WORM market will be limited, and the growth opportunity for writable DVD devices will move to DVD-RAM.

Table 3-1
DVD-Video Player and DVD-ROM Drive Manufacturers

	DVD-Video Player				DVD-ROM	
Manufacturer	Supplying a DVD-Video Product?	Model(s)	Planned Product Introduction Date	Planned Product Introduction Price	Supplying a DVD-ROM Product?	Planned Product Supply Date to PC OEM or Market
Aiwa	Yes		Q4/97			
Hitachi/Denon	Yes		Q1/97		Yes	Q4/96
JVC	Yes					
LG Electronics	Yes				Yes	
Matsushita	Yes	DVD-A100/DVD-A300	Q4/96	$500 - $700	Yes	Q3/96
Mitsubishi	Yes					
Mitsumi					Yes	Mid - 1997
NEC	Yes				Yes	Q4/96
Onkyo	Yes					
Philips	Yes				Yes	Mid - 1997
Pioneer	Yes	DVL-90/DVL-700/ DV-500	Nov. 1996/Oct. 1996		Yes	Q4/96
Samsung	Yes	DVD-760U	Nov. 1996	$599 - $699	Yes	
Sanyo	Yes				Yes	
Sony	Yes				Yes	Q3/96
Thomson Consumer Electronics	Yes	RCA: RC-5200/ RC-5500P ProScan:PS8600P		$499/$599-$649 $649-$699		
Toshiba	Yes	SD-3006/SD-1006	Aug. 1996	$699/$599	Yes	Q4/96
Zenith	Yes					

Source: Dataquest (June 1996)

Figure 3-1
DVD Market Revenue Forecast



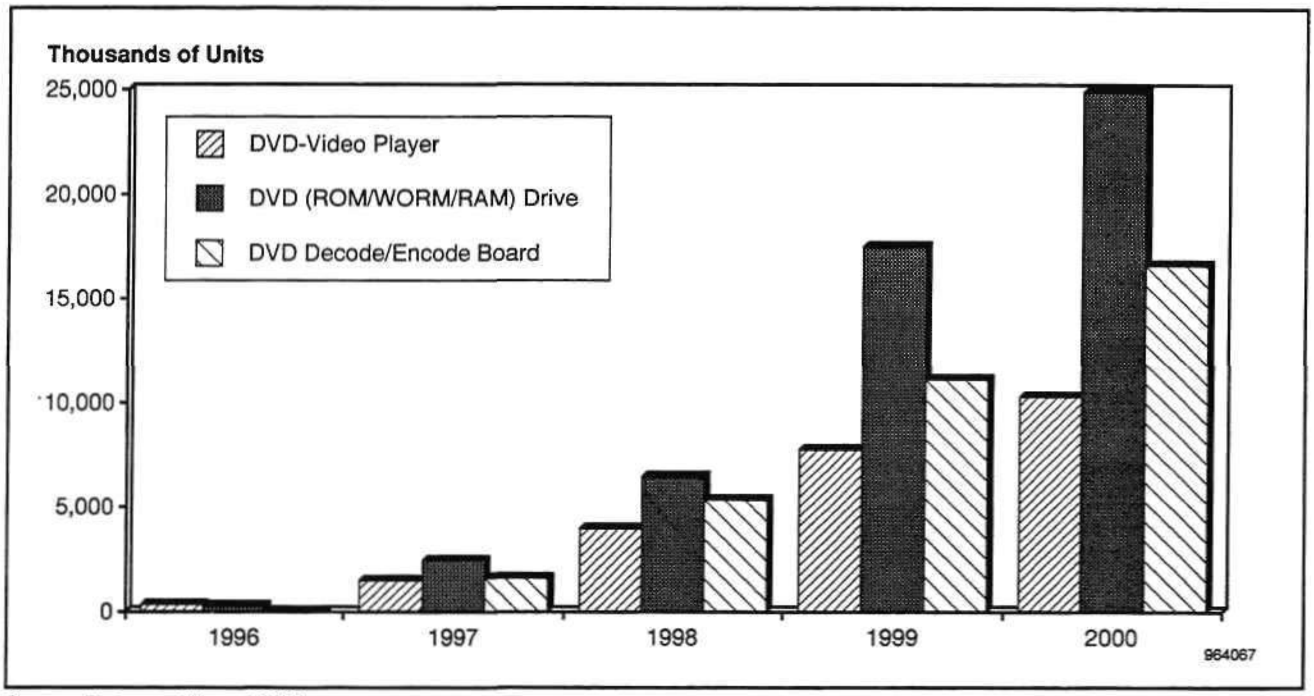
Source: Dataquest (June 1996)

Table 3-2
DVD Market Forecast (Thousands of Units)

	1996	1997	1998	1999	2000
DVD-Video Player					
Playback Only	60	750	2,750	5,350	6,983
One-Time Record/Playback	0	0	125	500	330
Recorder and Player	0	0	0	725	2,313
Total	60	750	2,875	6,575	9,626
DVD Optical Drive					
DVD-ROM	150	1,450	3,700	9,200	12,200
DVD-WORM	0	150	600	750	880
DVD-RAM	0	0	500	4,850	10,420
Total	150	1,600	4,800	14,800	23,500
DVD Video Decode/Encode Board for PC					
Decode Board	23	850	3,589	9,016	12,078
Encode/Decode Board	0	0	611	984	3,217
Total	23	850	4,200	10,000	15,295

Source: Dataquest (June 1996)

Figure 3-2
DVD Production Forecast



Source: Dataquest (June 1996)

Table 3-3
DVD-Video Player Production Forecast

	1996	1997	1998	1999	2000	CAGR (%) 1996-2000
Playback Only						
Units (K)	360	1,495	3,631	5,798	6,769	108.2
Factory ASP ($)	428	394	348	299	264	-11.4
Factory Revenue ($M)	154	589	1,263	1,731	1,786	84.6
Semiconductor Content ($)	146	133	116	100	88	-11.9
Semiconductor TAM ($M)	53	199	419	577	595	83.4
One-Time Record/Playback						
Units (K)	-	-	325	422	299	NA
Factory ASP ($)	0	0	555	510	445	NA
Factory Revenue ($M)	-	-	180	215	133	NA
Semiconductor Content ($)	0	0	190	168	148	NA
Semiconductor TAM ($M)	0	0	62	71	44	NA
Recorder and Player						
Units (K)	-	-	-	1,535	3,215	NA
Factory ASP ($)	0	0	0	538	462	NA
Factory Revenue ($M)	-	-	-	826	1,487	NA
Semiconductor Content ($)	0	0	0	166	147	NA
Semiconductor TAM ($M)	0	0	0	255	473	NA

(Continued)

Table 3-3 (Continued)
DVD-Video Player Production Forecast

	1996	1997	1998	1999	2000	CAGR (%) 1996-2000
Total						
Units (K)	360	1,495	3,956	7,755	10,283	131.2
Factory ASP ($)	428	394	365	357	331	-6.2
Factory Revenue ($M)	154	589	1,443	2,772	3,406	116.9
Semiconductor Content ($)	146	133	122	116	108	-7.3
Semiconductor TAM ($M)	53	199	481	903	1,112	114.4

NA = Not applicable
Source: Dataquest (June 1996)

Table 3-4
DVD Optical Drive Production Forecast

	1996	1997	1998	1999	2000	CAGR (%) 1996-2000
DVD-ROM						
Units (K)	295	2,230	4,891	9,646	12,778	156.5
Factory ASP ($)	230	211	186	165	146	-10.7
Factory Revenue ($M)	68	470	909	1,589	1,870	129.1
Semiconductor Content ($)	81	73	65	58	53	-10.1
Semiconductor TAM ($M)	24	164	316	559	676	130.7
DVD-WORM						
Units (K)	-	210	713	762	785	NA
Factory ASP ($)	0	298	248	220	193	NA
Factory Revenue ($M)	-	63	177	168	151	NA
Semiconductor Content ($)	0	103	85	76	68	NA
Semiconductor TAM ($M)	0	22	61	58	54	NA
DVD-RAM						
Units (K)	-	-	864	7,091	11,335	NA
Factory ASP ($)	0	0	266	232	205	NA
Factory Revenue ($M)	-	-	230	1,646	2,328	NA
Semiconductor Content ($)	0	0	86	78	71	NA
Semiconductor TAM ($M)	0	0	74	554	803	NA
Total						
Units (K)	295	2,440	6,467	17,500	24,898	203.1
Factory ASP ($)	230	218	204	194	175	-6.7
Factory Revenue ($M)	68	533	1,316	3,402	4,348	182.9
Semiconductor Content ($)	81	76	70	67	62	-6.6
Semiconductor TAM ($M)	24	185	451	1,170	1,532	183.1

NA = Not applicable
Source: Dataquest (June 1996)

Table 3-5
DVD-Video Decode/Encode Board/Chipset Production Forecast

	1996	1997	1998	1999	2000	CAGR (%) 1996-2000
Video Decode Board						
Units (K)	40	1,623	4,603	9,628	12,787	324.2
Factory ASP ($)	258	218	184	155	134	-15.1
Factory Revenue ($M)	10	354	848	1,492	1,712	260.1
Semiconductor Content ($)	85	77	68	57	49	-12.6
Semiconductor TAM ($M)	3	126	311	550	632	270.7
Video Encode/Decode Board						
Units (K)	-	-	758	1,480	3,824	NA
Factory ASP ($)	0	0	365	303	264	NA
Factory Revenue ($M)	-	-	277	449	1,008	NA
Semiconductor Content ($)	0	0	121	108	94	NA
Semiconductor TAM ($M)	0	0	92	159	361	NA
Total						
Units (K)	40	1,623	5,361	11,108	16,611	352.8
Factory ASP ($)	258	218	210	175	164	-10.7
Factory Revenue ($M)	10	354	1,125	1,941	2,720	304.3
Semiconductor Content ($)	85	77	75	64	60	-8.4
Semiconductor TAM ($M)	3	126	403	709	993	315.0

NA = Not applicable
Source: Dataquest (June 1996)

Chapter 4
The DVD Semiconductor Opportunity

The block diagram shown in Figure 4-1 illustrates the major semiconductor elements in a DVD product. As shown in this illustration, there are significant portions of a DVD-ROM drive and DVD-Video player that are common. This commonality is one of the strengths of the DVD standards. The only additional component needed for a DVD-ROM drive is a SCSI or EIDE interface. In a PC application, the only additional component needed for a DVD-Video decode board is a PCI interface. Table 4-1 provides greater detail of the various DVD functional blocks.

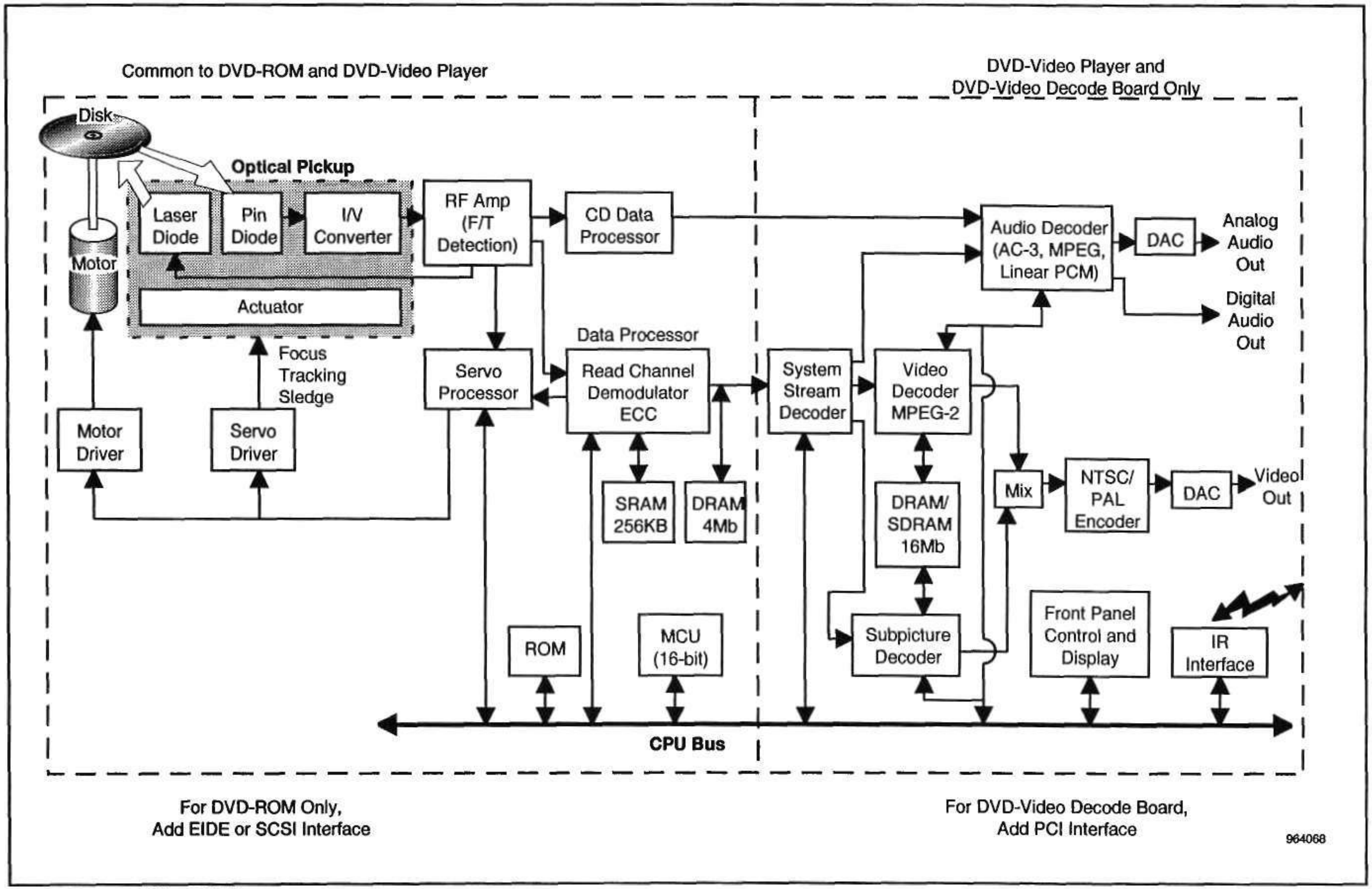
The semiconductor community has invested in DVD technology early. Although the early DVD players that come to market will have little integration, they will be replaced in a matter of a few months by products that will take advantage of integrated chipsets that have already been announced. The second-generation chipsets will be ready before the first-generation systems have even shipped! Figure 4-2 presents the projected integration trend for semiconductors targeted at DVD. Semiconductor manufacturers have outlined aggressive integration plans for DVD and other products that are based on MPEG-2 and AC-3 compression technology. Some companies have even presented plans to develop single-chip DVD processing solutions. Dataquest stops short of this level of integration because of the belief that there are no cost or performance advantages to be gained from integrating the channel-processing function and audio/video codec.

Announced chipsets for audio and video processing, the servo processor, and some channel demodulation functions will be based on a 0.35-micron CMOS process, which will migrate to 0.25 micron CMOS over the following two years. Other components in the DVD-drive electronics will be based on bipolar technology. As chipsets move along the integration path, a growing opportunity for BiCMOS will develop.

Semiconductor Market Forecast

Figures 4-3 and 4-4 and Tables 4-2, 4-3, and 4-4 present the semiconductor forecast for chips used in DVD applications. This forecast is based on the DVD production forecast and an analysis of semiconductor content and chip pricing trends. Dataquest forecasts the total DVD semiconductor market to grow from less than $80 million in 1996 to over $3.6 billion in just four years.

Figure 4-1
DVD-Video Player Block Diagram



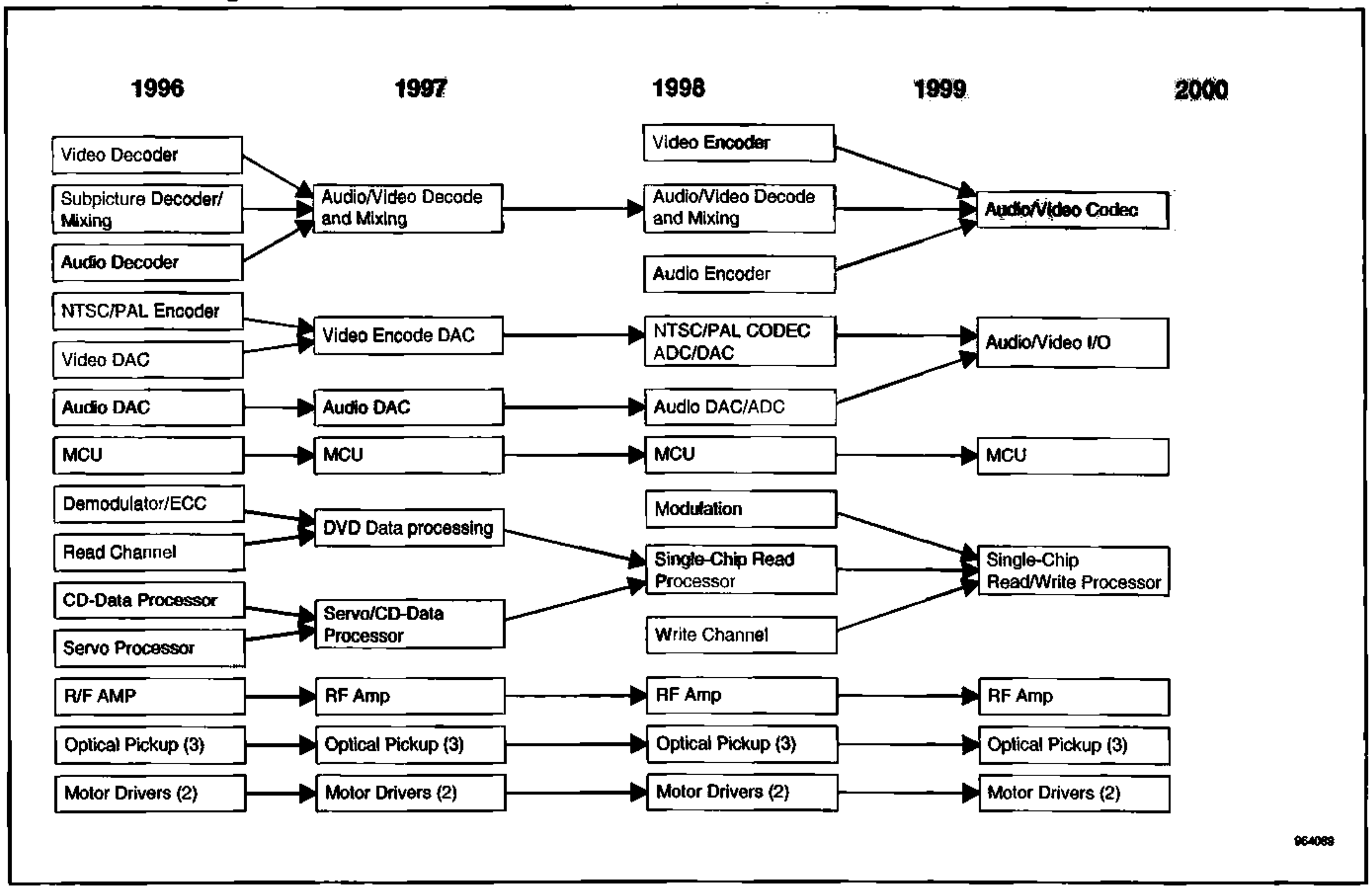
Source: Dataquest (June 1996)

Table 4-1
Functional Description of Major DVD Elements

Functional Block	Description
Optical Pickup/Laser Diode	635/650nm laser diode, pin diode, and current-to-voltage (I/V) conversion
RF Amplifier	Focus and tracking error detector, search signal generator, automatic gain control (AGC) and equalization, and laser diode automatic power control (APC)
Servo Electronics	Search control and servo control for focus and tracking actuators
Data Processor	DVD: EFM Plus demodulator, sync/ID detector, Reed-Solomon error correction code (ECC), and descrambler CD: data separator, EFM demodulator, ECC, interpolation, and muting
Audio Decoder	NTSC: AC-3 and linear PCM, plus optional standard audio decoding PAL: MPEG and linear PCM, plus optional standard audio decoding Sony/Philips digital interface (S/PDIF) formatter
Video Decoder	MPEG-2 video decoding
Subpicture Decoder, Mixer	Subpicture decoding and on-screen display (OSD) generator, audio/video synchronization, video image resizing, and graphics overlay and mixing

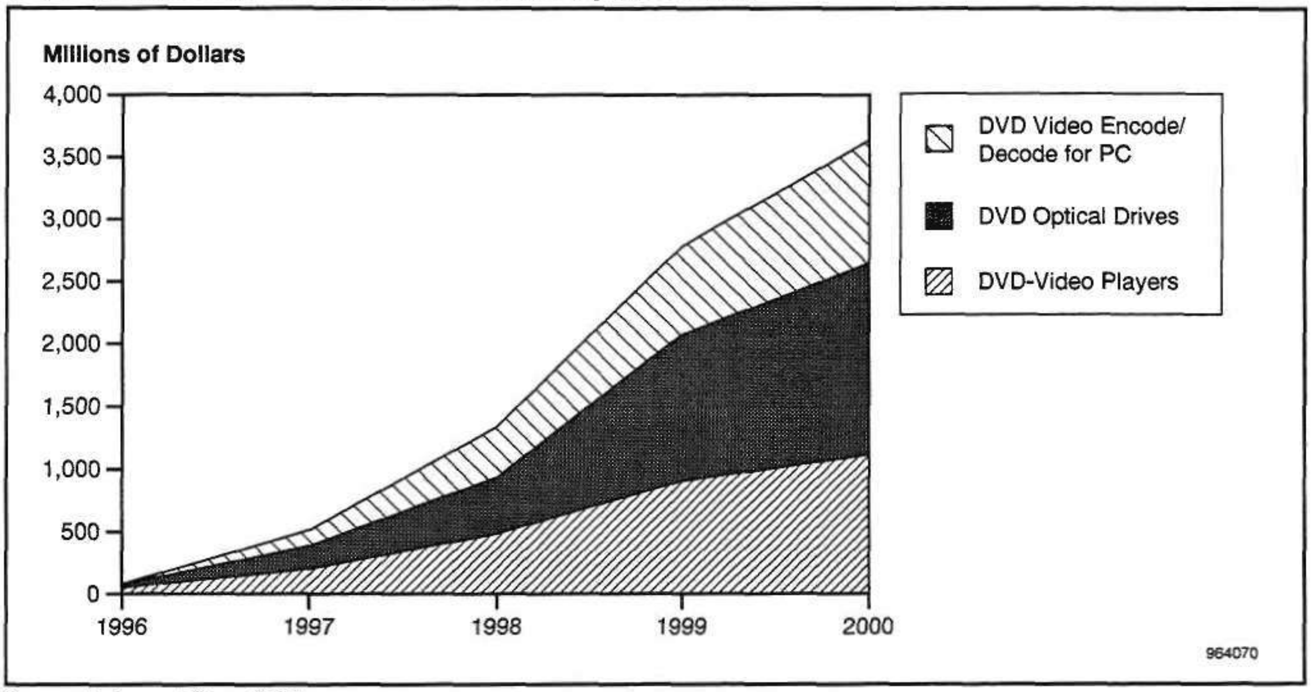
Source: Dataquest (June 1996)

Figure 4-2
Semiconductor Integration Trends in DVD



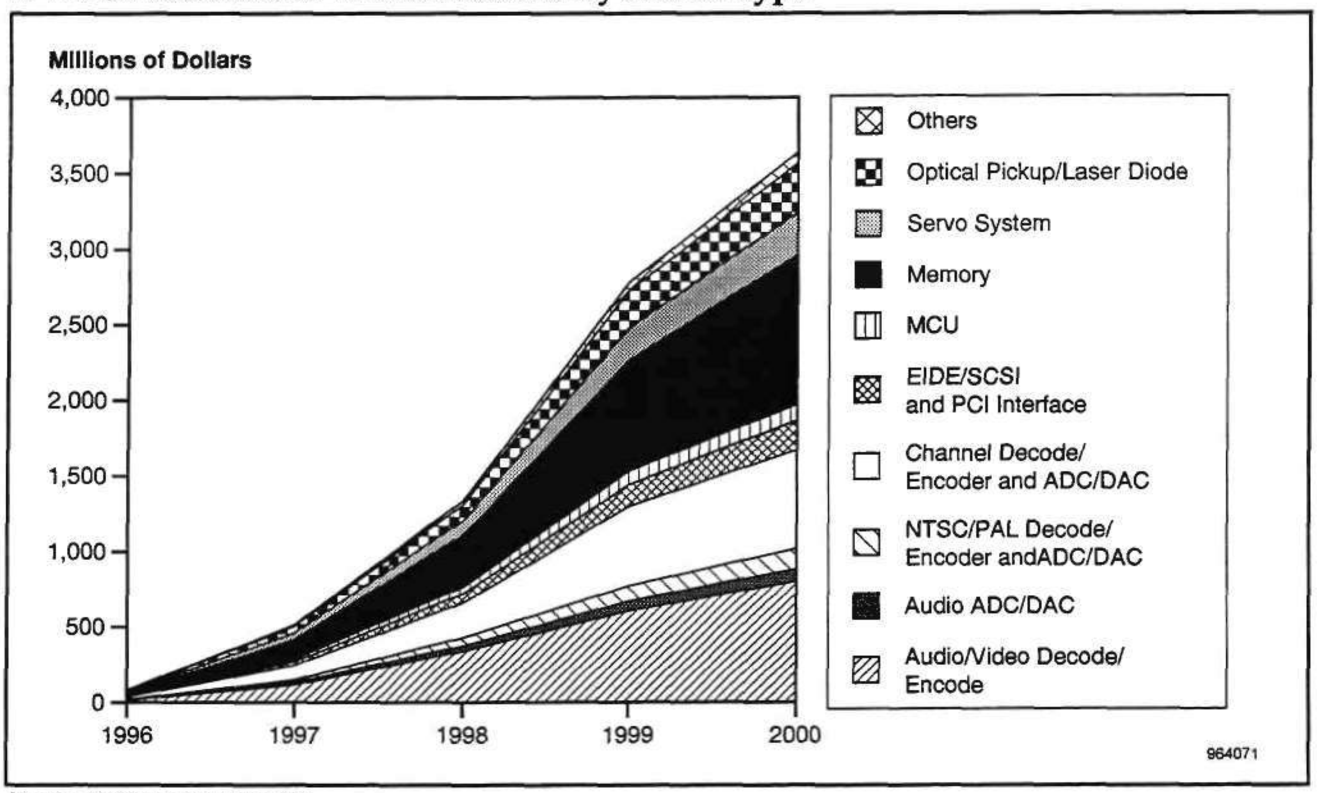
Source: Dataquest (June 1996)

Figure 4-3
DVD Semiconductor Market Forecast by Platform



Source: Dataquest (June 1996)

Figure 4-4
DVD Semiconductor Market Forecast by Device Type



Source: Dataquest (June 1996)

Table 4-2
DVD-Video Player Semiconductor Market Forecast (Dollars)

	1996	1997	1998	1999	2000	CAGR (%) 1996-2000
Playback Only						
Units (K)	360	1,495	3,631	5,798	6,769	108.2
Total Semiconductor Content	146.2	133.3	115.5	99.5	87.9	-11.9
Audio/Video Decode	40.0	37.0	32.0	26.0	22.0	-13.9
Audio DAC	4.5	4.2	3.7	3.2	2.8	-11.2
NTSC/PAL Encoder and DAC	6.4	6.0	5.5	4.7	4.0	-11.1
Channel Decode	25.0	23.0	20.0	17.0	15.0	-12.0
MCU	5.0	4.6	4.0	3.5	3.0	-12.0
DRAM	25.3	22.2	18.8	16.2	14.1	-13.6
SRAM and ROM	13.0	12.0	10.5	10.2	10.0	-6.3
Servo System	12.0	10.5	9.0	8.5	8.0	-9.6
Optical Pickup/Laser Diode	12.0	11.0	9.5	8.0	7.0	-12.6
Others	3.0	2.8	2.5	2.2	2.0	-9.6
Total Semiconductor Market ($M)	52.6	199.3	419.4	576.9	595.0	83.4
Audio/Video Decode ($M)	14.4	55.3	116.2	150.8	148.9	79.3
Audio DAC ($M)	1.6	6.3	13.4	18.6	19.0	84.9
NTSC/PAL Encoder & DAC ($M)	2.3	9.0	20.0	27.3	27.1	85.1
Channel Decode ($M)	9.0	34.4	72.6	98.6	101.5	83.3
MCU ($M)	1.8	6.9	14.5	20.3	20.3	83.3
DRAM ($M)	9.1	33.2	68.3	93.9	95.4	79.9
SRAM and ROM ($M)	4.7	17.9	38.1	59.1	67.7	95.0
Servo System ($M)	4.3	15.7	32.7	49.3	54.2	88.2
Optical Pickup/Laser Diode ($M)	4.3	16.4	34.5	46.4	47.4	82.0
Other ($M)	1.1	4.2	9.1	12.8	13.5	88.2
One-Time Record/Playback						
Units (K)	-	-	325	422	299	NA
Total Semiconductor Content	0	0	189.6	168.0	148.2	NA
Audio/Video Decode/Encode	0	0	65.0	58.0	50.0	NA
Audio ADC/DAC	0	0	5.2	4.5	4.0	NA
NTSC/PAL Decode/Encoder & ADC/DAC	0	0	9.5	8.6	7.8	NA
Channel Decode/Encode	0	0	32.0	27.0	23.0	NA
MCU	0	0	4.0	3.5	3.0	NA
DRAM	0	0	33.4	29.0	25.6	NA
SRAM and ROM	0	0	16.0	15.3	14.7	NA

(Continued)

Table 4-2 (Continued)
DVD-Video Player Semiconductor Market Forecast (Dollars)

	1996	1997	1998	1999	2000	CAGR (%) 1996-2000
Servo System	0	0	9.0	8.5	8.0	NA
Optical Pickup/Laser Diode	0	0	12.5	10.8	9.6	NA
Others	0	0	3.0	2.8	2.5	NA
Total Semiconductor Market ($M)	0	0	61.6	70.9	44.3	NA
Audio/Video Decode/Encode ($M)	0	0	21.1	24.5	14.9	NA
Audio ADC/DAC ($M)	0	0	1.7	1.9	1.2	NA
NTSC/PAL Decode/Encoder and ADC/DAC ($M)	0	0	3.1	3.6	2.3	NA
Channel Decode/Encode ($M)	0	0	10.4	11.4	6.9	NA
MCU ($M)	0	0	1.3	1.5	0.9	NA
DRAM ($M)	0	0	10.9	12.2	7.6	NA
SRAM and ROM ($M)	0	0	5.2	6.5	4.4	NA
Servo System ($M)	0	0	2.9	3.6	2.4	NA
Optical Pickup/Laser Diode ($M)	0	0	4.1	4.6	2.9	NA
Others ($M)	0	0	1.0	1.2	0.7	NA
Recorder and Player						
Units (K)	-	-	-	1,535	3,215	NA
Total Semiconductor Content	0	0	0	166.2	147.1	NA
Audio/Video Decode/Encode	0	0	0	58.0	50.0	NA
Audio ADC/DAC	0	0	0	4.5	4.0	NA
NTSC/PAL Decode/Encoder and ADC/DAC	0	0	0	8.6	7.8	NA
Channel Decode/Encode	0	0	0	27.0	23.0	NA
MCU	0	0	0	3.5	3.0	NA
DRAM	0	0	0	25.0	22.0	NA
SRAM and ROM	0	0	0	15.3	14.7	NA
Servo System	0	0	0	8.5	8.0	NA
Optical Pickup/Laser Diode	0	0	0	13.0	12.1	NA
Others	0	0	0	2.8	2.5	NA
Total Semiconductor Market ($M)	0	0	0	255.0	473.0	NA
Audio/Video Decode/Encode ($M)	0	0	0	89.0	160.8	NA
Audio ADC/DAC ($M)	0	0	0	6.9	12.9	NA
NTSC/PAL Decode/Encoder and ADC/DAC ($M)	0	0	0	13.2	25.1	NA
Channel Decode/Encode ($M)	0	0	0	41.4	74.0	NA
MCU ($M)	0	0	0	5.4	9.6	NA

(Continued)

Table 4-2 (Continued)
DVD-Video Player Semiconductor Market Forecast (Dollars)

	1996	1997	1998	1999	2000	CAGR (%) 1996-2000
DRAM ($M)	0	0	0	38.4	70.7	NA
SRAM and ROM ($M)	0	0	0	23.5	47.3	NA
Servo System ($M)	0	0	0	13.0	25.7	NA
Optical Pickup/Laser Diode ($M)	0	0	0	19.9	38.9	NA
Others ($M)	0	0	0	4.3	8.0	NA
Total						
Units (K)	360	1,495	3,956	7,755	10,283	131.2
Total Semiconductor Content	146.2	133.3	121.6	116.4	108.2	-7.3
Audio/Video Decode/Encode	40.0	37.0	34.7	34.1	31.6	-5.7
Audio ADC/DAC	4.5	4.2	3.8	3.5	3.2	-8.1
NTSC/PAL Decode/Encoder and ADC/DAC	6.4	6.0	5.8	5.7	5.3	-4.6
Channel Decode/Encode	25.0	23.0	21.0	19.5	17.7	-8.2
MCU	5.0	4.6	4.0	3.5	3.0	-12.0
DRAM	25.3	22.2	20.0	18.6	16.9	-9.6
SRAM and ROM	13.0	12.0	11.0	11.5	11.6	-2.8
Servo System	12.0	10.5	9.0	8.5	8.0	-9.6
Optical Pickup/Laser Diode	12.0	11.0	9.7	9.1	8.7	-7.8
Other	3.0	2.8	2.5	2.4	2.2	-7.8
Total Semiconductor Market ($M)	52.6	199.3	481.0	902.9	1,112.2	114.4
Audio/Video Decode/Encode ($M)	14.4	55.3	137.3	264.2	324.6	117.9
Audio ADC/DAC ($M)	1.6	6.3	15.1	27.4	33.0	112.5
NTSC/PAL Decode/Encoder and ADC/DAC ($M)	2.3	9.0	23.1	44.1	54.5	120.5
Channel Decode/Encode ($M)	9.0	34.4	83.0	151.4	182.4	112.2
MCU ($M)	1.8	6.9	15.8	27.1	30.8	103.5
DRAM ($M)	9.1	33.2	79.1	144.5	173.8	109.0
SRAM and ROM ($M)	4.7	17.9	43.3	89.1	119.3	124.7
Servo System ($M)	4.3	15.7	35.6	65.9	82.3	108.9
Optical Pickup/Laser Diode ($M)	4.3	16.4	38.6	70.9	89.2	113.1
Others ($M)	1.1	4.2	10.1	18.2	22.3	113.2

NA = Not applicable
Source: Dataquest (June 1996)

Table 4-3
DVD Optical Drive Semiconductor Market Forecast (Dollars)

	1996	1997	1998	1999	2000	CAGR (%) 1996-2000
DVD-ROM						
Units (K)	295	2,230	4,891	9,646	12,778	156.5
Total Semiconductor Content	80.9	73.4	64.6	57.9	52.9	-10.1
Channel Decode	25.0	23.0	20.0	17.0	15.0	-12.0
EIDE/SCSI Interface	6.5	6.2	5.9	5.5	5.2	-5.4
MCU	5.0	4.6	4.0	3.5	3.0	-12.0
DRAM	5.9	4.7	4.4	4.0	3.6	-11.6
SRAM and ROM	13.0	12.0	10.5	10.2	10.0	-6.3
Servo System	12.0	10.5	9.0	8.5	8.0	-9.6
Optical Pickup/Laser Diode	12.0	11.0	9.5	8.0	7.0	-12.6
Others	1.5	1.4	1.3	1.2	1.1	-7.5
Total Semiconductor Market ($M)	23.9	163.7	316.0	558.5	676.0	130.7
Channel Decode ($M)	7.4	51.3	97.8	164.0	191.7	125.8
EIDE/SCSI Interface ($M)	1.9	13.8	28.9	53.1	66.4	142.6
MCU ($M)	1.5	10.3	19.6	33.8	38.3	125.8
DRAM ($M)	1.7	10.5	21.5	38.6	46.0	126.7
SRAM and ROM ($M)	3.8	26.8	51.4	98.4	127.8	140.3
Servo System ($M)	3.5	23.4	44.0	82.0	102.2	131.8
Optical Pickup/Laser Diode ($M)	3.5	24.5	46.5	77.2	89.4	124.2
Others ($M)	0.4	3.1	6.4	11.6	14.1	137.4
DVD-WORM						
Units (K)	-	210	713	762	785	NA
Total Semiconductor Content	0	102.7	85.2	75.9	68.3	NA
Channel Decode/Encode	0	42.0	32.0	27.0	23.0	NA
EIDE/SCSI Interface	0	6.2	5.9	5.5	5.2	NA
MCU	0	4.6	4.0	3.5	3.0	NA
DRAM	0	4.7	4.4	4.0	3.6	NA
SRAM and ROM	0	19.0	16.0	15.3	14.7	NA
Servo System	0	10.5	9.0	8.5	8.0	NA
Optical Pickup/Laser Diode	0	14.0	12.5	10.8	9.6	NA
Others	0	1.7	1.4	1.3	1.2	NA

(Continued)

Table 4-3 (Continued)
DVD Optical Drive Semiconductor Market Forecast (Dollars)

	1996	1997	1998	1999	2000	CAGR (%) 1996-2000
Total Semiconductor Market ($M)	0	21.6	60.7	57.9	53.6	NA
Channel Decode/Encode ($M)	0	8.8	22.8	20.6	18.1	NA
EIDE/SCSI Interface ($M)	0	1.3	4.2	4.2	4.1	NA
MCU ($M)	0	1.0	2.9	2.7	2.4	NA
DRAM ($M)	0	1.0	3.1	3.0	2.8	NA
SRAM and ROM ($M)	0	4.0	11.4	11.7	11.5	NA
Servo System ($M)	0	2.2	6.4	6.5	6.3	NA
Optical Pickup/Laser Diode ($M)	0	2.9	8.9	8.2	7.5	NA
Others ($M)	0	0.4	1.0	1.0	0.9	NA
DVD-RAM						
Units (K)	-	-	864	7,091	11,335	NA
Total Semiconductor Content	0	0	86.1	78.1	70.8	NA
Channel Decode/Encode	0	0	30.0	27.0	23.0	NA
EIDE/SCSI Interface	0	0	5.9	5.5	5.2	NA
MCU	0	0	4.0	3.5	3.0	NA
DRAM	0	0	4.4	4.0	3.6	NA
SRAM and ROM	0	0	15.8	15.3	14.7	NA
Servo System	0	0	9.0	8.5	8.0	NA
Optical Pickup/Laser Diode	0	0	15.5	13.0	12.1	NA
Others	0	0	1.5	1.3	1.2	NA
Total Semiconductor Market ($M)	0	0	74.4	553.8	802.5	NA
Channel Decode/Encode ($M)	0	0	25.9	191.5	260.7	NA
EIDE/SCSI Interface ($M)	0	0	5.1	39.0	58.9	NA
MCU ($M)	0	0	3.5	24.8	34.0	NA
DRAM ($M)	0	0	3.8	28.4	40.8	NA
SRAM and ROM ($M)	0	0	13.6	108.5	166.6	NA
Servo System ($M)	0	0	7.8	60.3	90.7	NA
Optical Pickup/Laser Diode ($M)	0	0	13.4	92.2	137.2	NA
Others ($M)	0	0	1.3	9.2	13.6	NA

(Continued)

Table 4-3 (Continued)
DVD Optical Drive Semiconductor Market Forecast (Dollars)

	1996	1997	1998	1999	2000	CAGR (%) 1996-2000
Total						
Units (K)	295	2,440	6,467	17,500	24,898	142.8
Total Semiconductor Content	80.9	75.9	69.7	66.9	61.5	-6.6
Channel Decode/Encode	25.0	24.6	22.7	21.5	18.9	-6.8
EIDE/SCSI Interface	6.5	6.2	5.9	5.5	5.2	-5.4
MCU	5.0	4.6	4.0	3.5	3.0	-12.0
DRAM	5.9	4.7	4.4	4.0	3.6	-11.6
SRAM and ROM	13.0	12.6	11.8	12.5	12.3	-1.4
Servo System	12.0	10.5	9.0	8.5	8.0	-9.6
Optical Pickup/Laser Diode	12.0	11.3	10.6	10.1	9.4	-5.9
Others	1.5	1.4	1.3	1.2	1.1	-6.5
Total Semiconductor Market ($M)	23.9	185.2	451.0	1,170.2	1,532.1	183.1
Channel Decode/Encode ($M)	7.4	60.1	146.5	376.0	470.4	182.6
EIDE/SCSI Interface ($M)	1.9	15.1	38.2	96.2	129.5	186.7
MCU ($M)	1.5	11.2	25.9	61.2	74.7	166.8
DRAM ($M)	1.7	11.5	28.5	70.0	89.6	167.9
SRAM and ROM ($M)	3.8	30.8	76.4	218.5	305.9	198.9
Servo System ($M)	3.5	25.6	58.2	148.7	199.2	173.9
Optical Pickup/Laser Diode ($M)	3.5	27.5	68.8	177.6	234.1	185.2
Others ($M)	0.4	3.5	8.7	21.8	28.6	183.5

NA = Not applicable
Source: Dataquest (June 1996)

Table 4-4
DVD Video Decode/Encode Board/Chipset Semiconductor Market Forecast (Dollars)

	1996	1997	1998	1999	2000	CAGR (%) 1996-2000
Video Decode Board						
Units (K)	40	1,623	4,603	9,628	12,787	324.2
Total Semiconductor Content	84.7	77.4	67.5	57.1	49.4	-12.6
Audio/Video Decode	40.0	37.0	32.0	26.0	22.0	-13.9
Audio DAC	4.5	4.2	3.7	3.2	2.8	-11.2
NTSC/PAL Encoder & DAC	6.4	6.0	5.5	4.7	4.0	-11.1
PCI Interface	5.0	4.8	4.5	4.3	4.0	-5.4
DRAM	25.3	22.2	18.8	16.2	14.1	-13.6
SRAM and ROM	2.0	1.8	1.7	1.5	1.4	-8.5
Others	1.5	1.4	1.3	1.2	1.1	-7.5
Total Semiconductor Market ($M)	3.3	125.6	310.7	549.8	631.7	270.7
Audio/Video Decode ($M)	1.6	60.0	147.3	250.3	281.3	265.3
Audio DAC ($M)	0.2	6.8	17.0	30.8	35.8	276.7
NTSC/PAL Encoder & DAC ($M)	0.3	9.7	25.3	45.3	51.1	277.1
PCI Interface ($M)	0.2	7.8	20.7	41.4	51.1	301.2
DRAM ($M)	1.0	36.0	86.5	156.0	180.3	266.5
SRAM and ROM ($M)	0.1	2.9	7.8	14.4	17.9	288.0
Others ($M)	0.1	2.3	6.0	11.6	14.1	292.5
Video Encode/Decode Board						
Units (K)	-	-	758	1,480	3,824	NA
Total Semiconductor Content	0	0	121.3	107.7	94.4	NA
Audio/Video Decode/Encode	0	0	65.0	58.0	50.0	NA
Audio ADC/DAC	0	0	5.2	4.5	4.0	NA
NTSC/PAL Decode/Encoder and ADC/DAC	0	0	9.5	8.6	7.8	NA
PCI Interface	0	0	4.5	4.3	4.0	NA
DRAM	0	0	33.4	29.0	25.6	NA
SRAM and ROM	0	0	1.7	1.5	1.4	NA
Others	0	0	2.0	1.8	1.6	NA

(Continued)

Table 4-4 (Continued)
DVD Video Decode/Encode Board/Chipset Semiconductor Market Forecast (Dollars)

	1996	1997	1998	1999	2000	CAGR (%) 1996-2000
Total Semiconductor Market ($M)	0	0	92.0	159.4	361.0	NA
Audio/Video Decode/ Encode ($M)	0	0	49.3	85.8	191.2	NA
Audio ADC/DAC ($M)	0	0	3.9	6.7	15.3	NA
NTSC/PAL Decode/Encoder & ADC/DAC ($M)	0	0	7.2	12.7	29.8	NA
PCI Interface ($M)	0	0	3.4	6.4	15.3	NA
DRAM ($M)	0	0	25.3	42.9	97.9	NA
SRAM and ROM ($M)	0	0	1.3	2.2	5.4	NA
Others ($M)	0	0	1.5	2.7	6.1	NA
Total						
Units (K)	40	1,623	5,361	11,108	16,611	352.8
Total Semiconductor Content	84.7	77.4	75.1	63.8	59.8	-8.4
Audio/Video Decode/Encode	40.0	37.0	36.7	30.3	28.4	-8.2
Audio ADC/DAC	4.5	4.2	3.9	3.4	3.1	-9.1
NTSC/PAL Decode/Encoder and ADC/DAC	6.4	6.0	6.1	5.2	4.9	-6.6
PCI Interface	5.0	4.8	4.5	4.3	4.0	-5.4
DRAM	25.3	22.2	20.9	17.9	16.7	-9.8
SRAM and ROM	2.0	1.8	1.7	1.5	1.4	-8.5
Others	1.5	1.4	1.4	1.3	1.2	-5.1
Total Semiconductor Market ($M)	3.3	125.6	402.6	709.2	992.6	315.0
Audio/Video Decode/Encode ($M)	1.6	60.0	196.6	336.2	472.5	315.8
Audio ADC/DAC ($M)	0.2	6.8	21.0	37.5	51.1	311.8
NTSC/PAL Decode/Encoder & ADC/DAC ($M)	0.3	9.7	32.5	58.0	81.0	323.0
PCI Interface ($M)	0.2	7.8	24.1	47.8	66.4	328.3
DRAM ($M)	1.0	36.0	111.8	198.9	278.2	308.5
SRAM and ROM ($M)	0.1	2.9	9.1	16.7	23.3	314.2
Others ($M)	0.1	2.3	7.5	14.2	20.2	329.6

NA = Not applicable
Source: Dataquest (June 1996)

Semiconductor Suppliers

Although a number of semiconductor companies have announced plans to develop and market chips for the DVD market, there are still many companies that have not made formal announcements of their product plans. Table 4-5 presents a matrix of semiconductor products and chip companies that Dataquest expects to enter the DVD market. Many of the companies in this table have not actually announced plans for DVD. However, based on their participation in other mass storage markets, including optical drives and rigid disk drives, Dataquest believes they have a strong possibility of entering the DVD chip market.

Motorola, Hyundai, and Zoran have all revealed detailed DVD chipsets. The following sections provide a brief description of their products. Following these descriptions is a brief outline of DVD semiconductor announcements from other companies.

Motorola

Motorola's DVD chipset solution, shown in Figure 4-5, shows an advanced stage of integration in both the channel-processing and audio/video-processing sections of a DVD design. Its product is also well designed to target both the DVD-ROM and DVD-Video player segments. While the schematic in Figure 4-5 shows a complete design for a DVD-Video player, the Rabbit chip can be used separately to create a highly-integrated channel processing solution for a DVD-ROM drive. The Rabbit chip integrates all the major functions for a DVD-ROM drive, from the servo control to the EIDE interface, in a single mixed-signal chip. The company has also leveraged this design to provide a solution for the current high-volume CD-ROM market. A subsection of the Rabbit chip can be used to provide an integrated CD-ROM chip called the Raccoon.

Adding the Coyote chip to the Rabbit chip enables the creation of a complete DVD-Video player solution. In addition to providing support for all the standards for DVD, MPEG-2, AC-3, and linear PCM, the Coyote also performs MPEG-1 processing support for Video CD players. It is also notable that as of June 1996, Motorola was the only company besides Zoran to have Dolby Labs AC-3 certification. In a recent move, Motorola licensed Macrovision's copy-protection technology. This would appear to position Motorola so it can move quickly with potential enhancements to its DVD solution, depending on the outcome of copyright protection negotiations. With the combination of the Rabbit, Coyote, radio frequency (RF) amplifier, 16-bit microcontroller (MCU), and memory products that Motorola can supply, the company is almost a complete one-stop solution for DVD manufacturers.

Hyundai

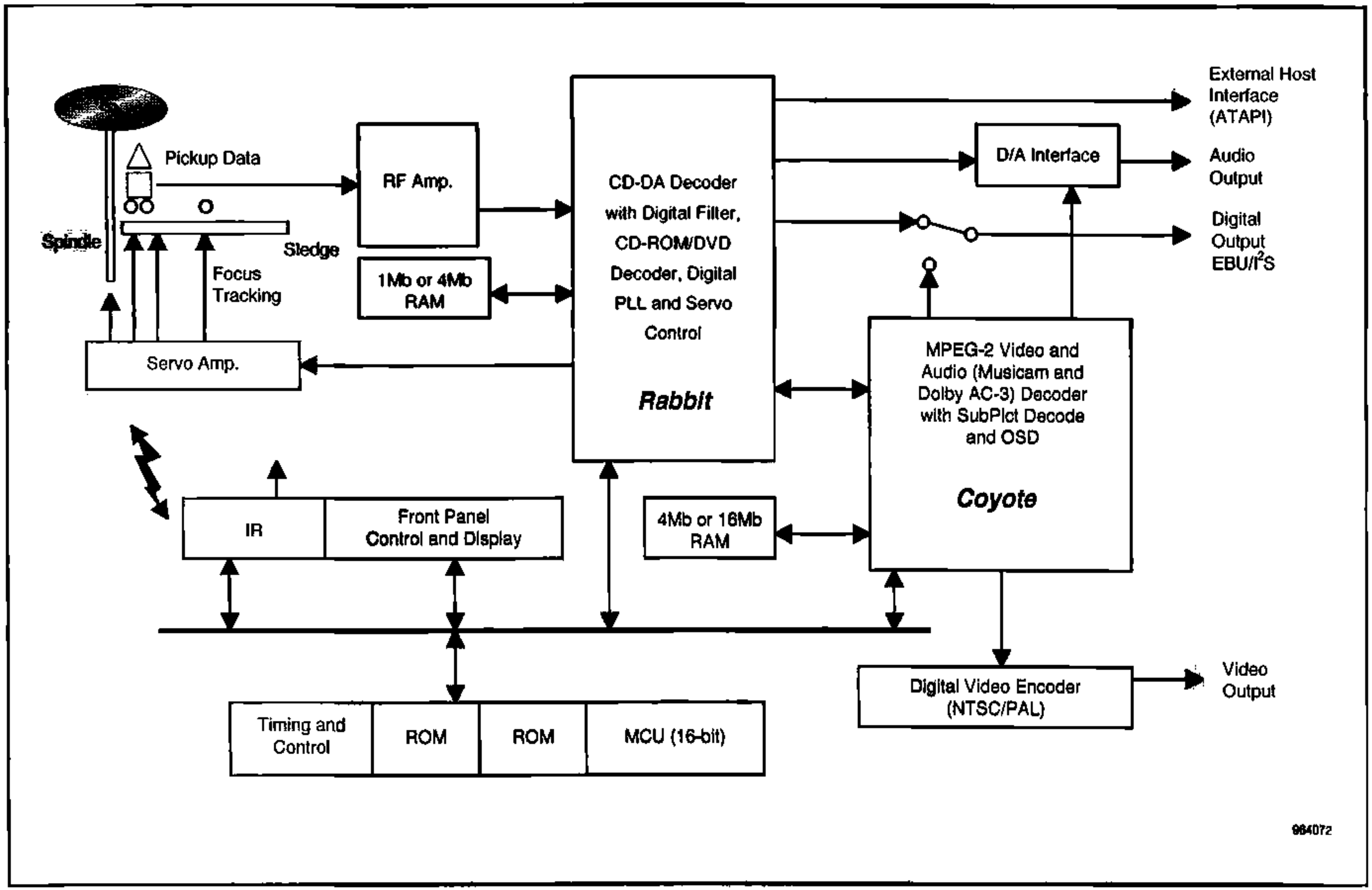
The PrAVO decoder from Hyundai leverages earlier designs developed for the set-top box market. Hyundai claims that over 80 percent of the functional cells used in its DVD decoder, shown in Figure 4-6, have already been proven in commercial products such as the HDM8200 MPEG-2 decoder and HDM8500 demodulator families for the set-top box market. At the core of Hyundai's chip is a micro-SPARC RISC processor that offers 50 mips of processing power. The architecture of this chip and

Table 4-5
Announced and Potential DVD Chip Supplier Matrix

Semiconductor Manufacturer	Announced or Expected Supplier	Video/ Audio Processing	Laser Diode	Servo Electronics	Channel Decode/ Encode	EIDE/ SCSI Interface
Adaptec	E					X
Allegro	E			X		
Analog Devices	E	X		X	X	
C-Cube	A	X				
Cirrus Technologies	E			X	X	X
GEC Plessey	E			X	X	X
Hitachi	A			X	X	X
Hyundai	A	X				
IBM	A	X				
IMP	E				X	
LSI Logic	A	X				
Lucent Technologies	E			X	X	X
Matsushita	A	X	X	X	X	
MicroLinear	E			X	X	
Mitsubishi	A	X			X	
Motorola	A	X		X		
National Semiconductor	E			X	X	
Oak Technology	A	X				
Philips	A	X	X	X	X	
Pioneer	A	X				
Q Logic	E			X	X	X
Samsung	E	X				
Sanyo	A		X	X	X	
SGS-Thomson	A	X		X	X	X
Sharp	A		X	X	X	
Silicon Systems	A			X	X	X
Siliconix	E			X		
Sony	E	X	X	X	X	
Symbios	E					X
Texas Instruments	A	X		X	X	X
Toshiba	A	X	X			
VLSI Technology	A	X				
Zoran	A	X				

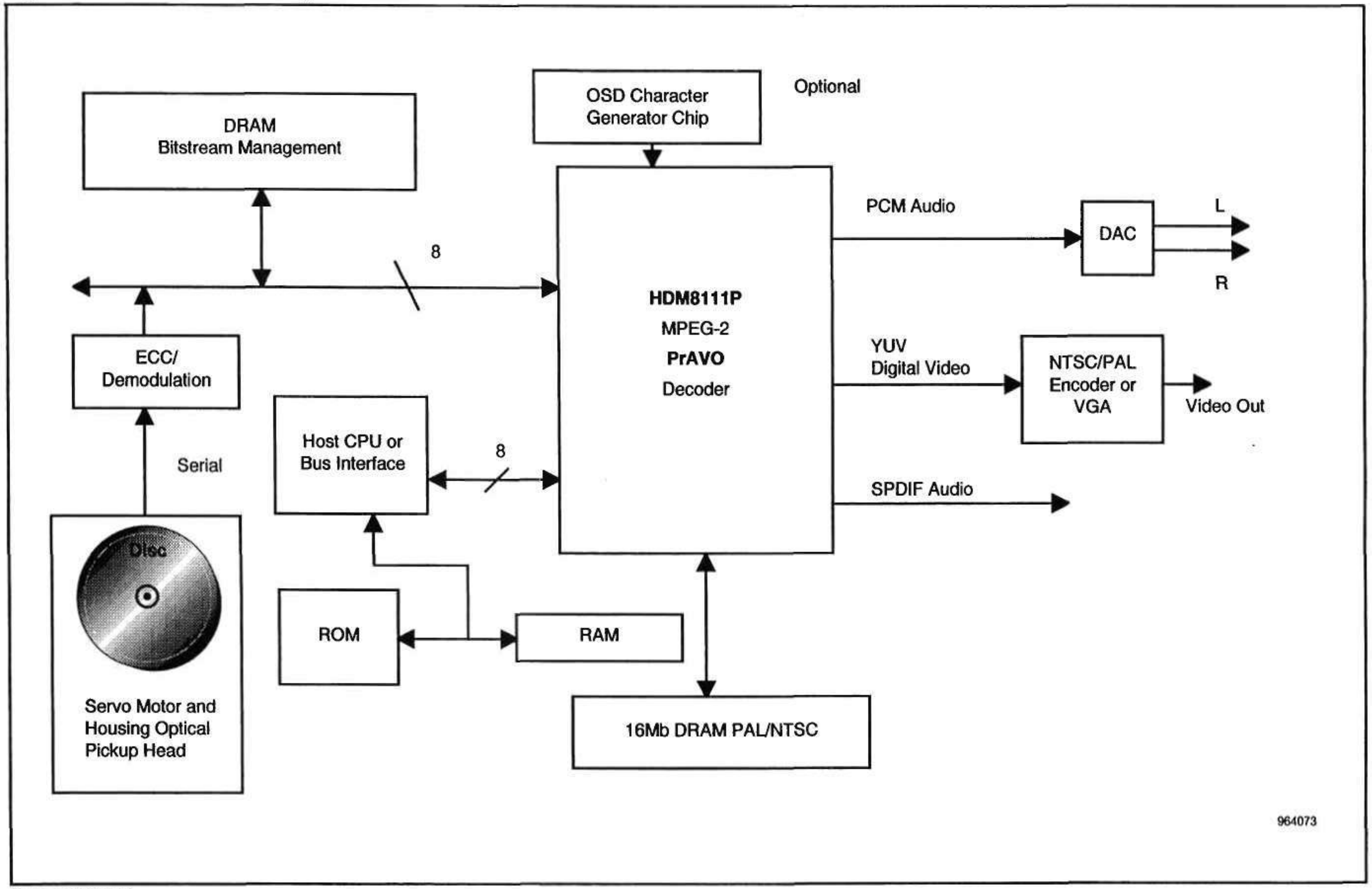
Note: A = announced supplier, E = expected supplier
Source: Dataquest (June 1996)

Figure 4-5
Motorola DVD Player Chipset



Source: Motorola

Figure 4-6
Hyundai PrAVO DVD Chip Solution



Source: Hyundai

the support offered by important software tools help to simplify the overall system design task. For example, the PrAVO is programmable using the high-level C programming language, which will help reduce time to market, and the chip offers a glueless interface to both Intel and Motorola bus types. Samples of the PrAVO will be available in July 1996, with volume production planned for October 1996. Cost of the chip in production quantities will be under $45.

Zoran

The DVD4PC from Zoran is actually a reference design that implements a complete DVD decode solution on a PCI add-in card. At the heart of the design shown in Figure 4-7 are a two-channel AC-3 chip, the ZR38521, from Zoran and an MPEG-2 video decoder from SGS-Thomson, the STi3520A. At the time AC-3 was selected for the audio decoding in the final DVD specification, Zoran was the only Dolby-approved manufacturer of an AC-3 chip. AC-3 chips were actually developed as part of a technology partnership between Dolby Labs and Zoran beginning in 1991. The DVD4PC solution offers the advantage of fast time to market, since it is based on chips from the current high-volume producers of AC-3 and MPEG-2 chips, Zoran and SGS-Thomson. The availability of a current Dolby-approved solution is significant because in the Dolby certification process a chip must pass strict tests at both the system and chip level, which can be a lengthy process. While other manufacturers can claim that they offer AC-3 solutions, they must pass this certification process before they can actually supply chips.

Zoran's track record in the audio decoder market is very impressive, with an established presence in the Japanese company-dominated audio electronics sector. Zoran claims that 11 Japanese manufacturers are using its AC-3 chip in their audio products and that its six-channel surround-sound chip has also been designed into a number of first generation DVD-Video players. Over 5,000 theaters also offer AC-3 audio based on Zoran products. Zoran is working to migrate from a high-performance/high-end product market to a high-performance/high-volume product. The DVD4PC reference board is targeted at the PC add-in decoder card market. Zoran has announced that the ZR38521 is available now for $22 in quantities of 10,000. Zoran also supplies a PCI controller for this design, the ZR36120.

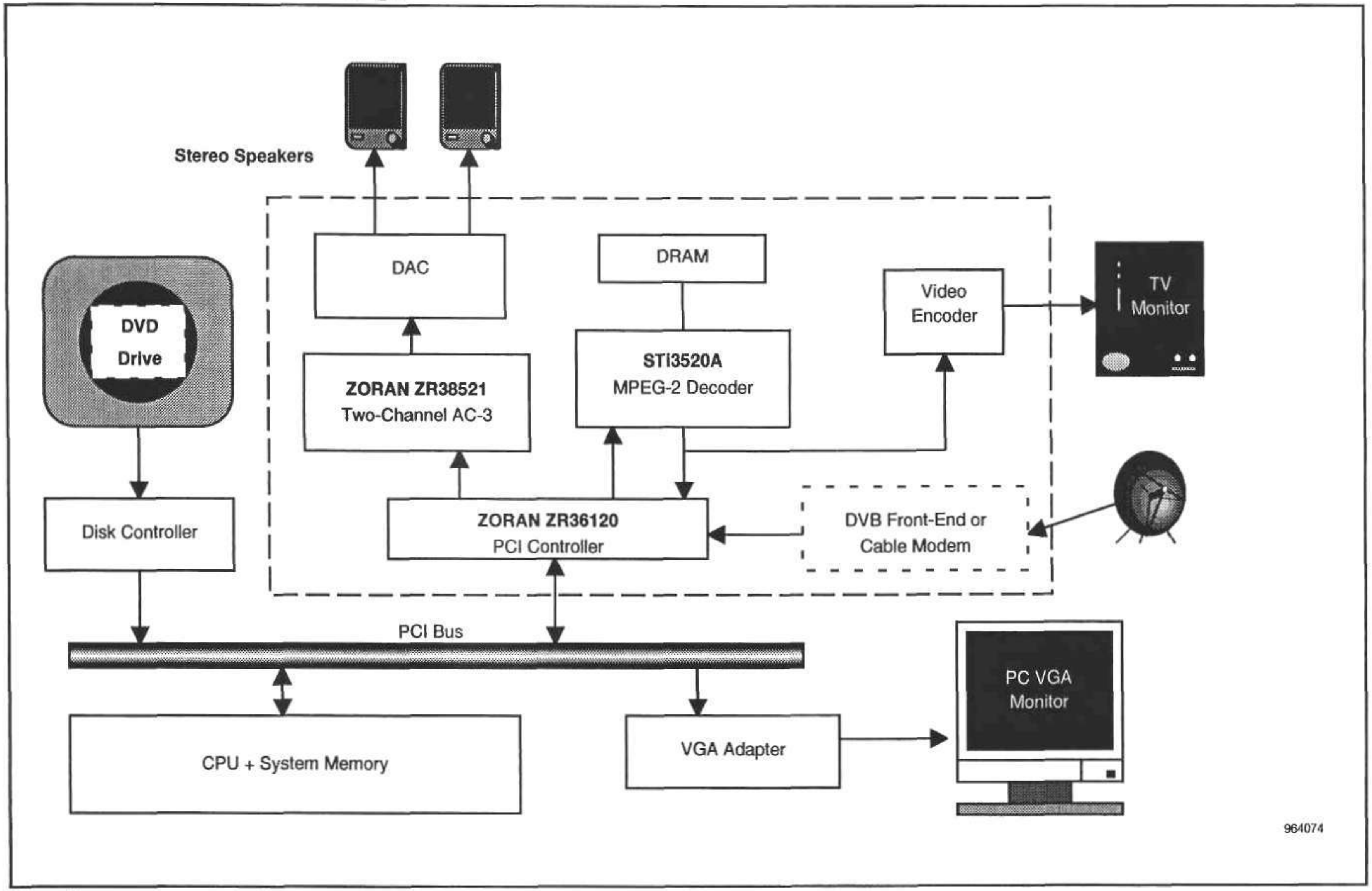
Other Announced Plans from Chip Suppliers

Information on DVD semiconductor announcements from other chip companies is presented below. These companies, along with Motorola, Zoran, Hyundai, LSI Logic, and VLSI Technology, have been working with DVD manufacturers for many months leading up to the launch of DVD products.

Philips

The company is offering a DVD chipset that includes a servo IC, a read channel IC, motor controllers, and an MPEG-2 audio/video decoder. Its current audio/video decoder, the SAA7201, will soon be replaced by a second-generation design, the SAA7202.

Figure 4-7
Zoran's DVD4PC Reference Design



Source: Zoran

Texas Instruments

Texas Instruments has presented a complete chipset solution, from the RF amplifier to the channel and audio/video decoders. Its design includes an ARM7 RISC processor and TMS320XXXX DSPs in the decoder functions and a TMC578xx for the servo controller. The company already has a second-generation integrated DVD solution in development.

Silicon Systems

In May 1996, Silicon Systems Inc. (SSI) announced two new chips for DVD-ROM drives, the 33P3720 analog front-end/read channel processor and the 33C3911 CD-ROM decoder with EIDE interface. The 33P3720 is a high-performance BiCMOS chip that includes a complete DVD servo algebra repertoire. The company plans to begin sampling chips in January 1997, with the 33P3720 priced at $10 and the 33C3911 at $12 in quantities of 1,000. SSI has been a strong player in providing semiconductor products for optical storage devices and is one of the earliest companies to announce a front-end solution for DVD drives. Shortly after it announced its DVD chipset, the company was acquired by Texas Instruments.

SGS-Thomson

On the front end, SGS-Thomson has been working on two analog ICs, including a preamplifier and two digital ICs for demodulation. The company has already begun sampling these chips to its customers. In addition to supplying MPEG-2 chips to the market, it is developing its own integrated back-end solution and working on new architectures for the PC and DVD-Video player market, which it plans to patent. It is now producing chips in a 0.5-micron process and will soon move to a 0.35-micron fabrication.

Oak Technology

Oak Technology has announced a single-chip audio/video decoder, the OTI-226. The design is based on a proprietary 32-bit RISC engine core and is fabricated in 0.35-micron technology.

Summary and Conclusions

The number of systems manufacturers and chip companies that will compete in the DVD arena will create a dynamic and highly competitive environment. While the forecast market growth will create very profitable opportunities, the nature of the competition will lead to a number of casualties among systems and semiconductor players. Competitors should expect the consumer to be very demanding in terms of system performance and price. These demands will be reflected back to the semiconductor companies, which will be placed under heavy price and performance pressures.

Because the technologies shaping this market will continue to develop over the forecast period, chip companies seeking to be successful in this market should be prepared to continue making major investments in their product development. As they seek to reduce their product development costs, systems manufacturers will value complete systems solutions from semiconductor manufacturers. Chip companies that are unable to provide a complete solution with their own product line should seek alliances with other companies that can complement their strengths. Also, semiconductor manufacturers should develop strategies that will allow them to leverage their products across multiple next-generation consumer electronics products. This will allow them to maximize their profits and reduce their risks in this exciting but turbulent market segment.

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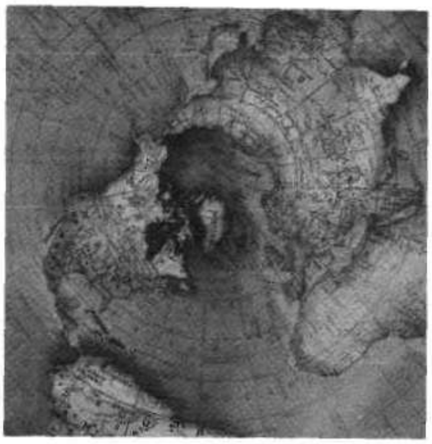

Dataquest

New Video Game Hardware: Technology Playing at the Next Level

Focus Report

Program: Consumer Multimedia Semiconductors and Applications Worldwide
Product Code: MSAM-WW-FR-9601
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Chapter 1
Executive Summary

Exciting new video game platforms such as Saturn, Playstation, Ultra-64, Virtual Boy, M2, and Jaguar have captured the attention of the video game industry in 1995. With the 16-bit video game market continuing to slump after its 1993 peak, video game companies are looking to these next-generation 32- and 64-bit platforms to drive a new wave of video games into the consumer markets. Behind these new platforms is an impressive array of technology enabling the features that will draw video game players back into the market for new video game controllers and software.

Dataquest predicts that worldwide shipments of these new video game controllers will climb to almost 18 million by the year 2000. With the semiconductor content in this new generation of controllers leaping to over 66 percent of manufacturing cost, the semiconductor market driven by video game controllers will reach $2.3 billion by the year 2000. This forecast is based on the average factory price of new video game controllers dropping below $200 by the year 2000. If prices decline more rapidly, the unit shipments and semiconductor market could grow even larger. This report presents an in-depth analysis of the technologies and semiconductor products shaping the new game controllers that will fuel the video game market.

Building on the market overview presented in Chapter 2, exhaustive analyses of the Sega Saturn and the Sony Playstation are presented in Chapters 3 and 4. A complete bill of materials with forecast component and manufacturing costs is also provided for these two systems. Chapter 5 provides detailed information on products from other major players, such as Nintendo, 3DO, and Atari, along with a cross-platform system comparison of these new video game controllers. In-depth discussions of critical technologies such as compression, advanced DRAM architectures, 3-D graphics, CD-ROM drives, sound, modems, and virtual reality are presented in Chapter 6. This is followed by an analysis of the new MPUs, graphics chips, controller chips, and memory products that are competing for a slice of the next-generation video game semiconductor market. At the end of Chapter 6, a detailed forecast of the market opportunity by major semiconductor categories is presented. Chapter 7 highlights the products and design wins of a number of key semiconductor suppliers. The final chapter provides insight into the challenges faced by semiconductor companies competing in this market segment and strategies that may be employed to leverage investments and reduce risks.

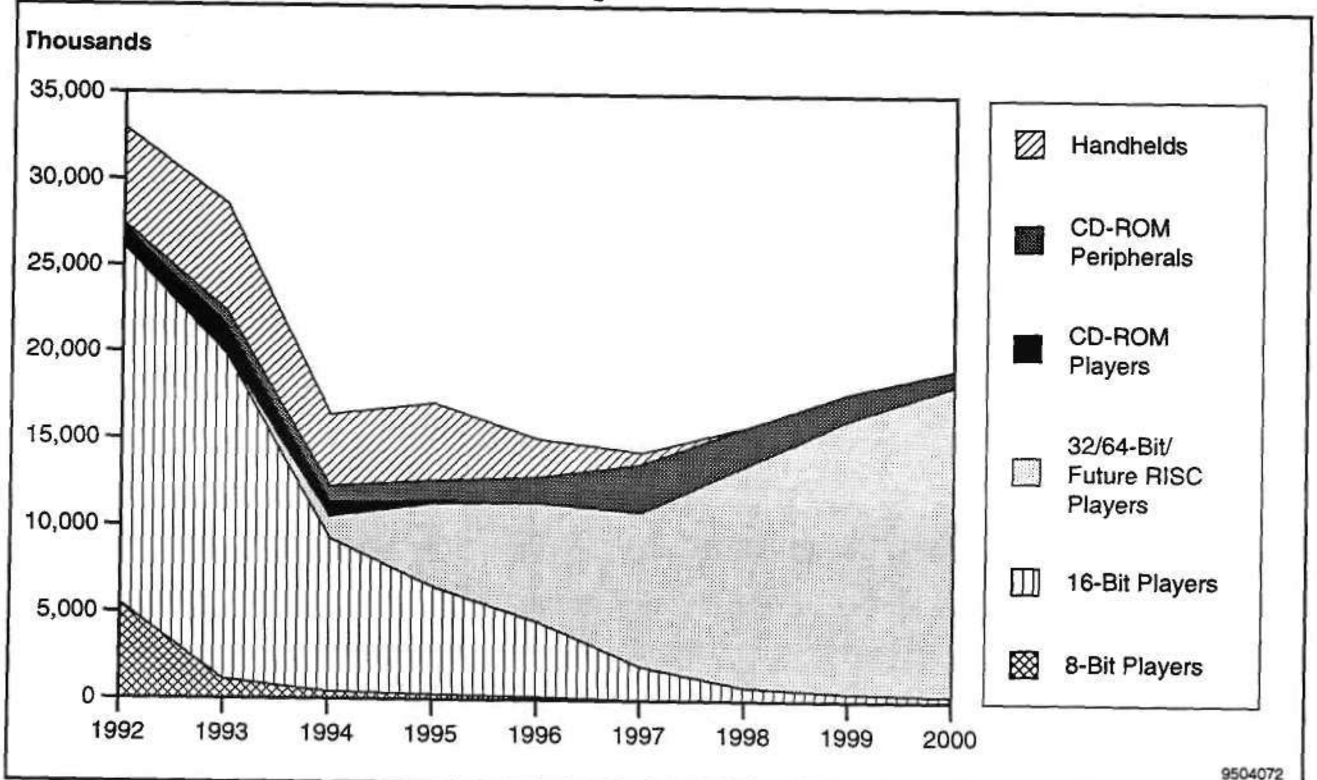
Project Contributors: Dale Ford, Geoff Ballew, Allen Leibovitch, Greg Sheppard, and Kun Soo Lee

Chapter 2
Market Overview

The Video Game Controller Market

The major news in the video game market during 1995 has been the introduction of 32/64-bit next-generation video game controllers by major players in the industry. Following the 8- and 16-bit market cycles, these 32/64-bit controllers are expected to drive the next wave of video game sales and technology. As shown in Figure 2-1 and Table 2-1, overall shipments of video game controllers peaked during 1993 on the strength of the 16-bit game generation. However, 1994 saw a sharp decline in both player and software sales. Shipments of a new generation of controllers is expected to slow the overall market decline during 1995 and then provide the strength for a return to market growth during 1997. This report focuses on this new emerging market of 32/64-bit and beyond game technology and the opportunities it presents for suppliers of semiconductors in this market.

Figure 2-1
Worldwide Video Game Hardware Shipment Forecast



Source: Dataquest (July 1995)

Table 2-1
Shipments and Revenue of Video Game Hardware, Worldwide

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Shipments (K)									
8-Bit Players	5,460	1,110	400	280	182	-	-	-	-
16-Bit Players	20,620	18,710	8,860	6,202	4,341	1,954	781	469	328
32/64-Bit/Future RISC Players	-	100	1,237	4,802	6,809	8,886	12,791	15,797	17,869
CD-ROM Players	1,115	1,525	860	120	-	-	-	-	-
CD-ROM Peripherals	200	900	900	1,200	1,500	2,794	2,200	1,500	900
Handhelds	5,558	6,196	4,115	4,455	2,200	660	-	-	-
Total	32,953	28,541	16,372	17,059	15,032	14,294	15,772	17,766	19,097
Revenue (U.S.$K)									
8-Bit Players	369,278	53,320	13,720	8,400	4,914	-	-	-	-
16-Bit Players	1,958,929	1,665,144	713,218	424,344	252,485	96,595	32,822	16,750	9,840
32/64-Bit/Future RISC Players	-	32,800	395,840	1,680,700	1,940,565	2,292,588	3,044,258	3,190,994	3,395,110
CD-ROM Players	375,397	496,249	239,962	25,144	-	-	-	-	-
CD-ROM Peripherals	32,060	144,270	144,270	251,160	313,950	444,265	283,800	733,950	440,370
Handhelds	360,550	350,785	215,485	267,907	125,860	36,658	-	-	-
Total	3,096,213	2,742,569	1,722,495	2,657,655	2,637,774	2,870,106	3,360,880	3,941,694	3,845,320
Average Selling Price, Factory (U.S.$)									
8-Bit Players	68	48	34	30	27	-	-	-	-
16-Bit Players	95	89	80	68	58	49	42	36	30
32/64-Bit/Future RISC Players	-	328	320	350	285	258	238	202	190
CD-ROM Players	337	325	279	210	-	-	-	-	-
CD-ROM Peripherals	160	160	160	209	209	159	129	489	489
Handhelds	65	57	52	60	57	56	-	-	-
Overall Average	86	82	92	98	102	98	81	100	87

Source: Dataquest (July 1995)

Major Players in the Video Game Market

The most familiar names in the video game industry have been Sega and Nintendo. Table 2-2 shows the dominance of these two companies in the video game industry, where they captured 99 percent of the 16-bit player market in 1994. However, the rise of new 32/64-bit controllers has brought the entrance of new players 3DO and Sony, along with the re-emergence of certain players such as Atari.

Table 2-2
Worldwide Video Game Hardware Revenue Market Share, 1994 (Thousands of Units and Millions of U.S. Dollars)

	Units (K)	Percentage Share	Revenue (U.S.$M)	Percentage Share
16-Bit Players				
Nintendo	6,296	52.5	506.83	52.5
Sega	5,584	46.5	449.51	46.5
Others	119	1.0	9.56	1.0
32/64-Bit Players				
Sega	500	37.5	71.96	23.5
Panasonic/3DO	412	30.9	129.55	42.3
Sony	300	22.5	84.00	27.4
Atari	50	3.8	8.75	2.9
Others	70	5.3	12.25	4.0

Source: Dataquest (July 1995)

Although this report focuses on video game products from leading players such as Sega, Sony, and Nintendo, a brief overview of all the players with a significant presence in the market is given below:

- Sega: Beginning with the introduction of its 16-bit Genesis video game, Sega has been one of the major forces in the industry. Since then the company has brought the following systems to the market: Sega Game Gear, Sega CD, Sega 32X, and, most recently, Sega Saturn. Although the company has discussed another platform called Neptune, the status of this system is still uncertain.
- Nintendo: This is one of the pioneers of the video game industry and one of the top players today. Nintendo Entertainment System (NES) established the company as a major player, and it followed this 8-bit system with the 16-bit Super NES and portable Game Boy. Its most recent introduction is the 32-bit Virtual Boy, and the 64-bit Ultra-64 platform is expected to ship in April 1996.
- Sony Computer Entertainment: A newcomer to the video game market, Sony has made a big splash with its 32-bit Sony Playstation. It is expected to benefit from its consumer marketing experience and its knowledge of U.S. consumer markets.
- Atari: Following its phenomenal early success with the Pong and Atari 2600 systems in the 1970s and early 1980s, Atari made significant investments in the emerging PC market and lost its presence in the video game industry. The introduction of Jaguar in 1993 signaled its return to the video game market.

- 3DO: Its initial product design was a 32-bit 3DO interactive multiplayer, introduced in October 1993, that used CD-ROM technology instead of the traditional cartridges for games. Panasonic, LG Electronics (Goldstar), Sanyo, and Creative Labs offer four brand names with 3DO technology. 3DO introduced an upgraded version of this 32-bit system in 1995 and has announced plans to ship a 64-bit platform called M2.
- Philips: Its CD-i machine was first introduced in October 1991 at a list price of $899. The digital video cartridge premiered two years later. Its newest box, the CDI450, was introduced at the end of 1994 for $299 ($399 with MPEG). Philips has tried to position its player as a home entertainment system because of its ability to play movies and music as well as video games. Most of its success has been in European markets.
- NEC: NEC Home Electronics has enjoyed most of its success in Japanese video game markets. It introduced its PC-FX machine at the end of 1994.
- SNK: It marketed its first NeoGeo platform several years ago. Its first game player was a high-end system ($600) that played $200 video tape-sized cartridges. It introduced its NeoGeo CD system at the Electronic Entertainment Expo (E3). This system will begin shipping in the United States in fall 1995 for under $500.

Production Trends

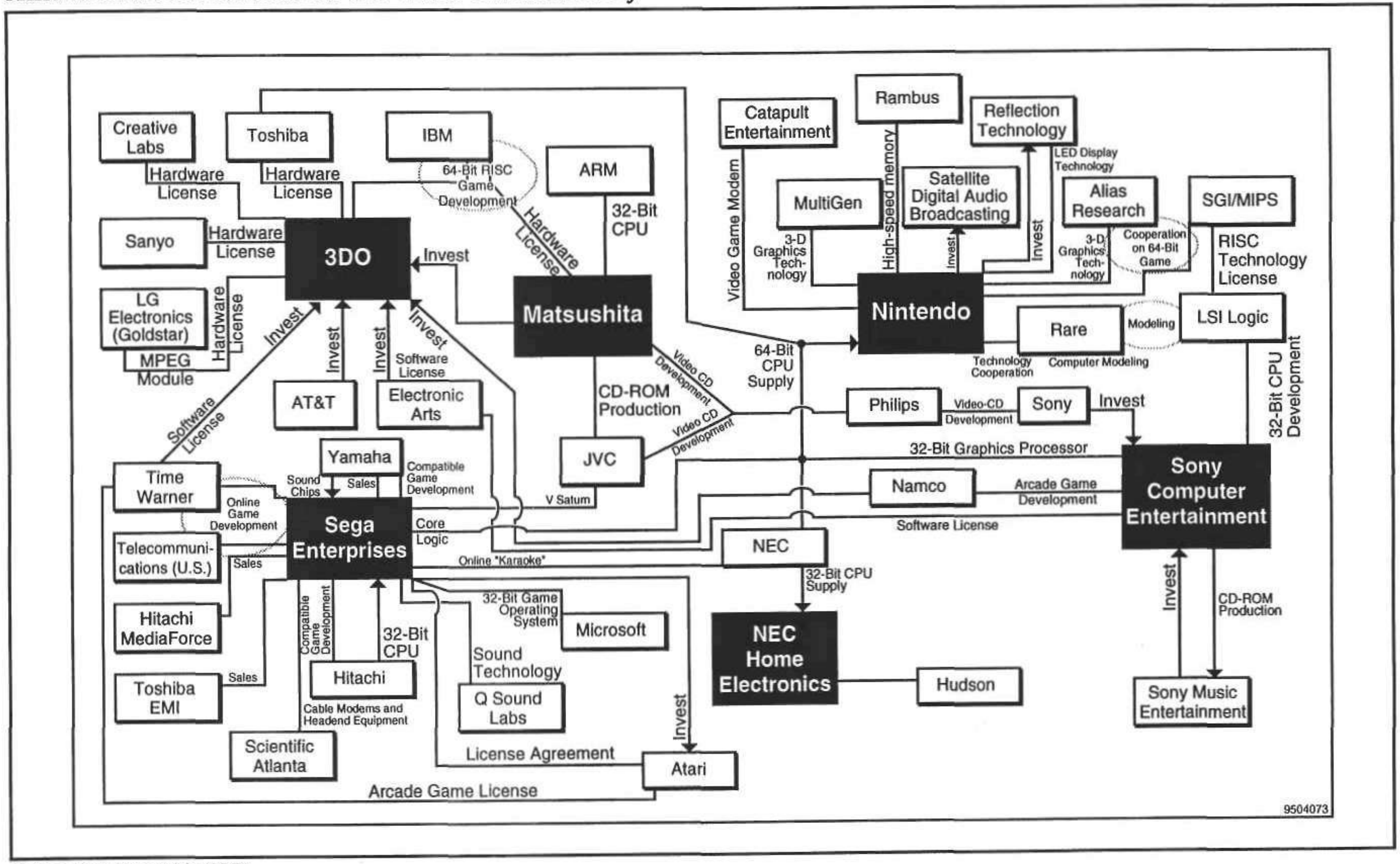
The dramatic rise in the value of the yen has created a major challenge for Japanese manufacturers of video games. Under the business model followed by the many video game companies, hardware is priced very aggressively and sold at little or no profit. These companies realize their profits from software and licensing fees. Production and sale of hardware is viewed chiefly as a means to an end for video game companies like Nintendo, Sega, and Sony. The strong yen has forced these companies to begin moving production of video game players offshore to meet critical price targets for increasing consumer demand.

At the end of 1994, Sega Enterprises announced that it would shift production of its next-generation 32-bit video game machines to Taiwan and other Southeast Asian countries during 1995. The appreciation of the yen was given as the principal reason for this shift. In the past, a subsidiary of Hitachi in Japan has manufactured video game hardware for Sega. In its last public announcement, Sega said it was meeting with a possible foreign partner for producing video games. Sega has also explored the possibility of using Hitachi's overseas manufacturing plants.

Strategic Relationships

Alliances and joint ventures play a central role in the development of the video game market. Figure 2-2 maps out a summary of some of the major alliances in the industry. Players in the video game industry have found that capitalizing on the skills and assets of leading semiconductor companies, hardware manufacturers, and software houses is critical for leveraging resources in an extremely competitive market. Well-managed strategic relationships can improve chances of success in this rapidly evolving industry.

Figure 2-2
Alliances and Investments in the Video Game Industry

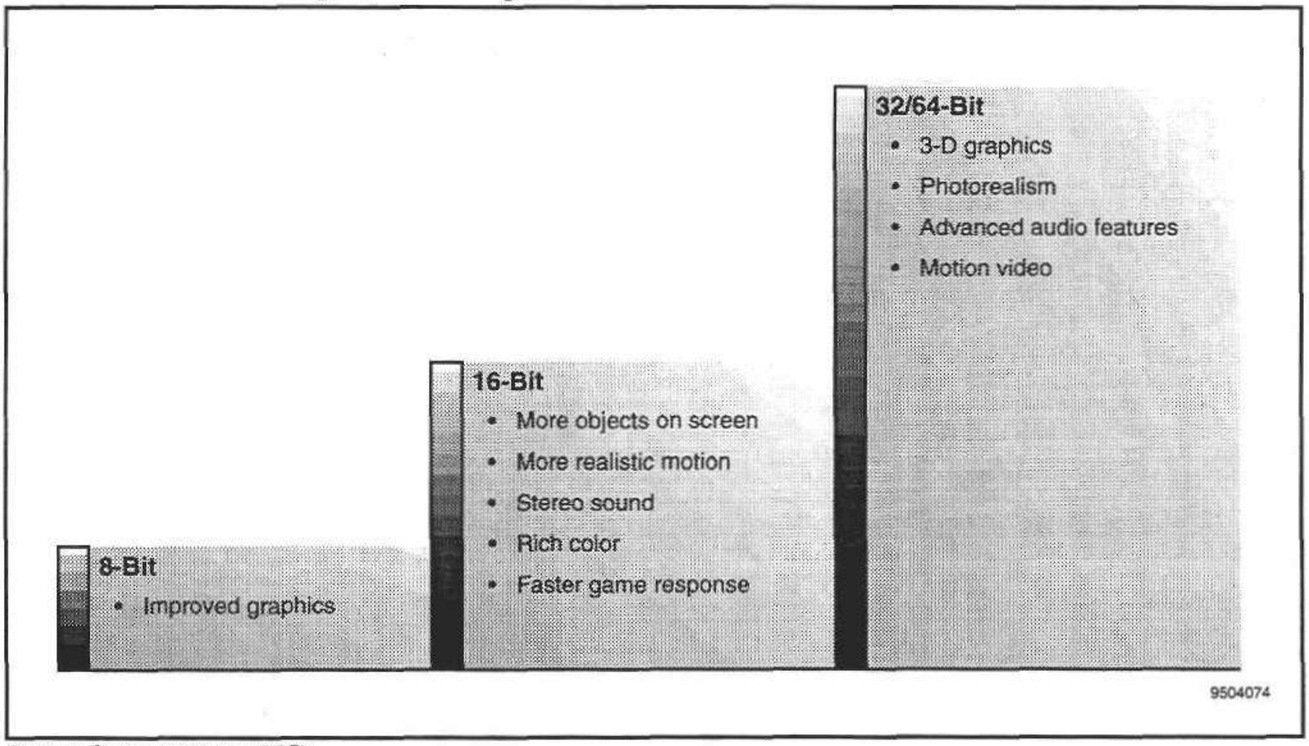


Source: Dataquest (July 1995)

The Semiconductor Market Opportunity

The video game market presents a very attractive opportunity for suppliers of RISC-based CPUs, new DRAM architectures, graphics and audio controllers, compression solutions, and CD-ROM controllers. Key features enabled by each new generation of chips in video game hardware are illustrated in Figure 2-3. The semiconductor market opportunity presented by this new generation of video games is expected to grow from $263 million in 1994 to $2.3 billion by 2000. A discussion of semiconductors and the video game market is presented in Chapter 6, along with a detailed forecast.

Figure 2-3
Next-Generation Chips Delivering Next-Generation Features



Source: Dataquest (July 1995)

Chapter 3
Sega

Sega was founded in the 1950s in Japan as Service Games by an American named David Rosen. The charter of Service Games was to develop and manufacture amusement games, but in 1956, after seeing the popularity of mechanical amusement games in the United States, Rosen began importing them for U.S. military bases. In 1965, Service Games purchased a factory for making jukeboxes and slot machines and returned to manufacturing games. The company began stamping SEGA on its units as a shorthand for SErvice GAmes, and the short form stuck.

After successfully introducing a game called Periscope, Rosen sold Sega to Gulf+Western, retaining his position as CEO. Sega enjoyed continued success and in 1982 posted over $200 million in revenue. The following year, Sega made headlines with three firsts, all in the Japanese market: the first laser disc game, the first 3-D video game, and the first home video game platform.

Soon after, the market crashed for both arcade and home video games. Gulf+Western sold the U.S. assets of Sega to Bally Manufacturing Corporation, but retained Sega's Japanese assets. In 1984, Gulf+Western sold the remaining assets to a group of investors led by David Rosen and a Japanese entrepreneur named Hayao Nakayama. Rosen became the head of U.S. operations and Nakayama assumed CEO responsibilities. Later that same year, the ownership changed once again as Sega's management team and a company called CSK purchased Sega from the previous investor group. Now renamed Sega Enterprises Limited, the company is still based in Japan. Sega Enterprises Limited was listed on the Tokyo Exchange as an over-the-counter stock in 1986. Sega of America Inc. was created that same year with a charter to develop software titles targeted to the U.S. market.

Sega's fortunes as a company truly turned in 1989 with the introduction of the Sega Genesis game unit. The Genesis 16-bit design brought a new level of video game performance to the consumer. Tom Kalinske, president and CEO of Sega of America Inc. since 1990, has championed an aggressive, in-your-face marketing strategy with MTV-style advertising. This marketing effort paid off in skyrocketing Sega Genesis sales, with even greater popularity in the teenage market. Genesis competed primarily with Nintendo's 8-bit Entertainment System (NES) until Nintendo introduced its 16-bit Super NES in 1991. Between 1989 and 1991, Sega captured significant market share from Nintendo.

To keep revenue up as the Genesis game unit grew older and faced new competition from Nintendo, Sega introduced a series of accessories, including the Sega CD and Sega 32X game accelerator. Most recently, of course, Sega brought out its next-generation game platform, Saturn. Introduced in Japan in the fall of 1994, the Sega Saturn was unleashed for the U.S. market on May 11, 1995, the opening day for the Electronic Entertainment Expo in Los Angeles, with much fanfare. Despite rumors of an early release, the announcement was a surprise because Sega had doggedly maintained a release date of September and had even designated September 2 as "Saturn Day."

The Sega Saturn was developed in partnership with Hitachi. The unit uses an abundance of Hitachi parts and is actually manufactured by Hitachi for Sega. For a more detailed discussion of Hitachi's role in the Sega Saturn, see Chapter 7.

Today, Sega Enterprises Limited is still based in Japan, but holds four regionally focused companies: Sega of America Inc., Sega of Canada Inc., Sega of Mexico Inc., and Sega of Europe Ltd. For fiscal year 1995, ending in March 1995, Sega posted net earnings of $59.1 million, down 54.3 percent from the previous year. Also in fiscal year 1995, Sega had $4.42 billion in sales, down 7.9 percent from fiscal 1994. Sega's losses were tied to the home video game market, which posted an operating loss of $52.7 million in fiscal 1995. These losses were offset by operating profits in both the arcade video game and karaoke markets.

Sega Saturn

Executive Product Summary

Announcement/Shipment

- Japan: Shipped November 1994
- United States: Announced March 1995, shipped May 1995

Configuration

- Game unit case with top-mounted CD-ROM drive and cartridge slot
- Two SH2, 32-bit RISC processors, 28.6 MHz, 25 MIPS
- 2MB main memory, two SDRAM 128Kx16x2, 17.5ns, 3.3V, two DRAM 256Kx16, 70ns, 5V, soldered, expandable (RAM cartridge)
- 32Kx8, 100ns backup SRAM
- Core logic implemented in ASICs, FH3007 and 4L02F2718
- CD-ROM drive, double-speed, with 16-bit RISC controller and 512KB DRAM buffer (256Kx16, 80ns), compatible with Saturn CD, audio CD, CD with graphics, and photo CD
- Graphics processors, HD64440F (sprites and polygons), FH3006 (backgrounds), 32K simultaneous colors from a 16.8-million color palette, 320x224 and 720x576 resolution
- 1.5MB SDRAM frame buffer, one 128Kx16x2, 17.5ns, 3.3V, four 128Kx16, 12ns, 3.3V
- 68EC000 sound processor, YMF-292-F FM sound synthesizer
- 32-channel PCM stereo sound, 44.1KHz FM sampling, DSP, QSound compatible
- Audio buffer, 512KB DRAM, 256Kx16, 80ns
- Composite video output and communication connector
- Hand controller, with directional input and nine buttons
- Power supply, 100V in, 15W
- Expansion slot for MPEG (full-motion video) capability

Design/Cost Advantages

The following are the design and cost advantages of the Sega Saturn:

- Large memory, wide array of specialized controllers
- CD-ROM drive for software, cartridge slot for game-saving memory cartridge (battery-powered, sold separately)
- Sturdy case appropriate for younger users

Design/Cost Disadvantages

The following are the design and cost disadvantages of the Sega Saturn:

- High numbers of expensive controllers, ASICs, DRAMs
- System card components spread out; board could have been smaller, more integrated
- Bulky CD-ROM drive increases case height.

Costs and PCB Layouts

A summary semiconductor cost analysis is shown in Table 3-1. A summary of total cost by subsystem is shown in Table 3-2. Figures 3-1 and 3-2 show costs for system electronics and total system, based on high-volume, best-pricing component purchases. Figures 3-3, 3-4, and 3-5 show PCB layouts with functional subsystems.

Table 3-1
Summary Cost Analysis by Semiconductor Category (U.S. Dollars)

	1995 Best Pricing	1996 Best Pricing	1997 Best Pricing
Total Semiconductor	261.61	235.69	212.61
Total IC	261.22	235.31	212.23
Bipolar Digital	1.79	1.58	1.40
MOS Digital	259.42	233.73	210.84
MOS Memory	166.64	148.53	132.45
MOS Microcomponent	82.72	76.52	70.90
MOS Logic	10.07	8.67	7.48
Analog	0	0	0
Total Discrete	0.39	0.39	0.38
Total Optical Semiconductor	0	0	0

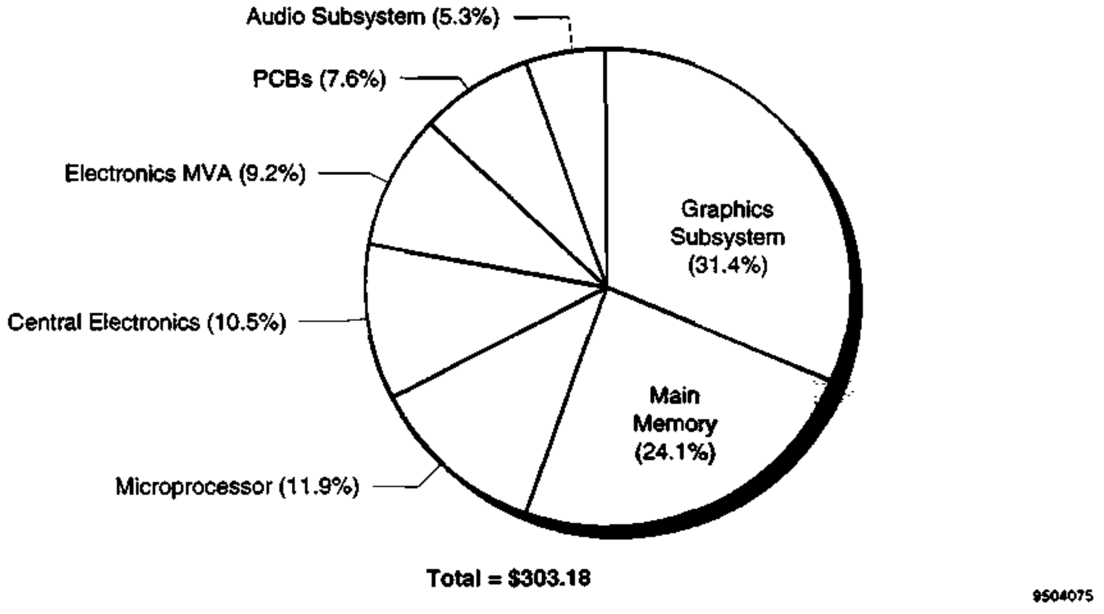
Source: Dataquest (July 1995)

Table 3-2
Summary Cost Analysis by Subsystem (U.S. Dollars)

	1995 Best Cost	1996 Best Cost	1997 Best Cost	Three-Year Average Cost
Graphics Subsystem	95.16	85.51	76.88	85.85
Central Electronics	31.80	29.35	27.19	29.45
Audio Subsystem	16.02	14.33	12.84	14.40
Microprocessor	36.07	34.26	32.55	34.29
Main Memory	73.13	64.50	56.93	64.85
PCBs	23.00	22.54	22.09	22.54
Electronics MVA	28.00	29.12	30.28	29.13
Total Electronics	303.18	279.61	258.75	280.51
CD-ROM Subsystem	92.70	83.50	79.50	85.23
Power Supply	8.98	8.96	8.94	8.96
Mechanical	8.85	8.99	9.13	8.99
Publications	0.25	0.25	0.25	0.25
Hand Controller	5.24	5.14	5.03	5.14
Box MVA	2.81	2.92	3.04	2.92
Freight/Duty	6.00	6.00	6.00	6.00
Total	428.01	395.37	370.65	398.01

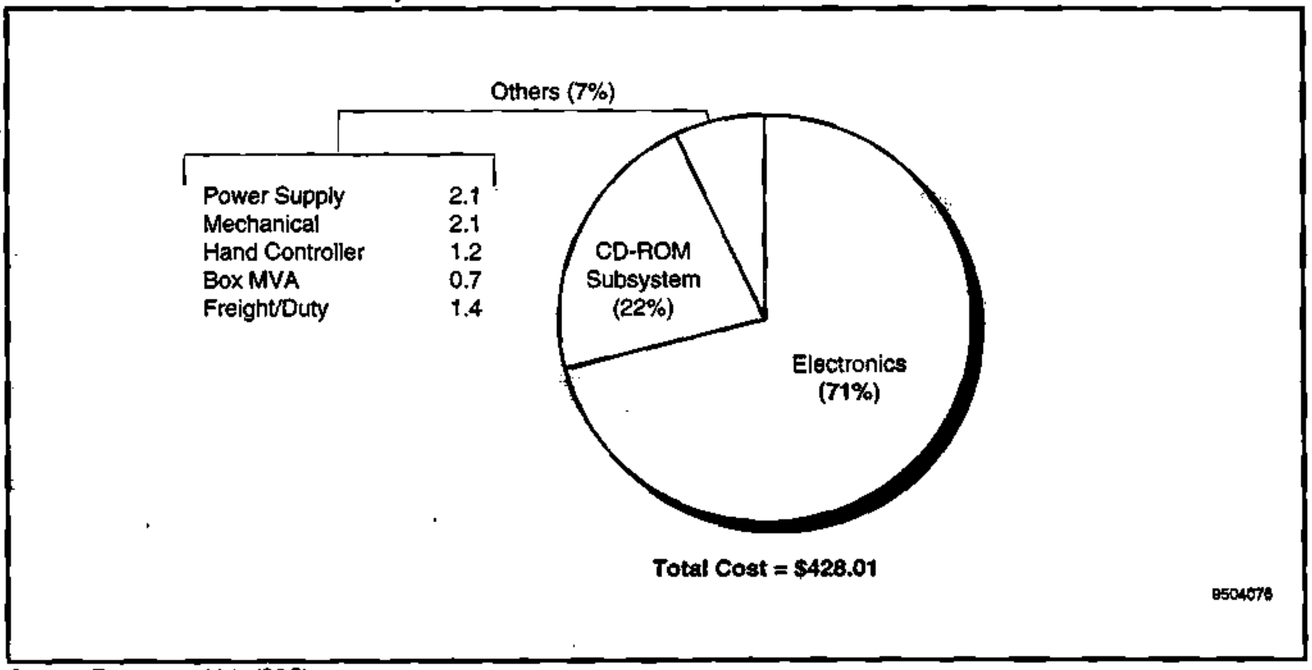
Note: A complete bill of materials with detailed pricing is found in Appendix A.
Source: Dataquest (July 1995)

Figure 3-1
1995 Best Costs for System Electronics



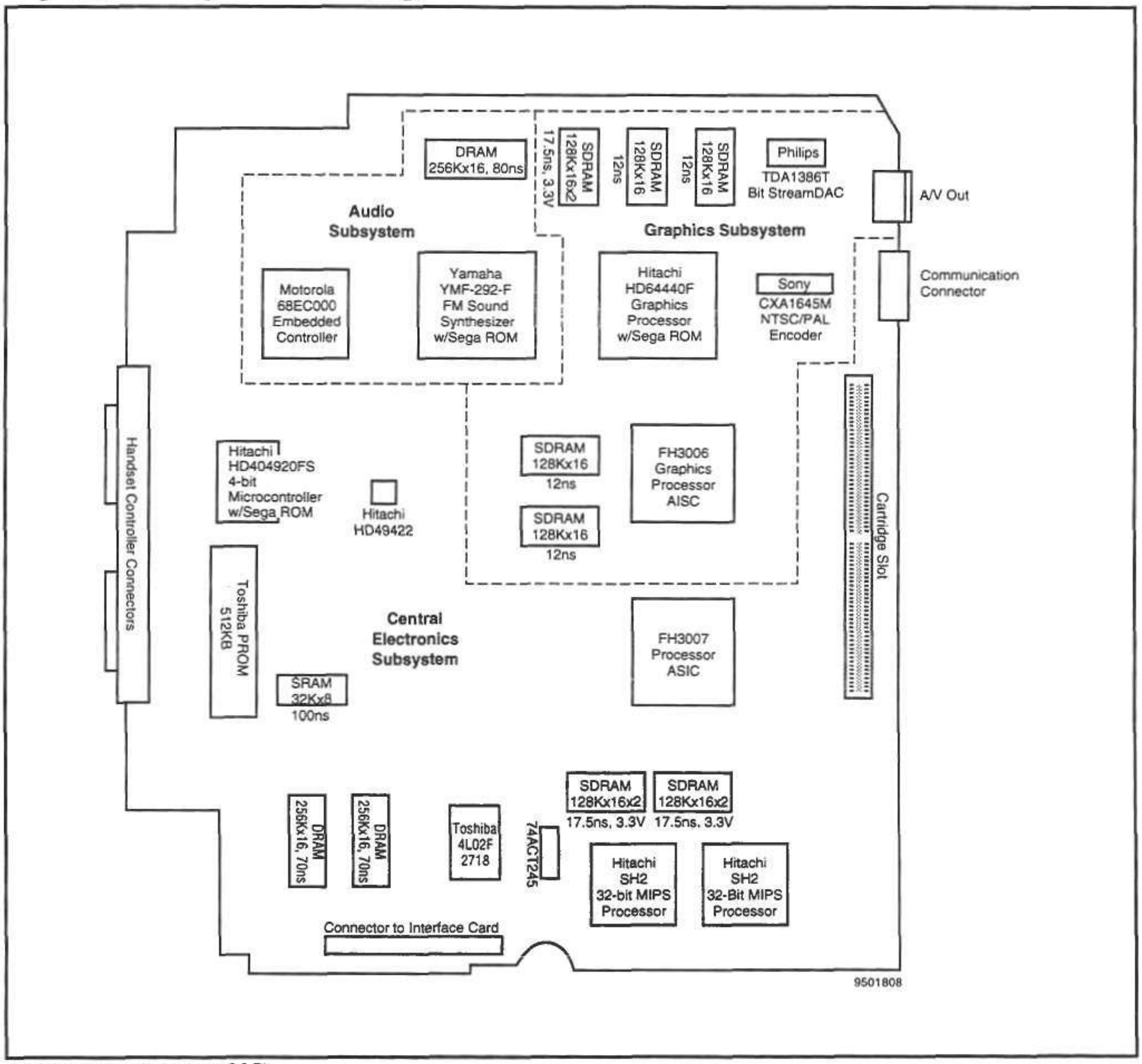
Source: Dataquest (July 1995)

Figure 3-2
1995 Best Costs for Total System



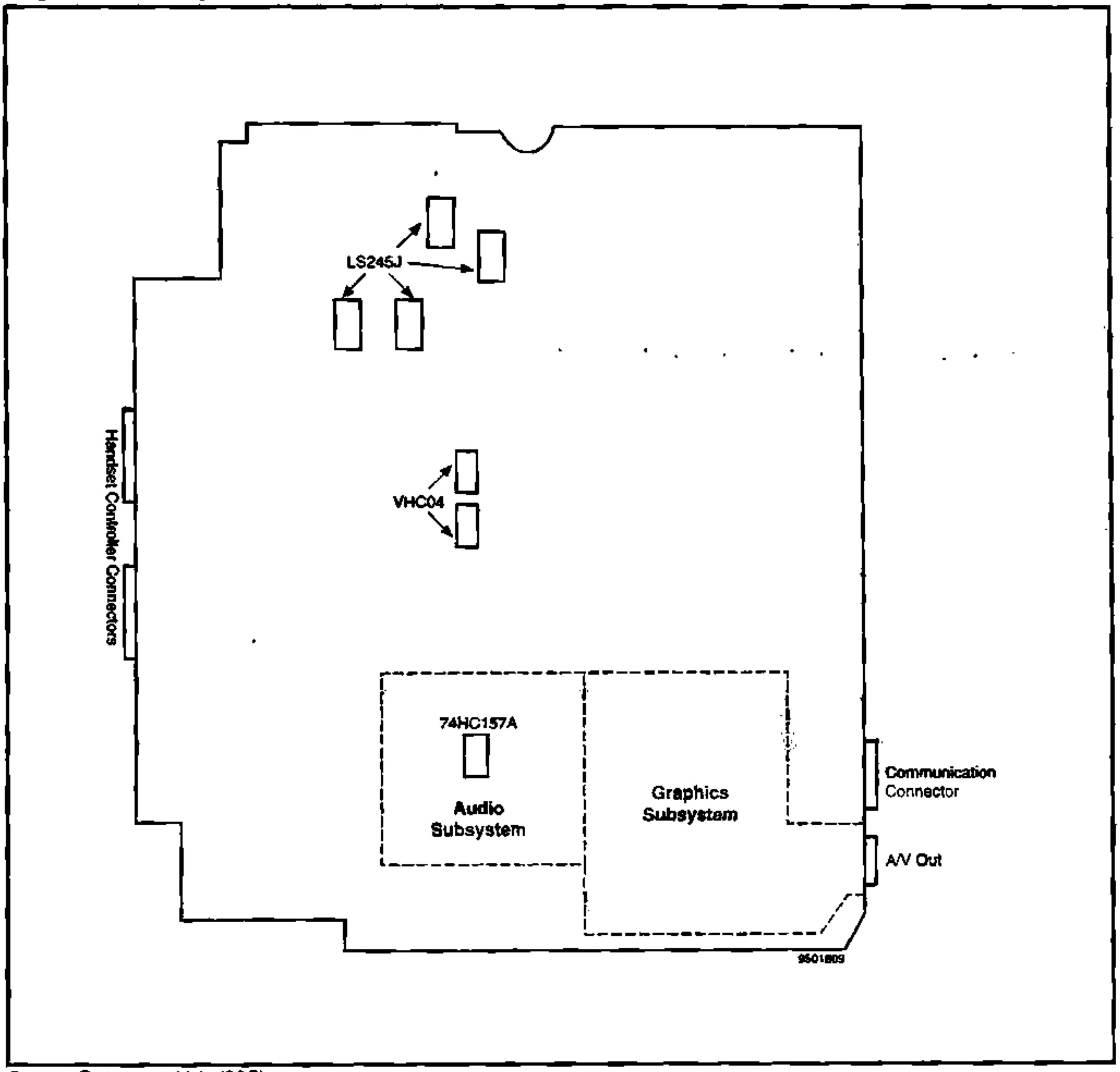
Source: Dataquest (July 1995)

Figure 3-3
Sega Saturn—System Card (Top)



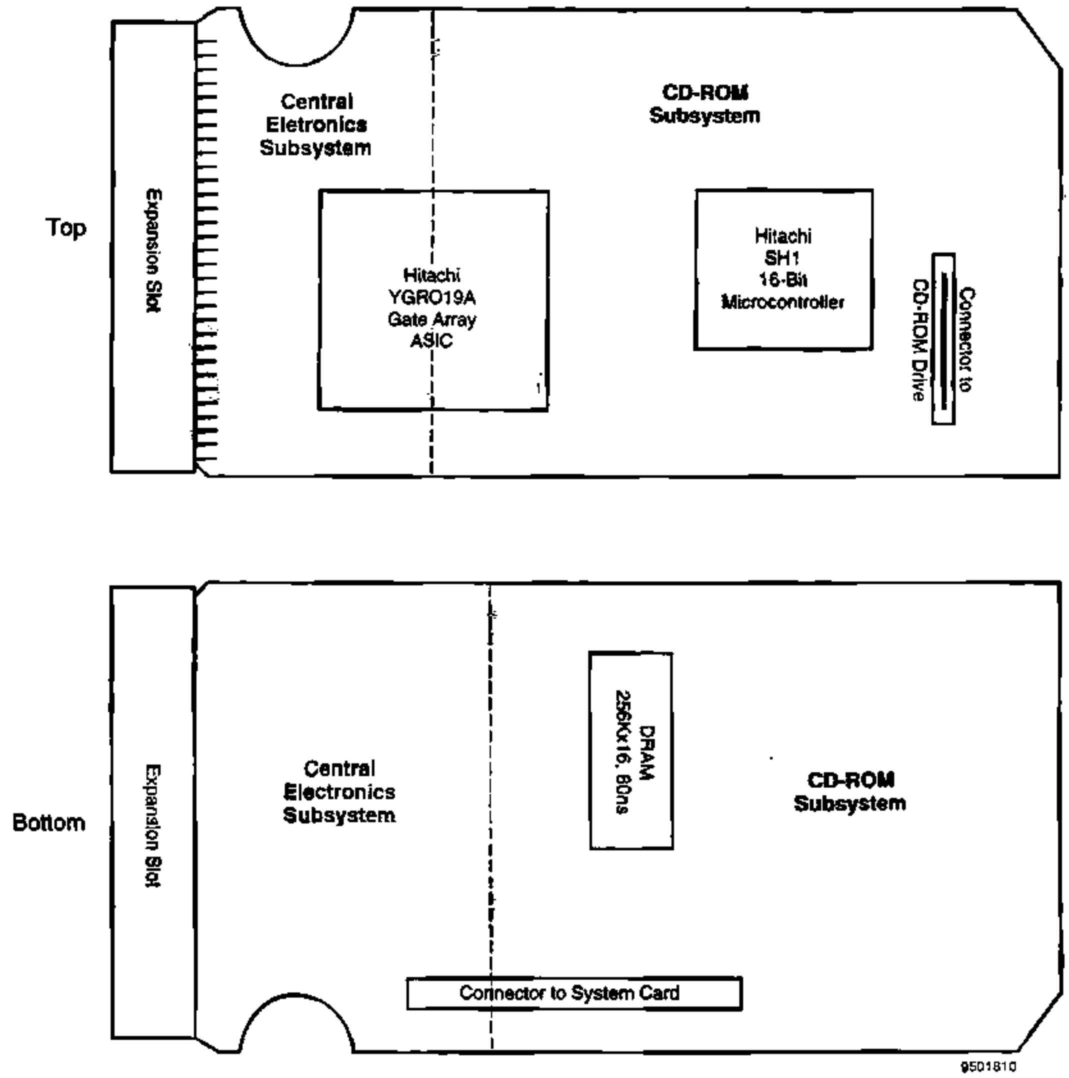
Source: Dataquest (July 1995)

Figure 3-4
Sega Saturn—System Card (Bottom)



Source: Dataquest (July 1995)

Figure 3-5
Sega Saturn—Interface Card



Source: Dataquest (July 1995)

Major Commodities—Sourcing
Table 3-3 provides a sourcing summary for the Sega Saturn.

Table 3-3
Sourcing Summary of the Sega Saturn

Processor	Hitachi/Japan
Core Logic	Toshiba (ASIC)/Japan
	Sega (ASIC)/Japan
Main Memory	Hitachi/Japan, Korea
Graphics Processors	Hitachi/Japan
	Sega (ASIC)/Japan
Frame Buffer	Hitachi/Japan
	NEC/Japan
Audio Processor	Motorola/USA
Audio Synthesizer	Yamaha/Japan
CD-ROM Drive	Unknown
Power Supply	Voltek/Taiwan
Hand Controller	Sega/Japan
System Raw Card	Unknown
Interface Raw Card	Unknown
Final Assembly	Hitachi/Japan

Source: Dataquest (July 1995)

Mechanical Package
The following is an overview of the mechanical packaging of the Sega Saturn:

- Rugged two-piece ABS case is also main structural member.
- Soft-motion CD door opens and closes slowly.
- Top-mounted cartridge slot has spring-loaded door.
- Small rear panel opens for access to backup battery, reset switch, and expansion slot.
- Fan was designed into the unit, but not implemented.
- CD-ROM drive is mounted on shock absorbers.

Vendor Sourcing

Availability
- Japan: Shipped November 1994
- United States: Announced March 1995, shipped May 1995

Processors
- Two SH2, 32-bit RISC, 28.6 MHz, 25 MIPS
- Hitachi/Japan

Core Logic
- Implemented in ASICs
- 4L02F2718, Toshiba/Japan
- FH3007, Sega/Japan

Main Memory
- 1MB SDRAM 128Kx16x2, 17.5ns, 3.3V, Hitachi/Japan,
- 1MB DRAM 256Kx16, 70ns, 5V, Hitachi/Korea

Cache
- No secondary cache

Graphics Subsystem
- HD64440F, 32-bit, sprite, polygon, and geometry, Hitachi/Japan
- 512KB SDRAM 128Kx16x2, 17.5ns, 3.3V, Hitachi/Japan
- 512KB SDRAM, 128Kx16, 12ns, 3.3V, NEC/Japan
- FH3006, 32-bit, background, Sega (ASIC)/Japan
- Five simultaneous scrolling backgrounds, two simultaneous rotating playfields
- 32K simultaneous colors from a palette of 16.8 million colors, 320x224 and 720x576 resolution
- 512KB SDRAM, 128Kx16, 12ns, 3.3V, NEC/Japan

Audio Subsystem
- 68EC000 processor, 11.3 MHz, Motorola
- YMF-292-F FM sound synthesizer, Yamaha/Japan
- 512KB DRAM buffer, 256Kx16, 80ns, Hitachi/Malaysia

CD-ROM Subsystem
- Double-speed drive, ball bearings locking disc into place
- Controller, SH1 16-bit RISC, Hitachi/Japan
- 512KB DRAM buffer, 256Kx16, 80ns, Hitachi/Korea

Power Supply
- 100V in, 15W
- Voltek/Taiwan

Controller
- 13 buttons, 10 rubber membrane, three switches
- Sega/Japan

Slots and Bays

Table 3-4 outlines the slots and bays in the Sega Saturn.

Table 3-4
Sega Saturn Slots and Bays

System Slots		System Ports	
Total Slots	1	Total Ports	5
8-Bit	-	Cartridge	1
16-Bit	-	Video/TV Signal	1
32/64-Bit	1	Communication	1
		Controller	2
Slots Left	1		
8-Bit	-		
16-Bit	-		
32/64-Bit	1		
Dedicated Slots		Total Storage Bays	1
Used	-		
Available	1		

Source: Dataquest (July 1995)

System Specifications

- System—10.6 inches wide x 9.1 inches deep x 3.3 inches high
- System—260mm wide x 230mm deep x 83mm high
- Hand Controller—5.8 inches wide x 3.5 inches deep x 1.2 inches high
- Hand Controller—147mm wide x 88.9mm deep x 30.5mm high

FCC Classification

- Class B

Warranty

- Unknown

Software

- No software included with evaluation unit

Publications

- Manual
- Registration card

System Observations

- Final assembly in Japan
- Dual 32-bit MIPS RISC main processors, separate audio and graphics processors
- CD-ROM and audio with separate buffers
- Supports audio CD, photo CD, and CD+G, as well as Saturn CD software
- JVC and Hitachi also manufacture their own versions of the Saturn.

Card Assessments

- System Card
  - 9.4 x 8.25 x 0.07 inches thick, 2S2P
  - Bare board: Unknown
  - Board assembly: Unknown
  - 32 ICs, 24 SMT and one DIP on top, seven SMT on bottom
  - No rework jumpers or components, wave soldered
- Interface Card
  - 4.75 x 2.4 x 0.049 inches thick, 2S2P
  - Bare board: Unknown
  - Board assembly: Unknown
  - Three ICs, two SMT on top, one SMT on bottom
  - No rework jumpers or components, wave soldered

Packaging/Manufacturability

Overview

The Sega Saturn is packaged in a compact ABS case, with a top-mounted CD-ROM drive and cartridge slot. The two-piece, 0.097-inch–thick case is rugged enough to have the internals mounted to it and stand up to the expected abuse of young users.

The system card screws directly into the case bottom plastic, and the power supply board mounts to the case top via CRS brackets. Light-gauge metal EMI shields sit directly above and below the system card. A smaller interface card connects to the top of the system card and is held in place by clips that rise from the case bottom. A plastic tray sits on the system card behind the interface card to hold an expansion card or module. A rear panel allows easy access to the master reset switch, backup coin battery, and expansion slot.

The CD-ROM drive is mounted on standoffs that sit on the system card and screw to the case bottom. Rubber shock absorbers between the standoffs and the drive isolate the drive from vibrations. The drive itself has the laser and disc holder mounted to a CRS plate and the motors and electronics mounted to a card with 3/4-inch plastic standoffs between. A door with a soft spring-loaded hinge provides access to the drive. Cartridges are inserted into a door in the rear of the case top and plug directly into a raised slot on the system card. The cartridge opening has a spring-loaded door to keep dust from falling into the unit. The front of the case top is the operator panel, which includes power and CD-ROM access LEDs, power and reset switches, and a button to open the CD door.

Table 3-5 provides a construction analysis.

Product Observations

System Card/Electronics

Table 3-6 provides an overview of the system card and electronics characteristics of the Sega Saturn.

Table 3-5
Construction Analysis

	Case Top	Case Bottom	Shielding
Thickness (mils)	98	96	13
Metal			
CRS Post-Zinc			
CRS Post-CAD			
CRS PreZinc			
CRS PreTin			
CRS PreAluminum			
Aluminum (AL)			
Die Cast (AL)			
Die Cast (Zinc)			
Other Stainless			X
Plastic			
ABS	X	X	
ABS Blend			
Polycarbonate (PC)			
ABS PC Blend			
Polypropylene (PP)			
Structural Foam			
Other			
Decorative Finish			
Molded In	X	X	
Paint			
Vinyl Clad			
Other Powder Coat			
EMC Coating			
Sheet Metal Liner			
Copper (CU) Paint			
Nickel (NI) Paint			
NI/CU Paint			
AL Deposition			
Foil Laminate			

Source: Dataquest (July 1995)

Table 3-6
System Card/Electronics Observations

Design/Manufacturing Opportunity	Advantage	Disadvantage	Rationale
Low level of chip integration		C	Higher integration would reduce chip count and board size.
Fast, high-quality audio and video	F		Large number of processors and controllers, audio and CD buffers
Large frame buffer memory	F		Several screens can be stored for fast scrolling.
Can play audio, Photo CD, CD+G	F		Versatile machine can do more than play games.

Note: C = Cost, F = Function, Q = Quality, O = Other
Source: Dataquest (July 1995)

Mechanical/Power

Table 3-7 provides an overview of the mechanical and power characteristics of the Sega Saturn.

Table 3-7
Mechanical/Power Observations

Design/Manufacturing Opportunity	Advantage	Disadvantage	Rationale
Rugged ABS case, shock-absorbing pillars allow CD-ROM drive mounting.	Q		Unit can stand up to use and abuse; antishock mechanism reduces track skipping.
Overall size is much larger than the Sony Playstation.		O	More difficult to store when not in use

Note: C = Cost, F = Function, Q = Quality, O = Other
Source: Dataquest (July 1995)

Chapter 4
Sony

Consumer electronics giant Sony needs no introduction. But what about this sassy new upstart called Sony Computer Entertainment? Sony Computer Entertainment of America was established in May 1994 as a business unit of Sony Electronic Publishing. The company's charter is threefold: to market and distribute the Sony Playstation, to design and produce software titles and peripherals for the Playstation platform, and to manage all third-party software developers in North America.

Sony Computer Entertainment of America (SCEA) is scheduled to begin selling products in September 1995. Only one of Sony's competitors is shipping a competitive system, the Sega Saturn, so strong sales are expected this fall when the Playstation is released. The Playstation is already selling well in Japan, where it was introduced for the Christmas 1994 buying season. SCEA will be selling the hardware and numerous software titles at launch.

In a direct comparison with the current competition, Sony appears to have a significant manufacturing cost advantage. It has already announced a suggested retail price of $299, which is aggressive, based on Dataquest's manufacturing cost estimates for the Playstation, and which is $100 lower than the suggested retail price for the Sega Saturn. This price difference should give SCEA a significant edge as it works to build market share with its first product.

SCEA has all of the ingredients for success, with the exception of a good track record (because it has not yet started selling any products). However, it does have a solid hardware platform, impressive software titles, financial backing from consumer electronics giant Sony Corporation, and a marketplace eager for the next generation of video games. The next few years will tell whether SCEA is going to succeed.

Sony Playstation

Executive Product Summary

Announcement/Shipment

- Japan: Announced October 1994, shipped December 1994
- United States: Shipment planned September 1995

Configuration

- Small game unit case with top-mounted CD-ROM drive
- Custom CPU chip with R3000 32-bit RISC MIPS microprocessor core (33 MHz), motion-JPEG decompression engine, graphics coprocessor, and core logic
- 2MB DRAM main memory, 256Kx16, 60ns, soldered, not expandable
- CD-ROM drive, double-speed, all electronics integrated onto system card
- CD-ROM buffer, 32KB SRAM, 32Kx8, 70ns

- Custom Toshiba 32-bit graphics processor, 16.7 million colors, 256x240 resolution
- 1MB VRAM frame buffer, 256Kx16, 60ns, soldered, not expandable
- Video outputs, S-video and composite
- Custom audio chip with 24-channel PCM sound
- Audio buffer, 0.5MB, 256Kx16, 80ns, 3.3V
- Power supply, 10.5W, 100V
- Hand controller, 10 buttons (not included with evaluation unit)

Design/Cost Advantages

The following are the design and cost advantages of the Sony Playstation:

- Highly integrated system card includes all CD-ROM drive electronics.
- Memory card slots above controller connections allow user to store game data on self-powered module (not included).
- Internal space maximized for low profile, small footprint.
- Large buttons on unit increase usability.

Design/Cost Disadvantages

The following is the design and cost disadvantage of the Sony Playstation:

- Uses VRAM as frame buffer

Costs and PCB Layouts

Table 4-1 provides a summary of costs by semiconductor category. Table 4-2 provides a summary of total cost by subsystem. Figures 4-1 and 4-2 show costs for system electronics and total system, based on high-volume, best-pricing component purchases. Figures 4-3 and 4-4 provide PCB layouts with functional subsystems.

Table 4-1
Summary Cost Analysis by Semiconductor Category (U.S. Dollars)

	1995 Best Pricing	1996 Best Pricing	1997 Best Pricing
Total Semiconductor	196.89	196.89	196.89
Total IC	195.79	195.79	195.79
Bipolar Digital	1.22	1.22	1.22
MOS Digital	194.57	194.57	194.57
MOS Memory	105.19	105.19	105.19
MOS Microcomponent	80.92	80.92	80.92
MOS Logic	8.46	8.46	8.46
Analog	0	0	0
Total Discrete	1.10	1.10	1.10
Total Optical Semiconductor	0	0	0

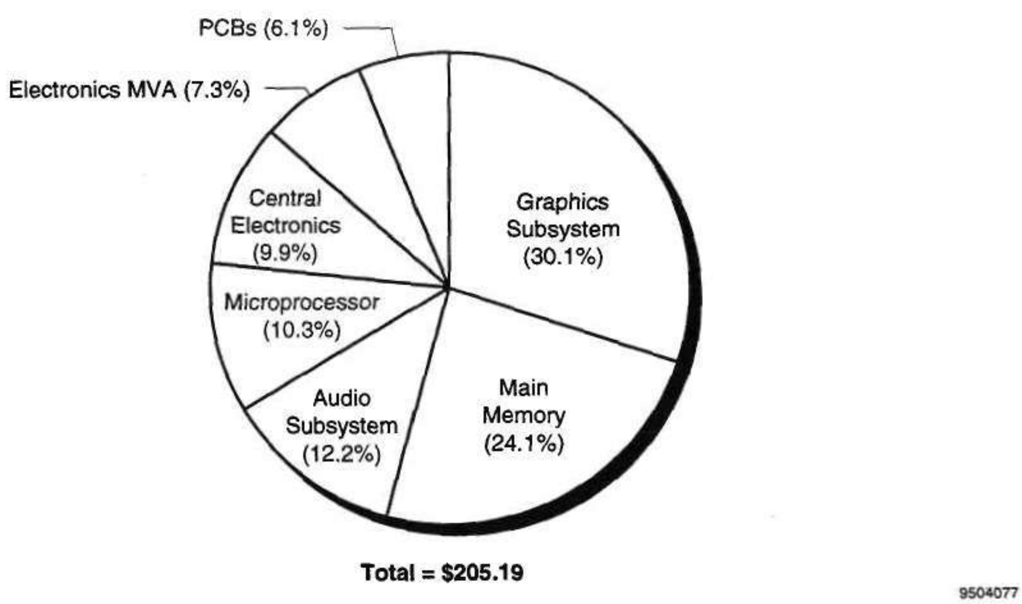
Source: Dataquest (July 1995)

Table 4-2
Summary Cost Analysis by Subsystem (U.S. Dollars)

	1995 Best Cost	1996 Best Cost	1997 Best Cost	Three-Year Average Cost
Graphics Subsystem	61.68	56.36	51.56	56.54
Central Electronics	20.36	19.79	19.25	19.80
Audio Subsystem	25.09	23.67	22.36	23.71
Microprocessor	21.11	17.94	15.25	18.10
Main Memory	49.45	45.49	41.85	45.60
PCBs	12.50	12.25	12.01	12.25
Electronics MVA	15.00	15.60	16.22	15.61
Total Electronics	205.19	191.12	178.50	191.61
CD-ROM Subsystem	55.17	52.66	50.29	52.71
Power Supply	8.00	8.00	8.00	8.00
Mechanical	7.43	7.58	7.73	7.58
Publications*	0.25	0.25	0.25	0.25
Hand Controller*	5.24	5.14	5.03	5.14
Box MVA	2.10	2.18	2.27	2.19
Freight/Duty	6.00	6.00	6.00	6.00
Total	289.39	272.93	258.07	273.46

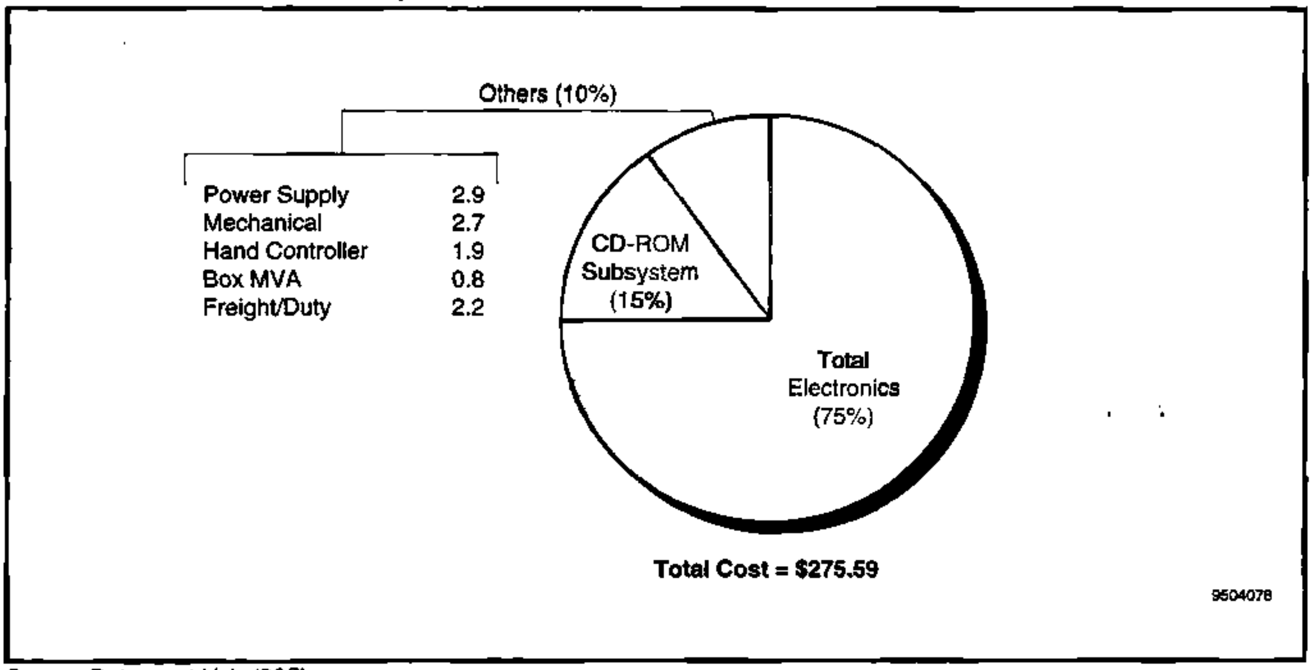
*Estimated costs; items were not included with evaluation unit.
Note: A complete bill of materials with detailed pricing is included in Appendix B.
Source: Dataquest (July 1995)

Figure 4-1
1995 Best Costs for System Electronics



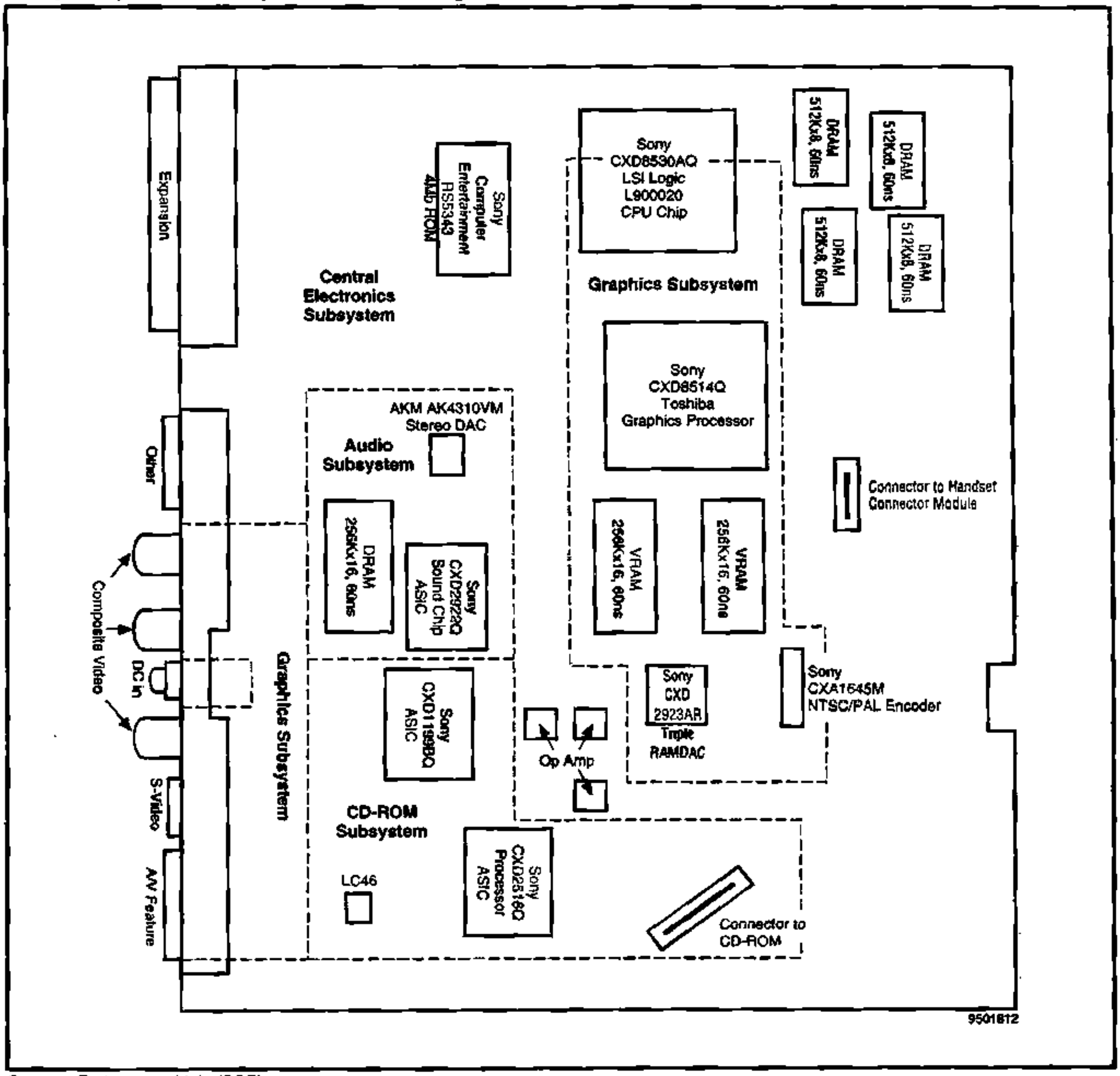
Source: Dataquest (July 1995)

Figure 4-2
1995 Best Costs for Total System



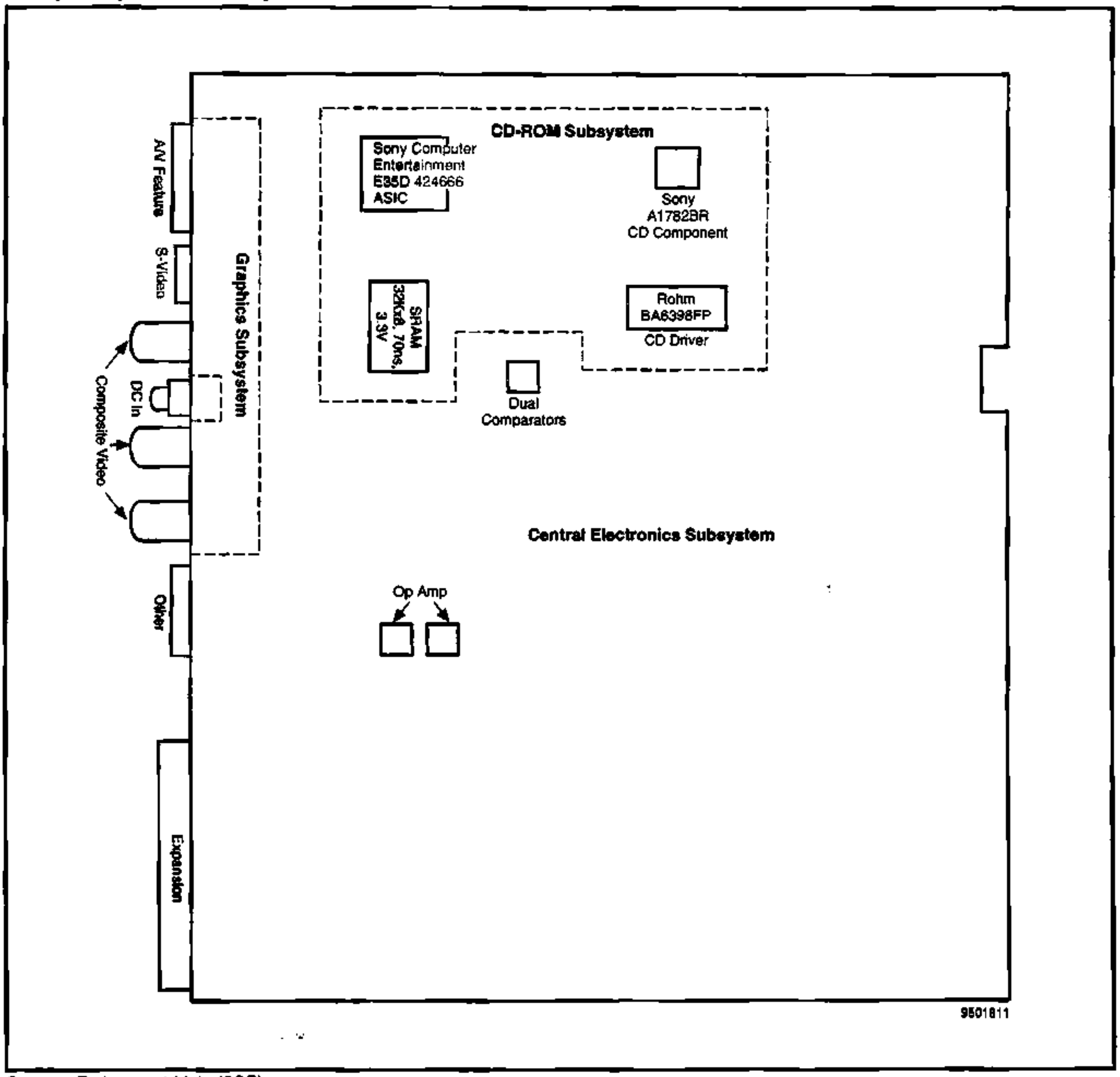
Source: Dataquest (July 1995)

Figure 4-3
Sony Playstation—System Card (Top)



Source: Dataquest (July 1995)

Figure 4-4
Sony Playstation—System Card (Bottom)



Source: Dataquest (July 1995)

Major Commodities—Sourcing

Table 4-3 provides a sourcing summary of major commodities of the Sony Playstation.

Table 4-3
Sourcing Summary of Sony Playstation

Processor	LSI Logic/Hong Kong
Core Logic	LSI Logic/Hong Kong (integrated with processor)
Main Memory	Samsung/Korea
Graphics Processor	Toshiba/Japan
Frame Buffer	Samsung/Korea
CD-ROM Drive	Sony/Japan*
Power Supply	Matsushita/Japan
Hand Controller	Not included with evaluation unit
System Raw Card	Unknown
Final Assembly	Sony/Japan

*CD-ROM electronics are integrated onto system card.
Source: Dataquest (July 1995)

Mechanical Package

The following is an overview of the mechanical package of the Sony Playstation:

- Two-piece, rugged ABS case is main structural member.
- CD-ROM mechanism is mounted on CRS EMI shield/structural member.
- Soft-motion CD door opens, closes slowly.

Vendor Sourcing

Availability

- Japan: Announced October 1994, available December 1994
- United States: Available fall 1995

Processor

- Custom CPU chip with R3000 32-bit RISC MIPS microprocessor core (33 MHz), JPEG video-decompression engine, graphics coprocessor, and core logic
- LSI Logic/Hong Kong

Core Logic

- Implemented on CPU chip
- LSI Logic/Hong Kong

Main Memory

- 2MB DRAM, 256Kx16, 60ns, soldered, not expandable
- Samsung/Korea

Cache

- No secondary cache

Graphics Subsystem

- Custom 32-bit graphics processor, 16.7 million colors, 256x224 resolution, Toshiba/Japan
- 1MB VRAM frame buffer, 256Kx16, 60ns, soldered, not expandable, Samsung/Korea

Audio Subsystem

- Custom audio chip with 24-channel PCM sound
- Audio buffer, 0.5MB, 256Kx16, 80ns, 3.3V

CD-ROM Drive

- Double-speed drive, ball bearings locking disc into place
- All CD-ROM electronics integrated onto system card
- Sony/Japan

Power Supply

- 10.5W, 100V
- Matsushita/Japan

Controller

- Not included with evaluation unit
- 14 buttons

Slots and Bays

Table 4-4 outlines the slots and bays in the Sony Playstation.

Table 4-4
Sony Playstation Slots and Bays

System Slots		System Ports	
Total Slots	-	Total Ports	7
8-Bit	-	Video	2
16-Bit	-	A/V	1
32/64-Bit	-	Expansion	1
		Controller	2
Slots Left	-	Other	1
8-Bit	-		
16-Bit	-		
32/64-Bit	-		
Dedicated Slots			
Used	-	Total Storage Bays	1
Available	-		

Source: Dataquest (July 1995)

System Specifications
- System—10.5 inches wide x 7.25 inches deep x 2.3 inches high
- System—267mm wide x 184mm deep x 58.7mm high

FCC Classification
- Japanese model, no classification

Warranty
- Unknown

Software
- Not included with evaluation unit

Publications
- Not included with evaluation unit

System Observations
- Final assembly in Japan
- Custom-integrated CPU chip including 32-bit MIPS RISC processor
- Low-profile case
- Can play audio CDs as well as Playstation CDs

Card Assessments
- System card
- 6.31 x 7.5 x 0.041 inches thick, 2S2P
- Bare board: Unknown
- Board assembly: Sony/Japan
- 26 ICs, 19 on top, seven on bottom, all SMT
- One rework component on bottom

Packaging/Manufacturability

Overview
The Sony Playstation is packaged in a low-profile, compact ABS case with a top-mounted CD-ROM drive. The two-piece, 0.116-inch thick case is extremely rugged.

The system and power supply cards are screwed to the case bottom. A rigid CRS structural member sits on top of the system card and is held by the same screws. This member serves as EMI shielding above the system card and has three small posts for mounting the CD spindle/motor/laser unit. The CD unit, not considered a separate drive because it has no electronics, has three rubber shock absorbers to isolate it from the posts. A light-gauge (0.009-inch) metal EMI shield sits below the system card. A shielded connector module screws down on the front edge of the system card and contains the controller and memory card connectors. A small EMI shield sits on top of the module. All other I/O connectors are integrated onto the system card at the rear edge. The front area of the case top serves as the operator panel, with large power and CD door buttons, a smaller reset button, and a power LED. The CD door is spring loaded, with a soft-motion mechanism.

The Playstation is designed for minimized profile and footprint space and easy assembly, with a low part count. There are two flex and two discrete cables internally, and the case top secures the internals via screws from the case bottom and positioning posts for the CD mechanism. The small size, thick casing, large buttons, and rugged construction show a consideration for the young target market.

Table 4-5 provides a construction analysis.

Table 4-5
Construction Analysis

	Case Top	Case Bottom	Upper Shielding	Lower Shielding
Thickness (mils)	116	116	33	9
Metal				
CRS Post-Zinc				
CRS Post-CAD			X	
CRS PreZinc				
CRS PreTin				
CRS PreAluminum				
Aluminum (AL)				
Die Cast (AL)				
Die Cast (Zinc)				
Other Stainless				X
Plastic				
ABS	X	X		
ABS Blend				
Polycarbonate (PC)				
ABS PC Blend				
Polypropylene (PP)				
Structural Foam				
Other				
Decorative Finish				
Molded In	X	X		
Paint			X	
Vinyl Clad				
Other Powder Coat				
EMC Coating				
Sheet Metal Liner				
Copper (CU) Paint				
Nickel (NI) Paint				
NI/CU Paint				
AL Deposition				
Foil Laminate				

Source: Dataquest (July 1995)

Product Observations

System Card/Electronics

Table 4-6 provides an overview of the system card and electronics of the Sony Playstation.

Table 4-6
System Card/Electronics Observations

Design/Manufacturing Opportunity	Advantage	Disadvantage	Rationale
System electronics are highly integrated with surprisingly few ICs.	C, Q		This design packs lots of functionality into a very compact package.
CD-ROM electronics are integrated onto system card.	C		Design reduces total number of ICs and board space.
VRAM is used for frame buffer.		C	Expensive compared to DRAM alternatives
Memory card slots are provided.	F		User can save game information on separate, battery-powered module (sold separately).

Note: C = Cost, F = Function, Q = Quality, O = Other
Source: Dataquest (July 1995)

Mechanical/Power

Table 4-7 provides an overview of the mechanical and power characteristics of the Sony Playstation.

Table 4-7
Mechanical/Power Observations

Design/Manufacturing Opportunity	Advantage	Disadvantage	Rationale
Small profile and footprint		O	Convenient to store when not in use
Large buttons on unit	F		Easy to use
Rugged case with shock absorbers for CD-ROM mechanism	Q		Can stand up to use and abuse; shock system reduces track-skipping problems
CD-ROM structural member doubles as EMI shielding	C		Saves an extra part, contributes to solid construction

Note: C = Cost, F = Function, Q = Quality, O = Other
Source: Dataquest (July 1995)

Chapter 5
Nintendo, 3DO, Atari, and a Cross-System Comparison

In addition to the Sega and Sony systems described in Chapters 3 and 4, it is important to note the products and plans of Nintendo, 3DO, and Atari. This chapter provides information on major announcements and products from these companies and then concludes with a cross-system comparison of the Sega Saturn, Sony Playstation, Atari Jaguar, and 3DO M2.

Nintendo

Now one of the giants of the video game industry, Nintendo made its initial entrance into the industry in 1981 when it introduced its successful Donkey Kong game in arcades. In 1983 Nintendo introduced the Family Computer System (Famicon) in Japan, and by 1985 it was test marketing the Nintendo Entertainment System (NES) in New York. Sales of the 8-bit NES, introduced in the United States in 1986, moved Nintendo into the dominant position in the industry. It followed this success with the introduction of the popular Game Boy in 1989. However, Nintendo experienced stiff competition from Sega with the introduction of 16-bit video game systems. Its Super NES was launched in the U.S. market in 1991.

Nintendo's sales and earnings for fiscal year 1995, ending March 31, 1995, fell sharply from 1994 levels, reflecting the slowdown in the 16-bit game market, intense competition, and the high value of the yen. It announced consolidated net earnings of $480.5 million, down 20.9 percent from fiscal 1994, and total sales of $4.79 billion, down 14.4 percent. These numbers include revenue from both hardware and software sales. The approximate shipment numbers announced by Nintendo for major video game hardware categories were 4 million Super NES units, 3.2 million Game Boy units, and 1 million NES units.

Shipments of Nintendo's next-generation Ultra-64 have been delayed from the originally announced date of November 1995 to April 1996. Nintendo maintains that the actual hardware is ready for market, but they have decided to hold back on launching the product until a library of truly breakthrough software has been developed. Late software development kit shipments have slowed the development of software for this platform. So far, Nintendo has kept this new hardware under wraps and has demonstrated only the machine's graphics and speed, which are impressive. Nintendo is the sole hardware vendor introducing a cartridge-based next-generation system. The company will pursue a strategy of reducing the price on the video game hardware to gain market penetration while absorbing higher costs to produce and distribute software titles. It has stated its plan to bring the Ultra-64 to market with a very aggressive price of $250 or less, with the goal of gaining quick acceptance by consumers.

Nintendo has assembled what it calls a dream team to drive the development and marketing of the Ultra-64. Participants in the alliance to design and test the hardware and software for the Ultra-64 include Nintendo, Silicon Graphics, Rambus, Alias Research, and MultiGen. This next-generation game is the first application of "reality immersion technology," a new generation of video entertainment that enables players to step inside real-time, three-dimensional worlds. Silicon Graphics/MIPS Technologies is supplying a 64-bit RISC processor, which will be combined with 500-MHz Rambus memory technology to enable fluid three-dimensional imagery. Alias and MultiGen, software development tool companies, are supplying tools to allow game publishers to create games with realistic imagery, graphics, environments, and character movements.

Its new Virtual Boy platform was demonstrated at both the Winter Consumer Electronics Show and the E3 show in Los Angeles. This new game will be introduced in both the Japanese and U.S. markets at about the same time. Nintendo has announced August 16, 1995, for the U.S. market introduction, at a price of $179.95. At launch, the Virtual Boy will be supported by six games and a $25 million marketing budget. Nintendo has projected Virtual Boy hardware sales of 2 million units in the United States by March of 1996.

Nintendo's Virtual Boy game unit breaks the mold of the console-attached-to-TV standard. It is difficult to classify this product as either a handheld device like the Game Boy or a console device like the Super NES because it delivers a very different experience. Virtual Boy provides visually immersive, three-dimensional gaming using a self-contained display. As shown in Figure 5-1, the unit resembles a pair of large goggles resting on a small stand, wired to a handheld controller. The Virtual Boy is portable, but is designed for a stationary user because walking around with the goggles on would be dangerous. The unit is deceptively lightweight. The battery pack is attached to the hand controller, with all of the main electronic components contained in the goggles. A 32-bit RISC processor running at 20 MHz and a dual LED display create a smooth, three-dimensional display.

The display for Virtual Boy, designed by Reflection Technology, has an LED strip and a mirror assembly for each eye. Unfortunately, the colors on the Virtual Boy are limited to a few shades of red, but the images are crisp and offer surprising depth because each eye receives a different image. Previous concerns about image flicker associated with this type of display appear to be unwarranted, based on our "test drive" of the unit. The Nintendo Virtual Boy delivers a flicker-free image with sharp definition. Nintendo's belief in the LED display technology developed by Reflection Technology was demonstrated by its decision to acquire a minority interest in the privately held company. Nintendo's investment gives it exclusive worldwide licensing rights, within the video game market, to Reflection's patented virtual display technology. The 3-D titles that have been demonstrated for the Virtual Boy involve vertical graphic planes at different apparent distances from the viewer and true three-dimensional graphics where objects move fluidly toward or away from the viewer. Stereophonic sound is also incorporated in the headset.

Even after the introduction of the Virtual Boy platform during the 1995 holiday season, Nintendo will rely heavily on revenue from software sales of three 16-bit titles that use the Advanced Computer Modeling (ACM) technology that helped make Donkey Kong Country a hit.

Figure 5-1
Nintendo Virtual Boy

Source: Nintendo

3DO

The 3DO Company develops and licenses advanced interactive technology to hardware manufacturers and software developers. Its initial product design was a 32-bit 3DO Interactive Multiplayer, introduced in October 1993, that used CD-ROM technology instead of the traditional cartridges for games. Panasonic, LG Electronics (Goldstar), Sanyo, and Creative Labs offer four brand names with 3DO technology.

Upgraded versions of its 32-bit player were introduced in 1995 at the Winter Consumer Electronics Show. The FZ-10 REAL 3DO Interactive Multiplayer was developed to replace the earlier FZ-1 model. The new model features a dual-speed CD-ROM drive and a new memory management system for saving games in progress. Slowing sales of 3DO hardware in mid-1995 have been attributed to customers waiting for the announced M2 upgrade and momentum lost to the Sega Saturn launch, which has captured early adopters. Sales were stimulated by LG Electronics' announcement of a $50 rebate that brought the price of the new machine to $299 to $349, depending on the outlet. Both Panasonic and LG Electronics have also announced MPEG-1 adapters that can be used with their multiplayers to allow users to watch movies and music videos conforming to Video CD format.

3DO used the May 1995 E3 show in Los Angeles to announce many of the specifications for its next hardware offering, called the M2. (This was also the first show where there was a unified showing by 3DO, Panasonic, and LG Electronics.) The M2 represents 3DO's step into 64-bit technology. Although 3DO was not showing M2 hardware on the show floor, it did share many technical details. The core of the M2 technology is a 66-MHz IBM PowerPC 602 CPU with 10 custom coprocessors providing high-end three-dimensional graphics, advanced audio capabilities, and enhanced I/O performance. Other specifications include a 64-bit memory bus with 6MB (48Mb) of memory, including synchronous DRAM and ROM, an MPEG engine supporting both MPEG-1 and JPEG decompression, alpha-channel graphics processing, a 66-MHz DSP for audio processing (including MPEG audio decompression), and backward compatibility with existing 3DO software titles. The M2 architecture enables the processing of more than one million polygons per second, with each processor dedicated to a specific task. 3DO claims that the M2 technology will allow it to leapfrog the 32-bit competition with seven to 10 times more power and features such as Gouraud shading, texture mapping and filtering, and 3-D perspective correction. Availability of the new M2 system and a module for upgrading earlier game players, the M2 accelerator, is expected by the end of 1995.

Atari

Atari is a company steeped in video gaming tradition. From its groundbreaking introduction of Pong in 1972 to its wildly successful Atari 2600 home video game system, Atari made an early impact as the video game industry grew from infancy. Cumulative sales of the Atari 2600 topped 25 million units in 1983. Shortly thereafter, the market for home and arcade video games crashed, as did Atari's fortunes. The next year, a group of investors purchased the remains of Atari. That group included Jack Tramiel, founder of Commodore Business Machines, whose son Sam joined the company as chief operating officer.

Atari went public in 1986 and raised over $54 million, traded on the American Stock Exchange. Atari followed a business model of designing and building home computers with propriety technology, and its fortunes first improved, with revenue of almost $500 million in 1987, and then declined as it failed to compete with IBM PCs and clones. After losing $72 million in 1992, Atari gave up the computer business and revenue plummeted to $8 million per quarter. Sam Tramiel managed the corporate downsizing from 2,500 employees to only 100. Atari became a research and development company working on a next-generation home video game system.

In 1993, Atari introduced the Jaguar game system, the result of over a year of R&D. The Jaguar is a cartridge-based system, but has an optional CD-ROM drive for CD-based software titles. Sales of the Jaguar have been slow, with roughly 200,000 units sold through spring 1995, but Atari received a much-needed boost from Sega a few months ago. Atari's suit against Sega for violation of patents was settled, with Sega purchasing 7.4 percent of Atari for $40 million and paying an additional $50 million for future patent royalties. This gives Atari the cash necessary to compete with new entries to the market, such as the Sega Saturn and Sony Playstation.

Today, Atari is as close to a family-run organization as a publicly traded company can be. Jack Tramiel is chairman and three other Tramiels (his sons) are on the executive list. Sam Tramiel is president and CEO, and Garry Tramiel and Leonard Tramiel are vice president of sales and vice president of advanced software development, respectively.

Performance and Feature Comparison

Table 5-1 provides a comparison of performance and features based on information supplied by vendors of these video game systems.

Table 5-1
Feature and Performance Comparison of Selected Video Games

Feature	Sega Saturn	Sony Playstation	Atari Jaguar	3DO M2
Number of Processors	Eight	Five	Five	Ten
Main CPU	Hitachi SH-2 (two)	MIPS R3000 core from LSI Logic	Atari proprietary RISC-based 64-bit graphics processor unit	PowerPC 602
CPU Clock Frequency (MHz)	28.6	33	Unknown	66
Memory	2MB main, 1.5MB video, 512KB audio, 512KB CD-ROM cache	2MB main, 1MB video, 512KB audio, 32KB SRAM	Unknown	6MB SDRAM and ROM, unified memory architecture
Graphics	Two processors, 200,000 texture-mapped polygons/sec, 500,000 flat-shaded polygons/sec, 16 million colors, 720x576 maximum resolution	Two processors, 180,000 texture-mapped polygons/sec, 360,000 flat-shaded polygons/sec, 16 million colors, 640x480 maximum resolution	Three processors, polygon performance unknown	100 million pixels/sec rendering speed, 1,000,000 flat- shaded polygons/sec, 16 million colors, 640x480 maximum resolution, Z-buffering, alpha-channel support
Sound	Yamaha FH1 DSP, Motorola 68EC000 processor, 32 PCM channels, 8 FM channels, 44.1-KHz sampling, QSound 3-D sound capabilities	Sound processor, built-in digital effects such as reverb and envelope, 24 PCM channels, 44.1-KHz sampling	32-bit DSP, built-in digital effects such as reverb and envelope, 24 channels, 44.1-KHz sampling	66 MHz DSP, MPEG audio decompression, 32 channels, 44.1-KHz sampling
Decompression Standards	Proprietary	JPEG	Proprietary	MPEG-1, JPEG
CD-ROM Drive	2x speed	2x speed	Cartridge-based, 2x speed optional	2x speed
Video Output	Composite video standard, optional NTSC, S-video, RGB, and HDTV	Composite video, S-video, RGB output, 5V power for external RF converter	Composite video	Composite video

Source: Sega, Sony, Atari, 3DO

Chapter 6
Emerging Semiconductor Opportunities in Interactive Games

There are a number of critical technologies, such as compression, advanced DRAM architectures, 3-D graphics, CD-ROM drives, sound, modems, and virtual reality, that play a central role in video game hardware development. The following sections provide analysis of these technologies, followed by a discussion of the new MPUs, graphics chips, controller chips, and memory products that are competing for a slice of the video game market. In the final section, a forecast of the semiconductor opportunity in next-generation video games is presented.

Key Technology Trends and Issues

Compression

So far, the use of motion video images to enhance the gaming experience has received mixed reviews in the marketplace. Until recently, game producers struggled to integrate compelling motion video into all but the strategy games and reference titles.

One recent trend is typified by Sega's adoption of The Duck Corporation's TrueMotion software compression technology for elements of its NHL All-Star Hockey title. Software-based video decoders like TrueMotion, CinePak (SuperMac), Indeo (Intel), and MPEG (several suppliers) perform the decompression function while running on the host CPU. Game developers are using a variety of approaches, taking into account quality and performance trade-offs, for particular titles.

Until recently hardware MPEG 1 decoders, which offer superior performance and quality, have remained an expensive aftermarket option for consumers. 3DO's M2 and Philips' CD-i are the only systems employing MPEG hardware. As the prices come down, MPEG decoders could become more mainstream as part of an ASIC or standalone IC in model updates. MPEG's presence as a fixture in Windows 95 should help sway game developers because they can save resources by using one approach for two platforms.

The Sony Playstation does have built-in JPEG still frame decompression hardware (part of an ASIC) for decoding bit-mapped backgrounds and images. This appears to be a very practical use of compression for the large "twitch" segment of titles.

Audio compression is appearing in the form of ADPCM (Sony) and MPEG-1 (3DO and Philips). Both are popular in other markets, although MPEG appears headed for broader deployment—another consideration for game developers interested in leverage.

Advanced DRAM Architectures

It's interesting to note that although PC manufacturers are clamoring to find a way to move to a unified memory architecture, one in which the same DRAM chips are used for the main memory and the display memory, games manufacturers have moved from a unified memory model to a split memory model for the current 32-bit systems. A unified memory system tends to use fewer DRAM chips than a split memory system, which helps to reduce costs.

Games manufacturers have moved from unified memory to a split memory model because the increasingly sophisticated graphics demanded by the highly competitive games market creates mushrooming demand for DRAM bandwidth. Early evidence of this trend showed up in the 3DO REAL machines, and it is pronounced in the Sega Saturn and the Sony Playstation. Even with the use of high-bandwidth wide synchronous DRAMs, parts which were unavailable until just recently, Sega still finds a split memory necessary to simultaneously perform graphics manipulation and MPEG decompression while feeding a data-hungry high-performance CPU.

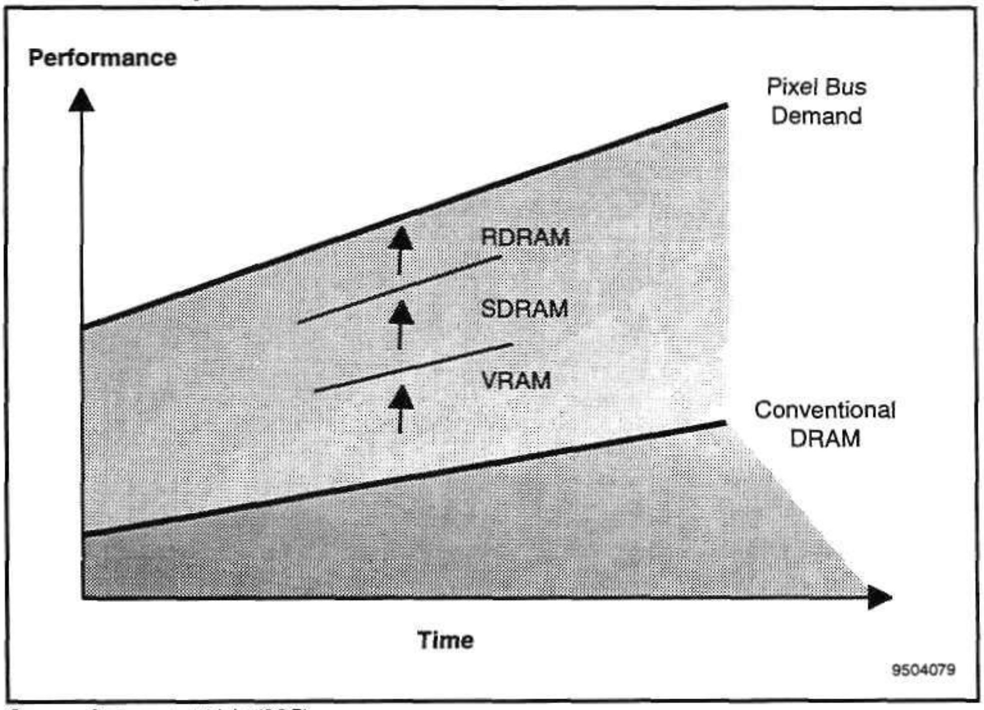
Nintendo, in its Ultra-64 system, has announced that it will take advantage of the Rambus DRAM channel to combine the memories in its system. The M2 architecture from 3DO will also employ a unified memory architecture. These are the first instances of unified architectures using one of the new DRAM I/O architectures in next-generation video game platforms. Dataquest expects other systems to follow this approach simply to reduce system costs.

In the far future we may see more exotic approaches, such as Mitsubishi's 3D-RAM or a synchronous graphics RAM (SGRAM). It is notable that the most sophisticated approaches to graphics rendering are poised to be used in workstations and video games, while tamer approaches are currently slated for use in PCs. This is driven by the less compelling graphics requirements for standard PCs as compared to workstations, which need to perform 3-D modeling and other sophisticated scientific and engineering functions, and for games, which compete more strongly if they use more sophisticated images. A graphical representation of the high-performance graphics driving the use of more advanced DRAM architectures in video games is shown in Figure 6-1. With the growing importance of multimedia PCs in the market, PC designers could be expected eventually to incorporate more advanced DRAM technology in their products, but they would be in the late majority segment of the traditional adoption curve. It is quite reasonable to assume that games will increase in importance as the high-performance DRAM driver of the future.

3-D Graphics

Three-dimensional perspective is a major component of enhancing the visual experience of video games. This draws the player into the game because it provides a closer approximation of everyday visual experience, which includes *depth* as well as height and width. Adding 3-D features to the graphics capabilities of a game unit (or other electronic equipment) requires a huge increase in processing power and greater use of floating-point functions.

Figure 6-1
New Memory for the Next Level



Source: Dataquest (July 1995)

Sprites are important graphic tools for two-dimensional graphics. A sprite is a graphic object that moves around but changes little. Sprites are efficient because the pixels within the sprite do not need to be recalculated; they move around the screen as a single block of pixels (rather than many single pixels). However, with 3-D graphics, objects need to change size as they move closer or farther from the viewer. Sprites may still be used with 3-D graphics, but the pixels within the sprite need to be recalculated as the sprite moves along the Z-axis. The calculation may be more involved than just resizing the sprite if a game or other application has diminished lighting effects where objects lose color and detail as they move farther away.

Polygons are used as building blocks for three-dimensional applications just as sprites are used for two-dimensional graphics. In the same way that sprites help reduce the number of calculations required, polygons are useful because they are relatively simple to resize and reposition in a graphic image. Multiple polygons can be drawn together to create an object that appears to be three-dimensional, with fewer calculations than rendering a true three-dimensional object. The human figures from the popular video game Virtua Fighter are a good example. Virtua Fighter pits two human figures in a martial arts match with a three-dimensional perspective. The figures themselves are drawn with polygons to give the appearance of having round arms and full hair.

Polygons placed next to each other but at different angles to the viewer give the impression of a three-dimensional object with many flat sides, in much the same way that an octagon gives the impression of a circle. Of course, the image is improved if more polygons are used, just as a 16-sided polygon is a closer approximation to a circle than an octagon. As more polygons are added, the angle and color changes from one polygon to the next are reduced, making the three-dimensional object appear smoother and more realistic. Polygons are so important for three-dimensional graphics that most companies designing hardware will use number of polygons per second as a measure of performance.

Lighting and shading are also critical issues for three-dimensional graphics. Good shading dramatically increases the realism in a graphic picture. When polygons are drawn, a color (or pattern of colors) must be chosen for each polygon. These colors must be chosen with respect to apparent light sources in the picture itself. For example, if the sun is shining, objects should cast shadows and the sides of objects facing the sun should be lighter. Common applications use two main techniques: flat shading and Gouraud shading. Another, Phong shading, produces better results than either flat or Gouraud shading but is too complex for common or low-cost applications.

Flat shading is the simplest of these techniques and involves the fewest calculations. A single color is calculated for each polygon according to its orientation to light sources and the object's intended color. The drawback to this technique is that sharp color transitions from one polygon to the next reduce the image's realism. Gouraud shading involves calculating a color for each vertex rather than each polygon. Once the vertex colors have been chosen, the polygon is shaded using the vertex colors as fixed points and interpolating colors between those vertexes. The result is more realistic than flat shading because many colors are used on each polygon. As the number of polygons in an object increases, the visual difference between these two methods is reduced, but Gouraud shading increases the realism more cost-effectively than adding additional polygon-processing capability.

3-D graphics have been available on high-end graphics workstations for years, but these features are becoming increasingly affordable for desktop PC and home video game use. The leading solution for low-cost 3-D graphics is the GLINT processor from 3D Labs, a single chip with capabilities previously achieved only with multiple chips. The performance specifications are: 300,000 shaded, depth-buffered, and anti-aliased polygons per second; 32-bit color; 2-D and 3-D graphics acceleration; PCI-bus interface logic; and integrated LUT-DAC control. A quick examination of Table 5-1 shows this to exceed the performance of the current generation of home video game hardware by 50 percent. The GLINT processor supports OpenGL, which is a the public variation of Silicon Graphics' graphic library, GL.

CD-ROM Technology

Speed and storage capacity are the two critical factors in measuring performance of CD-ROM drives. Two elements affect speed: transfer rates and access times. Transfer rates are established by how many bytes can be transferred or moved in a single second. The original CD-ROM standard established 150 KBps as the minimum transfer rate for "single speed." Subsequent CD-ROM technologies have been labeled according to their relationship to the single-speed standard (see Table 6-1).

Table 6-1
CD-ROM Drive Specifications

Speed Label	Transfer Rate (KB/sec)	Access Rate (Milliseconds)
Single Speed	150	300 to 450
Double Speed (2x)	300	250 to 400
Triple Speed (3x)	450	250 to 350
Quad Speed (4x)	600	175 to 300
6x	900	150 to 250

Source: Dataquest (July 1995)

Access rates may be just as important as transfer rates, especially for applications such as games where response times are critical. While CD-ROM technology has improved in both overall speed and transfer speed, access rates have also improved. One could have a drive that could transfer bytes out very quickly but that would be very slow in getting to the information in the first place. Thus, the slowest transfer rate drive can be more responsive than the highest transfer rate drive if its access time is substantially better.

3DO was the first video game maker to introduce CD-ROM drive technology in its platform when it used a single-speed drive in its first FZ-1 model. One of the key features of 3DO's new FZ-10 model was the introduction of a double-speed drive. Both the Sony Playstation and the Sega Saturn have also incorporated double-speed drives. In a market where profits are derived mainly from software sales, these companies have decided to take advantage of the lower costs in production and inventory offered by CD-ROM discs over cartridges. However, these platforms will pay a penalty in the form of higher costs for the actual video game players with CD-ROM drives. The additional cost of including CD-ROM drives in video game players will make it more difficult to lower prices enough to attract strong consumer market sales of video game players. Most CD-ROM drive companies shut down production of single-speed drives in 1995. They are now shutting down, or have already shut down, double-speed CD-ROM drive manufacturing lines and have converted, or will be converting soon, to quad-speed drives. Nintendo will be exploiting the hardware cost savings in its cartridge-based Ultra-64 system to introduce its new platform at or below $250.

In early 1995, a major competition developed between two proposed standards for the next generation of multigigabyte high-capacity optical disks—critical for space-constrained multimedia. This new generation of videodisk technology is called digital video disk (DVD). Sony and Philips have developed one technology, Multimedia CD (MMCD); Toshiba and Time Warner have developed another, called Super Density (SD). Both standards employ MPEG-2 compression to achieve much higher levels of storage capacity. Efforts to develop one common standard have failed. However, PC manufacturers, who would play the major role in determining a winner, are exerting their influence to push the two competing parties to a single standard. Before DVD technology could be employed in video game players, its cost would have to come down significantly. Sega has said it is examining the SD format, but it is still too early to predict when this technology could be used in video games.

Sound

Sound processing in computers and video games has progressed from simple beeps to 8-bit FM synthesis and then to three-dimensional sound processing and wavetable synthesis. The progression from one technology to the next has involved trade-offs between cost and performance, but high-performance technologies are now being bundled as standard features in both home video games and midrange and higher multimedia PCs. Just as the change from the simple PC speaker to the original Sound Blaster audio cards represented a leap in performance, the progression from those same 8-bit, FM-synthesized cards to the newest technologies represents another leap in performance. The advances are dramatic in terms of both the quality of sound reproduction and reproduction of spatial positioning.

Audio signals are naturally analog signals that must be converted to digital information before they can be stored on digital media such CD-ROM discs and rigid disk drives. This conversion is performed by a digital-to-analog converter (DAC). Because analog signals are continuous and digital signals are quantized, the digital-to-analog conversion involves the loss of some information about the signal. The digital signal is quantized in terms of both voltage and time. (If you graph an analog signal on a sheet of paper as it varies with time, you should be able to draw a single line on the graph to represent that signal.) However, if you digitize that signal, the information is stored periodically rather than continuously. (You would have to lift your pencil between each of the digital samples, and your graph of the digital signal would be a series of dots rather than a smooth, continuous line.) How much information is lost during the conversion from analog to digital depends on the sampling rate and the bit resolution of the DAC. Eight-bit DACs were used in the first sound cards, but they have been almost completely replaced by 16-bit DACs, which provide an overwhelming boost in audio quality.

FM synthesis has been the mainstream technique for reproducing an audio signal from digital information. This technique uses a carrier signal that is frequency modulated to store audio information. This carrier signal is digitized for storage on media such as hard disks. When the sound is played back, the digital information must be converted into frequency-modulated analog signals, then demodulated and mixed by the FM synthesizer before being amplified and sent to the speakers. The demodulation and mixing steps rely on algorithms to approximate the sounds of specific instruments, and these approximated sounds are noticeably different from the true sounds of the instruments.

Wavetable synthesis is overtaking FM synthesis in popularity because it reproduces sounds more accurately. This technique uses a stored sample—a high-quality, digitized recording—as an example of a specific instrument's sound. Samples are stored permanently in read-only memory (ROM). Because this method stores more information about the complex sound of an instrument than FM synthesis, it more closely approximates the real instrument's sound. Wavetable synthesis produces audio quality comparable to audio CDs.

Spatial positioning, or 3-D sound, also enhances the realism of audio playback by recreating sound directionality, the impression that a particular sound is coming from a particular direction, or even that the source of a sound is moving. The earliest application of this to audio equipment is stereo processing. Stereo sound uses two audio channels, left and right, to provide simple directionality to sound. Stereo is now being replaced with surround sound (three channels: left, right, and rear) and pro-logic, which adds a center channel to surround sound. Multiple channels enhance the audio realism by providing more unique sound sources. However, even with pro-logic's four channels, listeners can still feel that all of the sounds are coming directly from a speaker rather than from many directions.

3-D sound uses advanced audio processing (phase shifting) to trick the listener into believing that sounds are not tied to the speakers at all but emanate from all directions in front or at the sides of the listener. The listener may also believe that the source is moving. This has the effect of separating the apparent sound source from the actual sound source. When paired with visual cues, this audio effect provides a more realistic experience. For example, watching a graphic jet airplane fly across a computer screen is likely to be more interesting if the roar of the engines seems to follow the jet's path. The experience seems more real when the senses receive simultaneous and consistent information that closely approximates everyday experience.

Several companies are currently licensing or developing 3-D sound technologies. Offerings include Desper Products Spatializer, SRS Labs' Sound Retrieval System, and QSound Labs' QSound Virtual Audio System. Dolby Laboratories and Roland are also working on 3-D sound solutions.

Modems

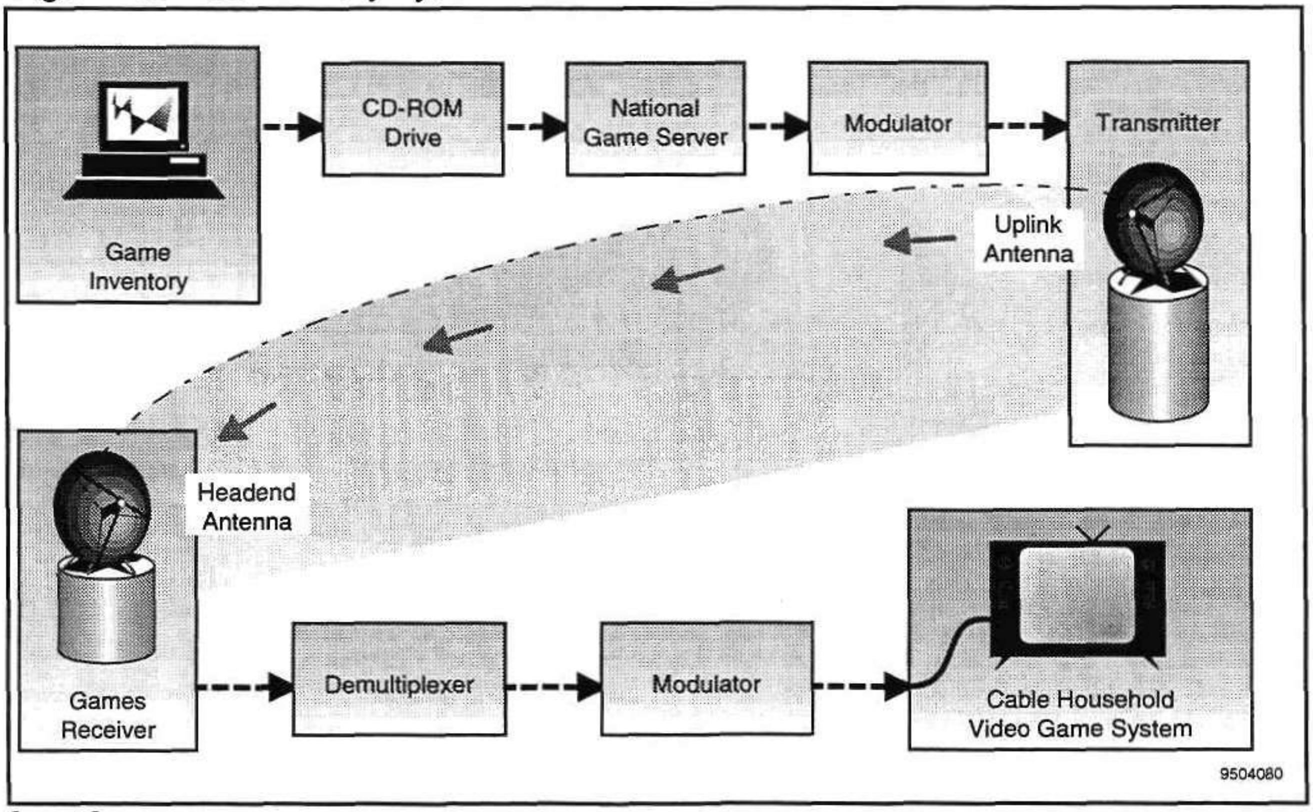
Modem technology has begun to make inroads into the video game arena and is showing promising potential. Catapult Entertainment has entered into licensing and support agreements with Sega and Nintendo that will allow Catapult to market its XBAND Video Game Modem for Sega's Genesis and Nintendo's Super NES platform. The XBAND modem makes it possible for video game players to hook into a network that allows them to compete against opponents in other locations in real time over a telephone line. Catapult claims that the XBAND game modem and network are designed to support all of today's popular multiplayer video games without modification to either game machine or software, which should allow it to gain easier market acceptance. Atari offers the Jaguar Modem, which will allow friends to play over phone and cable lines.

Video game companies are also taking advantage of modems to deliver software to the home. Sega completed testing of its Sega Channel in the United States during 1994 and began to roll out its interactive system in late 1994 and early 1995. More than 90 local cable systems have launched the Sega Channel service as part of plans by nearly 50 cable multisystem operators to offer the service around the United States. By the end of 1995, Sega Channel plans to be launched in systems serving about 20 million U.S. subscribers.

The technology developed for Sega Channel allows the channel to receive Genesis games from Sega and other publishers of Sega games, uplink them to a satellite and beam them to cable headends. At the headend, the operator will use a specially designed General Instrument or Scientific Atlanta receiver/modulator to pick up the games and pass them through to subscriber homes. In the home, the system entails modifying a Sega Genesis video game controller with a special cable adapter that downloads the games. A subscriber can select a game and, within a minute, the game will be downloaded into the adapter. A diagram of this system is shown in Figure 6-2. The adapter, which sells for $160 and is also made by General Instrument and Scientific Atlanta, manages the back channel for ordering specific games from the TV screen and the memory for storing downloaded games. The service costs $12 to $20 per month and allows subscribers to choose from 50 updatable games, preview soon-to-be-released titles, access special titles created solely for the Sega Channel, view game tips, and participate in contests and promotions. Sega worked with TCI and Time Warner to develop the Sega Channel, and each of the adapter makers, Scientific Atlanta and General Instrument, has been guaranteed an order of 250,000 adapters by TCI and Time Warner.

Atari has also been developing an interactive game delivery system working with Time Warner Cable and its Full Service Network trials in Orlando, Florida. In this system users are able to access games that are digitally compressed and stored on servers. The system supports games for Atari's Jaguar video game player.

Figure 6-2
Sega Game Data Delivery System



Source: Sega

Virtual Reality

The phrase "virtual reality" is an oxymoron, but does embody many important ideas. As the processing power of computers and other video game hardware increases, these games will feature more virtual reality (VR) features such as photorealism, three-dimensional audio capabilities, and natural input devices. Virtual reality aims to create an artificial environment that is experienced as real or at least as a suitable model of reality. Advances in hardware and software are narrowing the gap between the capabilities of both consumer and professional devices and the requirements for suspension of disbelief.

The newest generation of home video game hardware has taken steps toward the ideal of VR. The Sony Playstation and Sega Saturn support more colors than previous generations, as well as 3-D rendering capabilities using polygons. Nintendo's Virtual Boy is visually immersive, with a set of goggles that provide a stereo image (one image for each eye) for crisp 3-D graphics. The most VR-oriented game platform is the Atari Jaguar VR system. The Jaguar VR includes a head-mounted display and uses natural inputs created by tracking head motion and hand motion. In this system, turning the head to the left causes the screen to change: The viewer sees what previously was to the left. To point a gun to the right, simply move the arm to the right. This separation of view and gun pointing adds to the realism but is extremely difficult to control without natural inputs (those which require no learning) such as head movement tracking and joystick tracking.

Virtual reality is not all fun and games, however. There are practical applications for artificial environments in industry and science. For example, it may be useful to simulate human interaction with a machine being designed to determine if controls or gauges are conveniently placed. Is a new car design suitable for someone five feet tall as well as for someone six feet tall? Which of two (or more) designs do potential users prefer? These kinds of questions can be answered by building a physical model, but building iterative physical models is time consuming and expensive.

One drawback to virtual reality is the potential for negative side-effects. Some users of head-mounted displays have reported a type of simulator sickness that appears to be related to poor image stabilization. Others are concerned about possible long-term effects from using head-mounted displays. More research is needed before any long-term effects can be understood. In any case, short-term use of these devices is considered safe and risk-free.

Emerging Features and Technologies Summary

Table 6-2 illustrates emerging features that are being, or will be, delivered by the next-generation of video games and the key technologies behind each of these features.

Table 6-2
Emerging Features and Technology Requirements for Video Games

Feature	Technology Requirement
Advanced Graphics	
3-D Processing	16-bit, 32-bit, 64-bit MPU
Texture Mapping	Specialized sprite and background processors (100-200K-gate CMOS ASIC)
Rotation/Scaling	JPEG/MPEG decoders (ASSP or ASIC)
Scanned Images	Fast video memory (1MB, 2MB)
Motion Video	VRAM
	Synchronous DRAM
	Rambus DRAM (RDRAM)
Advanced Audio	DSP processor (16-bit, 32 bit)
CD Quality	Compression
Unlimited Sounds	ADPCM
3-D Sound	MPEG
	AC-3
	CD DAC (16-bit, 44 KHz)
	Audio RAM (0.5MB to 1MB)
Human Control Interface	
Memory Card	PCMCIA or Carbus (PCI) Interface
Wireless Control	IrDA and RF interface, UART, protocol processor
VR Goggles/Headphones	IEEE 1394 interface
Cost-Effectiveness	Further integration onto a 3- to 4-chip chipset

Source: Dataquest (July 1995)

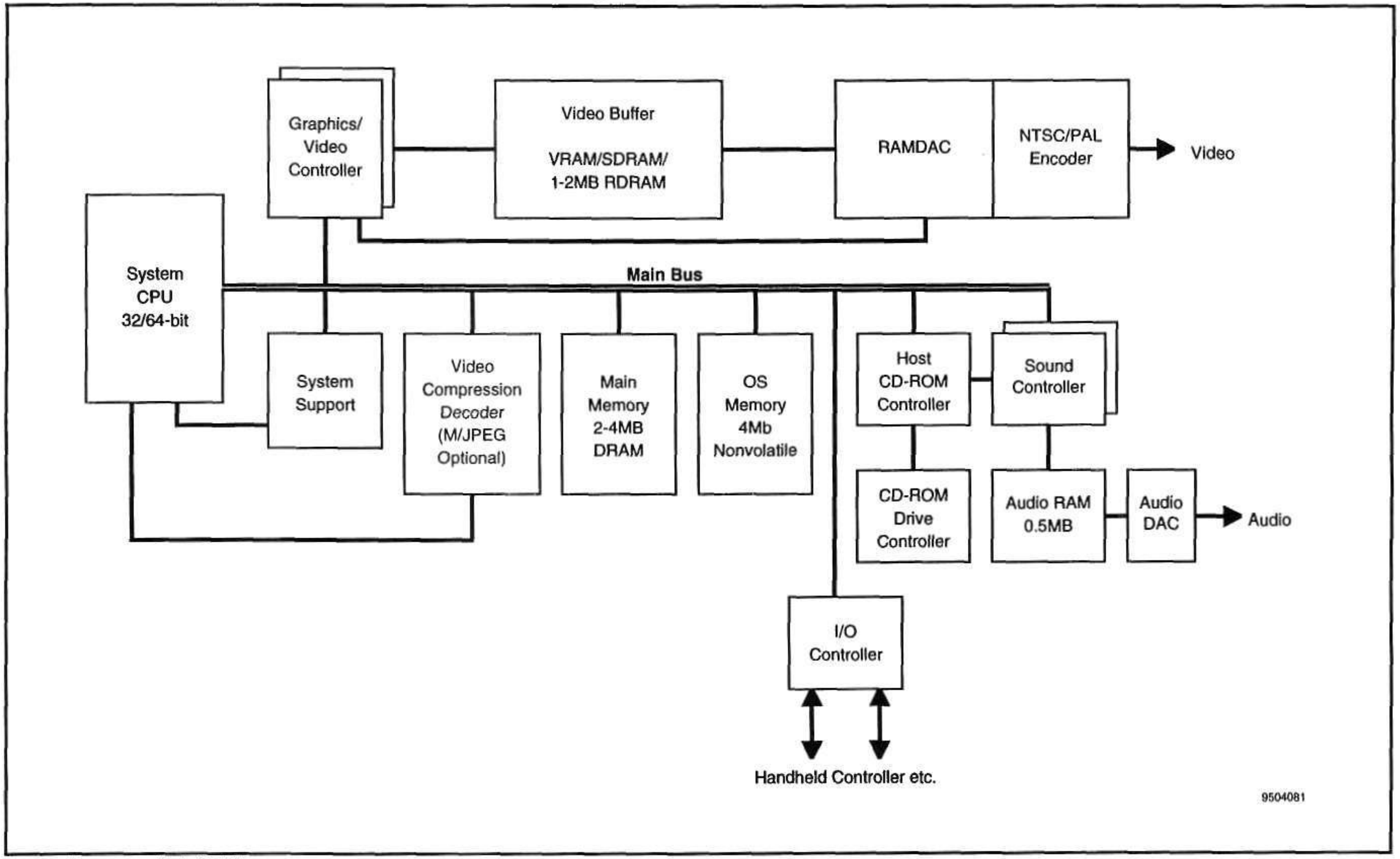
Semiconductor Opportunities

A generic block diagram of a RISC video game controller is shown in Figure 6-3. This diagram provides an overview of the key elements in advanced video game controllers and a valuable framework for understanding the key technologies and semiconductors in these systems. The following sections discuss specific semiconductor opportunities presented by this next generation of video game players.

MPUs

The opportunity for microprocessors in home video games is biased toward 64-bit RISC architectures. The current generation of hardware is overwhelmingly 32-bit RISC-oriented. Current systems do vary in their implementation strategies for the CPU, from using an off-the-shelf MPU to integrating a RISC core into an ASIC. The Sony Playstation uses a custom MPU from LSI Logic that includes a MIPS R3000 core with other functionality, and the Nintendo Ultra-64 is expected to have a custom MPU with a RISC core from Silicon Graphics. Other units, such as the 3DO M2 and the Sega Saturn, use generic microprocessors surrounded by custom processors for graphics and audio processing. The 3DO M2 will use a PowerPC 602 microprocessor, and the Sega machine has two Hitachi SH-2 microprocessors.

Figure 6-3
Generic Block Diagram of RISC Video Game Controller



Source: Dataquest (July 1995)

Opportunities for Motorola and IBM to supply microprocessors for the 64-bit generation of home video games are good because these companies already have a 64-bit chip in production (PowerPC 620), as well as a current design win in the M2. A rumor is circulating that Sega is interested in 3DO's M2 accelerator, but is denied by both companies. However, this speculation is interesting because Hitachi, which supplies microprocessors for the Sega Saturn, does not have a 64-bit microprocessor. Sega will have to design around a new CPU for its next system in any case. A second design win would be strong boost for the PowerPC architecture.

The Atari Jaguar uses a little of both these strategies: a powerful RISC-based graphics processor and a Motorola 68000 for central processing functions. The arguments for and against these two methods involve trade-offs. A highly integrated system is likely to be less expensive to manufacture in volume, but systems designed around standard microprocessors may be able to run variations of popular operating systems. As the opportunities evolve to leverage video game designs into set-top boxes for a multipurpose design, these issues become more important. Silicon Graphics has already taken the step of developing its Magic Carpet architecture to be used in its own set-top box designs as well as in Nintendo's Ultra-64. At this point, the best strategy is unclear, but there are opportunities for MPU companies to license their RISC cores as well as provide standard products for these units. Companies willing to do both will be able to take greatest advantage of opportunities. As far as functional requirements are concerned, the more powerful the processor, the better, but floating-point performance is becoming more critical as 3-D graphics increase in popularity.

Graphics Chips

Graphics chips are a critical component of home video games. The quality and speed of graphics are the primary performance benchmarks for video game hardware. As three-dimensional graphics grow in popularity, the graphics processor will increasingly define the system.

Polygon processing for 3-D graphics is floating-point mathematics intensive, so either the graphics controller or the CPU must provide good floating-point performance. Gouraud shading is also important, providing a dramatic improvement in 3-D images with lower processor overhead than that involved in increasing polygon-drawing capabilities. The third essential feature for video game graphics chips is video capabilities. Most of these units are CD-ROM based or have an optional CD-ROM accessory. The 680MB storage capability for CD-ROM discs allows many video clips to be stored inexpensively. The graphics chips must be able to decompress the video stream and to perform the color-space conversion and scaling required for playback. Semiconductor companies that want their graphics capabilities designed into home video games must address all these functional issues and must be willing to integrate functions into custom ICs for specific game platforms. Standard graphics controllers do not generally have the level of integration required for home video game designs.

Controller Chips

The key to auxiliary controller chips in home video games is flexibility. Semiconductor companies looking to sell disk controllers or audio controllers in the home video games market should be willing either to license their technology or to provide a custom IC to the buyer's specification. Home video game designers push the limits of technology in polygon processing and 3-D graphics, but they do not spend the time or money to create new disk I/O or audio standards because those standard technologies are suitable as they are. For this reason, they need off-the-shelf technologies, but may want to integrate these functions into custom ICs to reduce overall manufacturing costs.

Memory

Home video games have created a new market opportunity for memory device manufacturers. The current generation of games has set records in terms of megabytes of memory per system and for acceptance of alternative memory architectures. Almost all of this generation's units use varying amounts of standard DRAM, VRAM, SRAM, and ROM, but some of them break the mold. The Sega Saturn has 2.5MB of SDRAM, and the Nintendo Ultra-64 is scheduled to have a Rambus memory interface.

Price/performance is the key trade-off for memory devices in these systems. New architectures such as SDRAM and Rambus are acceptable because the ability of the user to upgrade and to use standard modules (SIMMs or DIMMs) is not important. With price/performance critical, there is little opportunity to use flash or EPROM devices inside the boxes. Flash and EPROM provide programmability benefits but cost so much more than standard ROM devices that they are not currently attractive. Video game designs are fairly static within a generation, so reprogrammability is not a critical issue. The largest opportunity for these devices is in auxiliary memory cards that would allow players to save games and later resume play. Several game makers have announced this capability for their CD-ROM–based games and some popular cartridges for cartridge-based games have a provision for saving games, but the memory requirements for this feature are measured in kilobytes rather than megabytes.

Semiconductor Forecast for Next-Generation Video Game Controllers

The emerging market for next-generation RISC-based video game controllers is expected to to reach almost 18 million unit shipments by the year 2000 (see Table 6-3). The average semiconductor content forecast for these new machines is outlined in Table 6-4. Some of the key assumptions behind this forecast are as follows:

- Average prices for video game controllers will drop below $200 by 2000.
- Advanced DRAM architectures that command a price premium will be used and the megabytes per system will increase.
- CD-ROM technology will be successful in video game applications.
- Decompression hardware will eventually penetrate 20 percent of the controller shipments.
- New MPUs and graphics controllers delivering more advanced features will be introduced in the future.

Forecasts for next-generation video game controller production is shown in Table 6-3. Semiconductor content is forecast in Table 6-4. Table 6-5 and Figure 6-4 present the semiconductor market opportunity for next-generation video game controllers, based on these forecasts. The semiconductor market share forecast by major segment is shown in Figure 6-5.

Table 6-3
RISC Video Game Controller Production, Worldwide

Controller Shipments	1993	1994	1995	1996	1997	1998	1999	2000
Units (K)	100	1,237	4,802	6,809	8,886	12,791	15,797	17,869
Average Selling Price, Factory (U.S.$)	328	320	350	285	258	238	202	190
Revenue (U.S.$M)	33	396	1,681	1,941	2,293	3,044	3,191	3,395

Source: Dataquest (July 1995)

Table 6-4
Semiconductor Content of Average RISC Video Game Controller (U.S. Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000
Total Semiconductor Cost	209.2	212.5	230.0	186.7	169.7	158.3	133.8	127.0
Memory	96.8	100.2	127.7	100.8	91.6	85.3	65.4	61.7
DRAM/VRAM/SDRAM/RDRAM	93.6	97.2	124.8	98.0	89.0	82.8	63.0	59.5
MB per system	3.0	3.0	4.0	4.0	5.0	6.0	6.0	7.0
Nonvolatile	3.2	3.0	2.9	2.8	2.6	2.5	2.4	2.2
Mb per system	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
MPU	28.0	33.0	28.0	24.0	22.0	21.0	20.0	20.0
System Support (ASIC)	4.4	4.2	4.0	3.8	3.6	3.4	3.3	3.1
Audio	15.3	14.2	13.2	12.2	11.3	10.4	9.6	8.9
Controller (ASIC)	10.3	9.6	9.0	8.4	7.8	7.2	6.7	6.3
Audio DAC (ASSP)	4.5	4.1	3.7	3.3	3.0	2.7	2.4	2.2
Amps/Mixer/etc.	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Graphics/Video	23.8	21.1	18.7	16.3	14.3	12.5	10.9	9.5
Controller (ASIC)	19.5	17.4	15.5	13.6	12.0	10.6	9.3	8.2
TV Encode (ASSP)	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7
Triple Video DAC (ASSP)	2.9	2.4	2.0	1.6	1.3	1.0	0.8	0.7
Compression	0	0.5	0.9	2.8	2.4	2.2	2.2	2.2
CD-ROM Control	34.7	33.1	31.5	20.9	18.8	17.8	16.9	16.1
I/O Control (MCU)	3.1	3.1	3.0	2.9	2.9	2.8	2.8	2.7
Standard Logic/Linear	2.1	2.0	2.0	2.0	1.9	1.9	1.8	1.8
Discrete	1.0	1.0	1.0	1.0	1.0	0.9	0.9	0.9
Compression Content Assumptions								
Compression Hardware Cost	35.0	25.0	18.0	14.0	12.0	11.0	11.0	11.0
Market Penetration (%)	0	2	5	20	20	20	20	20
Average Cost per Player	0	0.5	0.9	2.8	2.4	2.2	2.2	2.2
CD-ROM Content Assumptions								
CD-ROM Control Hardware Cost	34.7	33.1	31.5	29.9	28.4	27.0	25.7	24.4
Market Penetration (%)	100	100	100	70	66	66	66	66
Average Cost per Player	34.7	33.1	31.5	20.9	18.8	17.8	16.9	16.1

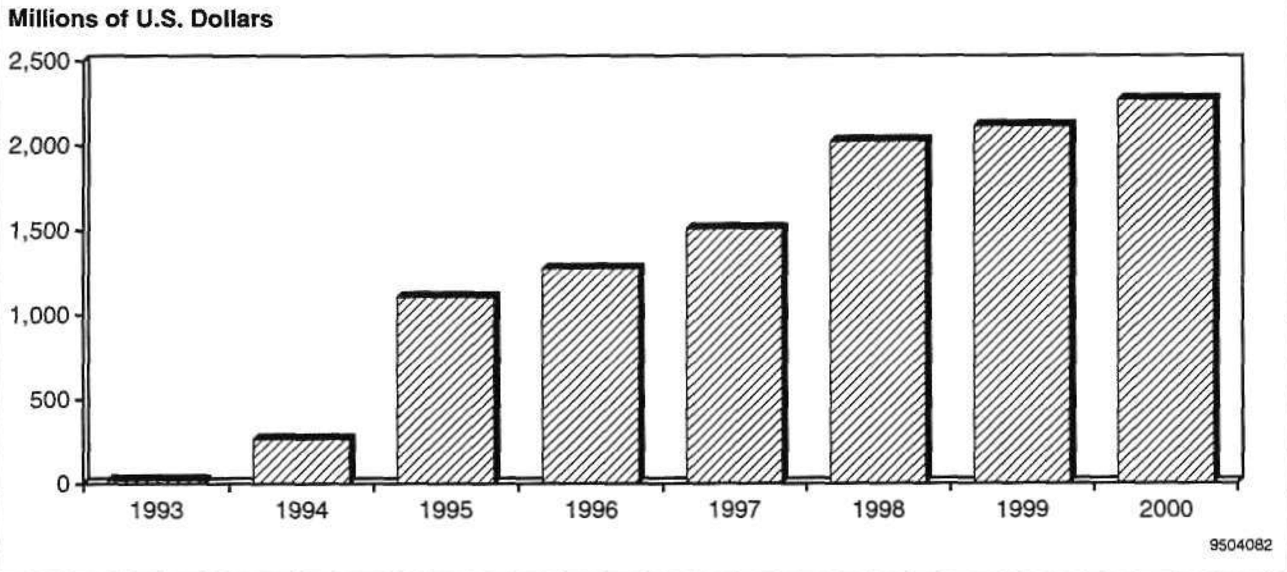
Source: Dataquest (July 1995)

Table 6-5
Next-Generation Video Game Controller Semiconductor Market Forecast, Worldwide (Millions of U.S. Dollars)

	1993	1994	1995	1996	1997	1998	1999	2000
Total Market	20.9	262.8	1,104.5	1,271.2	1,507.7	2,024.3	2,113.8	2,269.2
Memory	9.7	124.0	613.2	686.0	814.1	1,090.9	1,032.5	1,103.3
DRAM/VRAM/SDRAM/ RDRAM	9.4	120.2	599.3	667.3	790.9	1,059.1	995.2	1,063.2
Nonvolatile	0.3	3.8	13.9	18.8	23.3	31.8	37.3	40.1
Processor MPU/ASIC (32/64)	2.8	40.8	134.5	163.4	195.5	268.6	315.9	357.4
System Support (ASIC)	0.4	5.2	19.2	25.9	32.1	43.9	51.5	55.3
Audio	1.5	17.6	63.4	83.0	100.1	133.1	152.0	159.0
Controller (ASIC)	1.0	11.9	43.2	57.0	69.2	92.6	106.4	111.9
Audio DAC (ASSP)	0.5	5.1	17.8	22.7	26.6	34.5	38.3	39.0
Amps/Mixer/etc.	0.1	0.6	2.4	3.3	4.3	6.0	7.3	8.1
Graphics/Video	2.4	26.1	89.8	111.1	126.7	159.4	172.2	170.5
Controller (ASIC)	2.0	21.5	74.4	92.9	106.7	135.1	146.8	146.2
TV Encode (ASSP)	0.1	1.6	5.8	7.4	8.6	11.2	12.4	12.7
Triple Video DAC (ASSP)	0.3	3.0	9.6	10.9	11.4	13.1	12.9	11.7
Compression	0	0.6	4.3	19.1	21.3	28.1	34.8	39.3
CD-ROM Control	3.5	40.9	151.3	142.6	166.7	228.0	267.5	287.5
I/O Control (MCU)	0.3	3.8	14.4	20.0	25.6	36.1	43.7	48.5
Standard Logic/Linear	0.2	2.5	9.6	13.3	17.1	24.1	29.1	32.3
Discrete	0.1	1.3	4.8	6.7	8.5	12.0	14.6	16.2

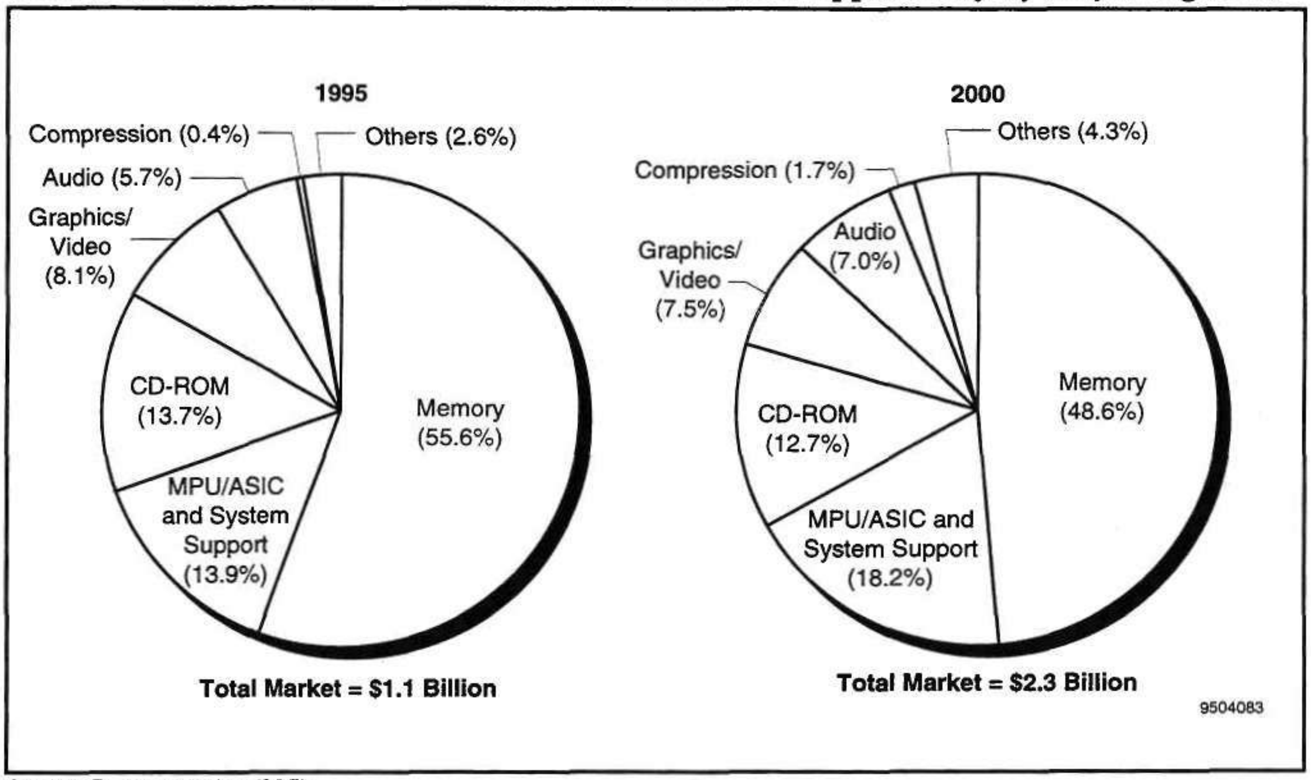
Source: Dataquest (July 1995)

Figure 6-4
Next-Generation Video Game Controller Semiconductor Market Forecast, Worldwide



Source: Dataquest (July 1995)

Figure 6-5
Next-Generation Video Game Semiconductor Market Opportunity by Major Segment



Source: Dataquest (July 1995)

Chapter 7
Major Semiconductor Suppliers to the Video Game Industry

A number of semiconductor suppliers have won key slots in the new 32-and 64-bit video game controller markets and are positioning themselves to develop future opportunities in the video game industry. A brief description of the products and design wins of some of these companies follows.

Hitachi

Hitachi's 32-bit SuperH RISC engines, graphics processors, controller ASICs, SDRAM memory, and other DRAM and memory chips dominate the Sega Saturn platform. The SH-2 and SH-1 processors provide the power that drives the Saturn. As one Sega executive phrased it, "We speak SH." The SH-1 includes on-board ROM, RAM, and peripheral control functions. Capitalizing on its success, Hitachi recently announced a new mini-RISC SH-1 core as part of a new cell-based ASIC family. The SH-2 offers high bus bandwidth, on-chip cache, and an SDRAM interface. Its design is optimized for use in multimedia applications such as video game controllers. The next series of the SuperH architecture, the SH-3, should be available in 1995. Hitachi claims this chip will be capable of 100 mips at 3.3 volts, with operation down to 1.8 volts.

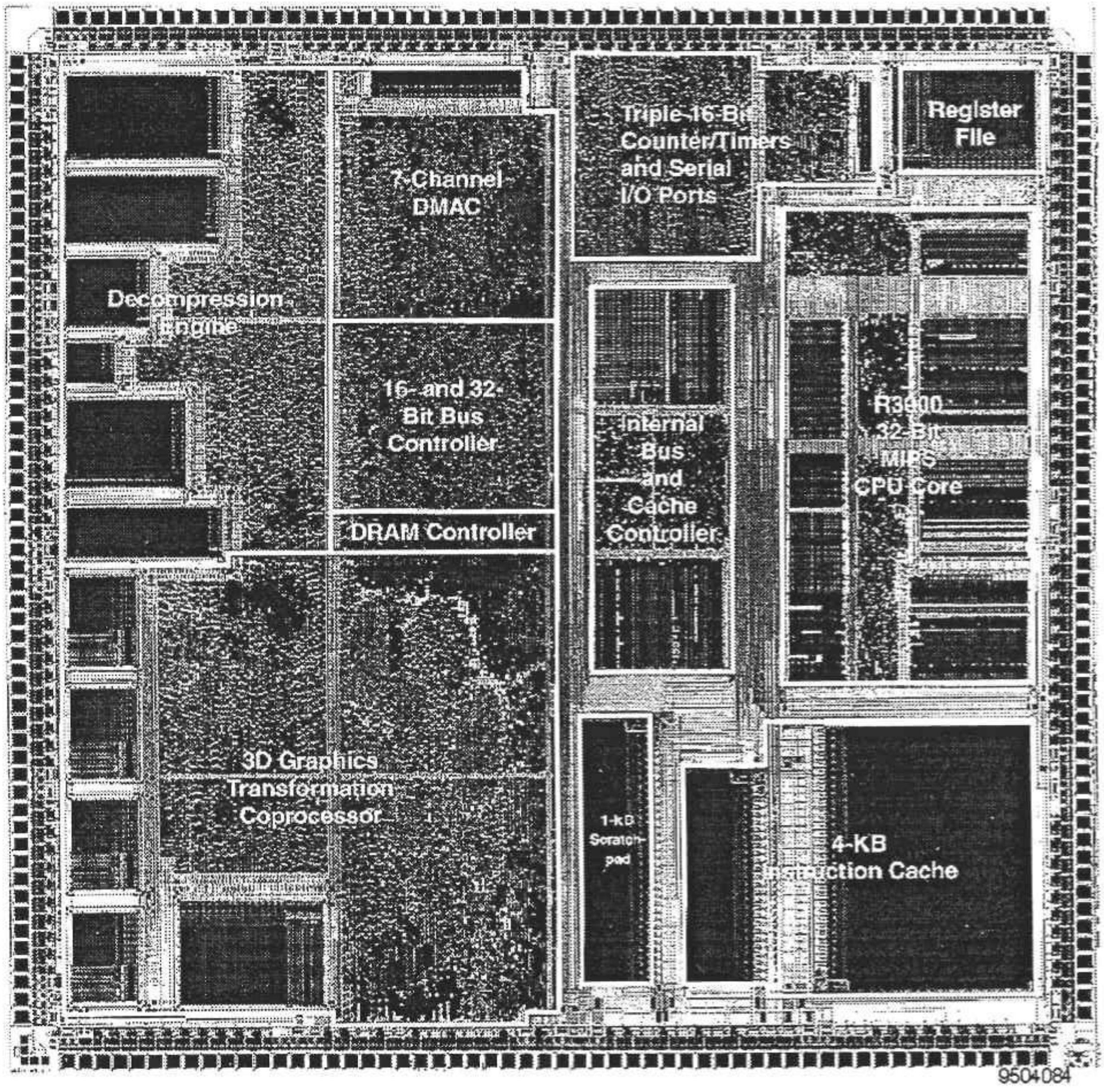
LSI Logic

At the heart of Sony's Playstation is LSI Logic's custom 32-bit R3000 RISC processor, which was designed using LSI's proprietary CoreWare methodology and 0.5μ process technology. The Playstation CPU, which was customized for Sony Computer Entertainment, comprises three high-performance subsystems that are part of LSI's Video Compute Engine architecture: a 32-bit RISC CPU, a graphics transformation engine (GTE), and a video decompression engine (VDE) based on Motion JPEG technology. This processor, which is illustrated in Figure 7-1, delivers 200 MIPS running at 34 MHz.

MIPS/Silicon Graphics

Few details about the RISC processor developed by Silicon Graphics as part of the Nintendo Dream Team have been disclosed. Perhaps the closest information about this chip comes from comparing it to the R4300i CPU, which was announced as part of the Magic Carpet Architecture developed by MIPS Technologies for the set-top box market. The CPU developed for Nintendo's Ultra-64 was based on the MIPS R4400 initially, but also borrowed ideas from the R4200. Although the Magic Carpet architecture uses a multimedia accelerator (MMA) to perform real-time MPEG-2 decoding, the Ultra-64 chipset will use a scaled-down Reality Engine coprocessor without a transformation engine to provide rendering, color conversion, and scaling functions. The chipset will be manufactured by NEC using 0.35μ process technology and should cost less than the $35 R4300i processor.

Figure 7-1
The Sony Playstation CPU



Source: LSI Logic

Toshiba

Toshiba supplies a variety of parts for the latest home video game systems, including custom logic, standard logic, and memory devices. The bill of materials for the Sony Playstation (shown in Appendix B-1) details a custom graphics processor and a 512K audio DRAM from Toshiba. The list is more varied in Sega Saturn bill of materials (shown in Appendix A-1) where Toshiba supplied custom logic, standard logic, and ROM. Two additional ASICs in the Saturn may have been fabricated by Toshiba, but this is uncertain.

NEC

NEC supplies synchronous DRAM (SDRAM) for the Sega Saturn. Hitachi also supplies SDRAM for the Sega Saturn, but the Hitachi devices are a little slower at 17.5ns compared to the 12ns access time for the NEC devices. NEC did not supply any parts for the Sony Playstation bill of materials shown in Appendix B-1.

Yamaha

Yamaha supplies one chip for the Sega Saturn and, not surprisingly, it is a sound chip. The Yamaha chip is an FM sound synthesizer and is paired with a Motorola embedded controller and some audio DRAM. Even though the package carries a Yamaha part number, there is probably some Sega ROM on chip.

Motorola

Motorola supplies an embedded 68EC000 controller for the Sega Saturn. This controller is tightly wired to a Yamaha FM synthesizer and appears to provide general audio control functions. Motorola has additional opportunities in the 3DO M2 design, which includes a PowerPC 602 microprocessor, though it will have to compete with IBM to supply those devices to the M2 equipment manufacturers, currently Goldstar and Panasonic.

Chapter 8
Conclusion and Dataquest Perspective

The 32- and 64-Bit Video Game Generations

The newest generation of home video game hardware is a mixture of 32-bit and 64-bit designs. Of the systems that are shipping today, only the Atari Jaguar can lay claim to having a 64-bit architecture because of its 64-bit bus and graphics processor. The central processor for the Atari Jaguar is a 32-bit microprocessor like that of the Sega Saturn, Sony Playstation, and Nintendo Virtual Boy. It is likely that all new systems announced will be 64-bit or higher designs. Two other 64-bit systems that have been announced (but are late to market) are the Nintendo Ultra-64 and the 3DO M2 units. However, the 3DO M2 is designed around a 32-bit CPU. These designs will raise the benchmark for the next round of systems, but millions of 32-bit units will already be sold by the time they ship next year. All of the current designs may receive some intermediate upgrades, such as quad-speed CD-ROM drives, to prolong their product life, but they will be replaced with 64-bit/128-bit units in a few years. The next generation of units will most likely be based on 64-bit MPUs and 64-bit buses, but some may feature 128-bit buses or 128-bit graphics controllers. It is extremely unlikely that a 128-bit microprocessor will be cost-effective for these units within the next few years.

The Semiconductor Market Challenge

Video game units are becoming fixed-function PCs in terms of both processing power and industry-standard features. The number and complexity of semiconductor devices in each unit are overwhelming, and these devices represent the cutting edge of consumer technology. All of the units are targeted to the price-sensitive and highly competitive consumer electronics market, which makes video game hardware a low-margin business where high volumes are required to recover start-up costs. Based on a teardown analysis of two game units, Dataquest expects that hardware platforms sold at very low margins, possibly at a loss, will capture early market share in the emerging 32-bit game market. Profits appear to be tied to software sales.

The market dynamics and pricing policies for video game hardware make this a high-reward and high-risk market for semiconductor manufacturers. Custom ICs are the rule rather than the exception inside these boxes, because each must have cutting-edge features in a highly integrated design. Standard chip products with these features either are not available or are not as integrated as they need to be to meet aggressive cost goals. Hardware designs for these game units are a mix of technologies from different vendors, but most of the technologies are integrated in ASICs rather than purchased as standard components. Sega, Nintendo, Atari, 3DO, and Sony are not defining the compression standards and sampling rates for multimedia technology; however. They are picking and choosing among the standards to deliver the greatest punch at the lowest price. For these reasons, semiconductor companies that want their core processors, MPEG decoders, or audio synthesizers in these units must work with the game developers from the beginning. The high level of integration required to make these game platforms profitable does not allow substitution of semiconductor technologies in the middle of the design process.

In spite of the risks, the high product volumes of successful home video game platforms make this market irresistible for many semiconductor companies. It is critical for semiconductor manufacturers to reduce the risk once a decision to pursue this market has been reached. Silicon Graphics is working to reduce the market risk of its Magic Carpet architecture by targeting multiple markets with the same core technology. For example, a proprietary version of the Magic Carpet architecture is the core technology for Nintendo's Ultra-64 video game platform, but Silicon Graphics is also releasing an open systems version of the architecture for the interactive set-top box market. In other words, Silicon Graphics has leveraged its design efforts to create opportunities in two different markets. Three alliance partners (AT&T Network Systems, Samsung Electronics, and Philips Electronics NV) have already announced plans to use the Magic Carpet architecture in set-top box products. Silicon Graphics has successfully reduced the market risk of this architecture by pursuing both of these growing opportunities and plans to promote the Magic Carpet architecture for additional consumer products in the future.

The Semiconductor Market Opportunity

Worldwide shipments of next-generation video game controllers are forecast to grow to almost 18 million by the year 2000, with the chip opportunity in these systems projected to grow to $2.3 billion in the same period. This would represent a compound annual growth rate of over 43 percent between 1994 and 2000. This forecast is based on the average factory price of new video game controllers dropping below $200 by the year 2000. If prices decline more rapidly, the unit shipments and semiconductor market could grow even larger. Semiconductor companies with technologies ranging from RISC-based CPUs to advanced DRAM architectures will be competing aggressively to demonstrate their ability to deliver optimized performance at low cost as they seek a slice of this rapidly expanding market.

Appendix A

Bill of Materials of Sega Saturn

Table A-1 shows the detailed bill of materials for the Sega Saturn.

Table A-1
Bill of Materials Model: Sega Saturn
(Dual SH2 32-Bit MIPS RISC Processors, Double-Speed CD-ROM)
Cost in Dollars

Subsystem	Type	Manufacturer	Qty.	Best 1995 Cost	Part #	Package	Description	Best 1995 Cost	Best 1996 Cost	Best 1997 Cost
System Card										
CES	Battery	Panasonic	1	0.42	CR2032		Battery, 3V coin-type	0.42	0.40	0.38
CES	Button		1	0.33		PIH-4	Button, small	0.33	0.33	0.32
Graphics	Capacitor		2	0.04		SMT	Capacitor, electrolytic, 22UF6.3V, metal can	0.09	0.09	0.08
Graphics	Capacitor		6	0.04		SMT	Capacitor, electrolytic, 220UF4V, metal can	0.26	0.26	0.25
CES	Capacitor		2	0.04		SMT	Capacitor, electrolytic, 10UF16V, metal can	0.09	0.09	0.08
Graphics	Capacitor		4	0.04		SMT	Capacitor, electrolytic, 10UF16V, metal can	0.18	0.17	0.17
Audio	Capacitor		1	0.04		SMT	Capacitor, electrolytic, 10UF16V, metal can	0.04	0.04	0.04
CES	Capacitor		3	0.04		SMT	Capacitor, electrolytic, 47UF6.3V, metal can	0.13	0.13	0.13
Graphics	Capacitor		1	0.04		SMT	Capacitor, electrolytic, 47UF6.3V, metal can	0.04	0.04	0.04
CES	Capacitor		2	0.04		SMT	Capacitor, electrolytic, 1UF50V, metal can	0.09	0.09	0.08
CES	Capacitor		2	0.04		SMT	Capacitor, electrolytic, 100UF6V, metal can	0.09	0.09	0.08
Graphics	Capacitor		2	0.04		SMT	Capacitor, electrolytic, 100UF6V, metal can	0.09	0.09	0.08
CES	Capacitor		2	0.04		PIH	Capacitor, electrolytic, 330UF6.3V, 85C, metal can	0.09	0.09	0.08
CES	Capacitor		79	0.03		SMT	Capacitor, small 0805	2.07	2.03	1.99
Graphics	Capacitor		27	0.03		SMT	Capacitor, small 0805	0.71	0.69	0.68
Audio	Capacitor		12	0.03		SMT	Capacitor, small 0805	0.32	0.31	0.30

(Continued)

Table A-1 (Continued)
Bill of Materials Model: Sega Saturn
(Dual SH2 32-Bit MIPS RISC Processors, Double-Speed CD-ROM)
Cost in Dollars

Subsystem	Type	Manufacturer	Qty.	Best 1995 Cost	Part #	Package	Description	Best 1995 Cost	Best 1996 Cost	Best 1997 Cost
Graphics	Capacitor		1	0.04		SMT	Capacitor, tantalum, EIA size A	0.04	0.04	0.04
CES	Capacitor		3	0.03		SMT	Capacitor, small 1206	0.09	0.09	0.09
CES	Crystal/Osc		1	0.35		METAL CAN, PIH	Crystal, 14.318138, metal can, 2 leads	0.35	0.33	0.31
CES	Crystal/Osc		1	0.35		METAL CAN, PIH	Crystal, unmarked, metal can package	0.35	0.33	0.31
CES	Crystal/Osc		1	1.09		PIH-3	Crystal/oscillator, ceramic package, 3 pins	1.09	1.07	1.05
CES	Diode		1	0.01		SMT	Diode, small	0.01	0.01	0.01
CES	Diode		3	0.01		SOT-23	Diode, small	0.03	0.03	0.03
Graphics	Diode		1	0.01		SOT-23	Diode, small	0.01	0.01	0.01
CES	Filter		25	0.11	101	PIH-3	Digital noise filter	2.63	2.57	2.52
Graphics	Filter		10	0.11	101	PIH-3	Digital noise filter	1.05	1.03	1.01
Graphics	Header/Conn.		1	0.11		PIH-8	Connector, round DIN, 10-pin	0.11	0.10	0.10
CES	Header/Conn.		1	0.21		PIH-11	Tab connector, male, 11 contacts, right-angle, shrouded	0.21	0.21	0.20
CES	Header/Conn.		1	1.31		PIH-124	Card-edge slot, 36+31 wide	1.31	1.29	1.26
CES	Header/Conn.		1	0.04		PIH-5	Header, 1x5, 0.15, w/tab	0.04	0.04	0.04
CES	Header/Conn.		2	0.05		PIH-4	Header, 1x4, 0.1, SH	0.09	0.09	0.09
CES	Header/Conn.		1	0.04		PIH-4	Header, 1x3, 0.1, SH	0.04	0.04	0.04
CES	Header/Conn.		1	0.08		PIH-18	2X tab connector, male, 9 contacts, right-angle, shrouded	0.08	0.08	0.08
CES	Header/Conn.		1	0.35	BCR20H4	PIH-2	Socket for coin-type battery	0.35	0.34	0.34
CES	Header/Conn.		0.25	0.92		SMT-100	Header, board-to-board, 2x50	0.23	0.23	0.22
CD-ROM Drive	Header/Conn.		0.75	0.92		SMT-100	Header, board-to-board, 2x50	0.69	0.68	0.66
Processor	IC	Hitachi	2	18.03	HD6417095	PQFP-144	SH2 32-bit mips RISC processor	36.07	34.26	32.55

(Continued)

Table A-1 (Continued)
Bill of Materials Model: Sega Saturn
(Dual SH2 32-Bit MIPS RISC Processors, Double-Speed CD-ROM)
Cost in Dollars

Subsystem	Type	Manufacturer	Qty.	Best 1995 Cost	Part #	Package	Description	Best 1995 Cost	Best 1996 Cost	Best 1997 Cost
Graphics	IC	Philips	1	1.00	TDA1386T	SOIC-24	Bit stream continuous calibration DAC	1.00	0.90	0.81
Graphics	IC	Sony	1	1.15	CXA1645M	SOIC-24	NTSC/PAL encoder	1.15	0.92	0.73
Graphics	IC	Hitachi	1	14.02	HD6440F	PQFP-168	Graphics processor, w/Sega ROM	14.02	12.62	11.36
Audio	IC	Yamaha	1	2.57	YMF292-F	PQFP-128	FM sound synthesizer, w/Sega ROM	2.57	2.18	1.85
Audio	IC	Motorola	1	6.62	MC68EC000	PLCC-68	Embedded controller, 16-bit	6.62	5.96	5.36
Graphics	IC	SEGA	1	5.66	FH3006	PQFP-160	Graphics processor ASIC	5.66	4.81	4.09
CES	IC	Hitachi	1	1.72	HD404920F	PQFP-64	4-bit microcontroller, w/Sega ROM	1.72	1.63	1.55
CES	IC	Hitachi	1	0.39	HD49422	TQFP-32	Analog control ASIC, Hitachi	0.39	0.39	0.38
CES	IC	SEGA	1	5.92	FH3007	PQFP-208	Core logic ASIC	5.92	5.03	4.28
CES	Memory	Toshiba	1	2.46	MPR-16606-T	DIP-40	Sega ROM, 0.5MB	2.46	2.09	1.78
CES	IC	Toshiba	1	0.55	74ACT245	SOIC-20	Octal bus transceiver, three-state, true	0.55	0.53	0.50
CES	IC	Toshiba	1	0.70	4L02F2718	PQFP-100	Core logic ASIC, Toshiba	0.70	0.67	0.64
Audio	IC	Toshiba	1	0.30	74HCT157A	SOIC-16	MUX, quad, 2-input data selector	0.30	0.29	0.27
CES	IC	Toshiba	2	0.08	74HC04	SOIC-14	Hex inverter	0.17	0.16	0.15
CES	IC	National	4	0.31	LS245SJ	SOIC-20	Octal bus transceiver, three-state, true	1.24	1.05	0.90
CES	Transistor		3	0.07		SOT-223	Transistor, SOT-223	0.21	0.21	0.20
CES	Inductor		6	0.18		SMT	Inductor, EIA size B	1.05	1.03	1.01
Graphics	Inductor		2	0.18		SMT	Inductor, EIA size B	0.35	0.34	0.34
Graphics	Memory	NEC	4	11.68	D4502161G5	TSOP-50	SDRAM, 128Kx16, 12ns	46.74	42.06	37.86
Memory	Memory	Hitachi	2	23.37	HM5241605	TSOP-50	Synchronous DRAM, double bank, 128Kx16, 17.5ns	46.74	42.06	37.86
Graphics	Memory	Hitachi	1	23.37	HM5241605	TSOP-50	Synchronous DRAM, double bank, 128Kx16, 17.5ns	23.37	21.03	18.93

(Continued)

Table A-1 (Continued)
Bill of Materials Model: Sega Saturn
(Dual SH2 32-Bit MIPS RISC Processors, Double-Speed CD-ROM)
Cost in Dollars

Subsystem	Type	Manufacturer	Qty.	Best 1995 Cost	Part #	Package	Description	Best 1995 Cost	Best 1996 Cost	Best 1997 Cost
CES	Memory	S-MOS	1	2.53	SRM20257	SOIC-28	SRAM, 32Kx8, 100ns	2.53	2.28	2.05
Memory	Memory	Hitachi	2	13.20	HM514260A	SOJ-40	DRAM, 256Kx16, 70ns	26.40	22.44	19.07
Audio	Memory	Hitachi	1	6.13		SOJ-40	DRAM, audio, 256Kx16, 80ns	6.13	5.52	4.97
CES	Resistor		8	0.08		SMT-10	Resistor network, 8 pins, 2012	0.62	0.56	0.50
CES	Resistor		73	0.01		SMT	Resistor, small 0805	0.51	0.50	0.49
Graphics	Resistor		28	0.01		SMT	Resistor, small 0805	0.20	0.19	0.19
Audio	Resistor		5	0.01		SMT	Resistor, small 0805	0.04	0.03	0.03
CES	Transistor		1	0.04		SOT-23	Transistor, small, SOT-23	0.04	0.03	0.03
Graphics	Transistor		3	0.04		SOT-23	Transistor, small, SOT-23	0.11	0.10	0.10
PC Boards	System Raw Card		1	19.00			4 layer card	19.00	18.62	18.25
Card MVA	System Card MVA		1	22.00			32 ICs, wave soldered	22.00	22.88	23.80
							Subtotal—System Card:	290.40	266.91	246.10
Header/Connector										
CD-ROM Drive	Capacitor		1	0.04		SMT	Capacitor, electrolytic, 47UF6.3V, metal can	0.04	0.04	0.04
CD-ROM Drive	Capacitor		8	0.02		SMT	Capacitor, 0603	0.15	0.15	0.14
CES	Capacitor		4	0.02		SMT	Capacitor, 0603	0.08	0.07	0.07
CD-ROM Drive	Crystal/Osc		1	0.35		METAL CAN-SMT	Crystal, unmarked, metal can package	0.35	0.33	0.31
CES	Header/Conn.		1	0.88		SMT-50, PIH-50	Card-edge slot, 50 wide	0.88	0.86	0.84
CD-ROM Drive	Header/Conn.		1	0.21		SMT-40	Flex cable connector, 20 leads, locking tab	0.21	0.21	0.20

(Continued)

Table A-1 (Continued)
Bill of Materials Model: Sega Saturn
(Dual SH2 32-Bit MIPS RISC Processors, Double-Speed CD-ROM)
Cost in Dollars

Subsystem	Type	Manufacturer	Qty.	Best 1995 Cost	Part #	Package	Description	Best 1995 Cost	Best 1996 Cost	Best 1997 Cost
CES	Header/Conn.		0.25	0.96		SMT-100	Connector, 2x50, board to board	0.24	0.24	0.23
CD-ROM Drive	Header/Conn.		0.75	0.96		SMT-100	Connector, 2x50, board to board	0.72	0.71	0.69
CES	IC	Hitachi	0.5	2.97	YGR019A	PQFP-168	Gate array ASIC	1.48	1.26	1.07
CD-ROM Drive	IC	Hitachi	0.5	2.97	YGR019A	PQFP-168	Gate array ASIC	1.48	1.26	1.07
CD-ROM Drive	IC	Hitachi	1	13.53	HD6437097F20	PQFP-112	SH1 16-bit MIPS RISC microprocessor	13.53	12.85	12.21
CD-ROM Drive	Memory	Hitachi	1	12.27	HM514270A	SOJ-40	DRAM 256Kx16, 80ns	12.27	11.04	9.94
CD-ROM Drive	Resistor		4	0.08		SMT-8	Resistor network, 8 pins, 1405	0.31	0.28	0.25
CD-ROM Drive	Resistor		10	0.01		SMT	Resistor, small 0603	0.09	0.09	0.09
PC Boards	Interface Raw Card		1	4.00			4 layer card	4.00	3.92	3.84
Card MVA	Interface Card MVA		1	6.00			3 ICs, wave soldered	6.00	6.24	6.49
							Subtotal—Interface Card:	41.83	39.55	37.50
Other										
Controller	Handset controller	Sega	1	5.24	HSS-0101		Handset controller, direction pad and 9 other buttons	5.24	5.14	5.03
CD-ROM Drive	CD-ROM Drive		1	62.00			Internal CD-ROM drive, double-speed, with ball-bearing disc retainers	62.00	55.00	53.00
Power	Power Supply	Voltek	1	8.00			Power supply, internal (no case), 100V in, 15W	8.00	8.00	8.00

(Continued)

Table A-1 (Continued)
Bill of Materials Model: Sega Saturn
(Dual SH2 32-Bit MIPS RISC Processors, Double-Speed CD-ROM)
Cost in Dollars

Subsystem	Type	Manufacturer	Qty.	Best 1995 Cost	Part #	Package	Description	Best 1995 Cost	Best 1996 Cost	Best 1997 Cost
CES	Switch/LED Card Assy.		1	0.50			Small card with 1 button switch, 2 LEDs	0.50	0.49	0.48
CES	LED Card Assy.		1	0.30			Small card with 2 LEDs	0.30	0.29	0.29
Power	Switch	Alps	1	0.98	SDL1P-A		Medium two-position button switch	0.98	0.96	0.94
Mechanical	Mechanical		1	3.80			Case top, ABS, including CRS door and mechanisms, CRS P/S brackets	3.80	3.88	3.95
Mechanical	Mechanical		1	1.95			Case bottom, ABS	1.95	1.99	2.03
Mechanical	Mechanical		1	0.35			Upper EMI shield, 0.013 brite	0.35	0.36	0.36
Mechanical	Mechanical		1	0.30			Lower EMI shield, 0.013 brite	0.30	0.31	0.31
Mechanical	Mechanical		1	0.15			Expansion module bracket, ABS/PC	0.15	0.15	0.16
CD-ROM Drive	Mechanical		4	0.15			CD-ROM drive standoff, PC	0.60	0.61	0.62
Mechanical	Mechanical		1	0.40			Expansion/battery door, ABS	0.40	0.41	0.42
CD-ROM Drive	Cable		1	0.25			Flex cable, 20 leads	0.25	0.26	0.26
Mechanical	Cable		1	1.30			Round-DIN to composite video patch cord	1.30	1.30	1.30
Mechanical	Cable		1	0.60			Line cord, two conductor	0.60	0.60	0.60
Pubs	Publications		1	0.25			Manual, registration card, paper slip	0.25	0.25	0.25
Box MVA	Box MVA	Tokai (Hitachi)	1	2.81			Box MVA	2.81	2.92	3.04
Freight/ Duty	Freight/Duty		1	6.00			Freight/Duty	6.00	6.00	6.00
							Subtotal—Other:	95.78	88.91	87.05
							Total:	428.01	395.37	370.65

Note: CES = Central Electronics System; MVA = Manufacturing Value-Added
Source: Dataquest (July 1995)

Appendix B
Bill of Materials of Sony Playstation

Table B-1 shows the detailed bill of materials for the Sony Playstation.

Table B-1
Bill of Materials Model: Sony Playstation
(Custom MIPS RISC Processor, Double-Speed CD-ROM)
Cost in Dollars

Subsystem	Type	Manufacturer	Qty.	Best 1995 Cost	Part #	Package	Description	Best 1995 Cost	Best 1996 Cost	Best 1997 Cost
System Card										
CES	Button		1	0.33		PIH-4	Button switch, right-angle	0.33	0.33	0.32
CES	Capacitor		2	0.09		SMT	Capacitor, electrolytic, 22UF16V, metal can	0.18	0.17	0.17
Audio	Capacitor		2	0.09		SMT	Capacitor, electrolytic, 22UF16V, metal can	0.18	0.17	0.17
CES	Capacitor		14	0.04		SMT	Capacitor, electrolytic, 10UF16V, metal can	0.61	0.60	0.59
CD-ROM Drive	Capacitor		4	0.04		SMT	Capacitor, electrolytic, 10UF16V, metal can	0.18	0.17	0.17
Graphics	Capacitor		6	0.04		SMT	Capacitor, electrolytic, 10UF16V, metal can	0.26	0.26	0.25
Audio	Capacitor		11	0.04		SMT	Capacitor, electrolytic, 10UF16V, metal can	0.48	0.47	0.46
CES	Capacitor		1	0.04		SMT	Capacitor, electrolytic, 220UF4V, metal can	0.04	0.04	0.04
CES	Capacitor		3	0.09		SMT	Capacitor, electrolytic, 47UF16V	0.28	0.28	0.27
Graphics	Capacitor		8	0.04		SMT	Capacitor, electrolytic, 220UF4V, metal can	0.35	0.34	0.34
CES	Capacitor		2	0.09		SMT	Capacitor, electrolytic, 47UF16V	0.19	0.18	0.18
CD-ROM Drive	Capacitor		1	0.09		SMT	Capacitor, electrolytic, 47UF6V	0.09	0.09	0.09
CD-ROM Drive	Capacitor		1	0.09		SMT	Capacitor, electrolytic, 4.7UF35V	0.09	0.09	0.09
CD-ROM Drive	Capacitor		1	0.09		SMT	Capacitor, electrolytic, .47UF50V	0.09	0.09	0.09
CES	Capacitor		1	0.04		SMT	Capacitor, electrolytic, 100uF16V, mc	0.04	0.04	0.04
CES	Capacitor		1	0.04		SMT	Capacitor, tantalum, EIA size B	0.04	0.04	0.04

(Continued)

Table B-1 (Continued)
Bill of Materials Model: Sony Playstation
(Custom MIPS RISC Processor, Double-Speed CD-ROM)
Cost in Dollars

Subsystem	Type	Manufacturer	Qty.	Best 1995 Cost	Part #	Package	Description	Best 1995 Cost	Best 1996 Cost	Best 1997 Cost
CD-ROM Drive	Capacitor		4	0.04		SMT	Capacitor, tantalum, EIA size A	0.18	0.17	0.17
CES	Capacitor		75	0.03		SMT	Capacitor, small 0805	1.97	1.93	1.89
Graphics	Capacitor		15	0.03		SMT	Capacitor, small 0805	0.39	0.39	0.38
Audio	Capacitor		6	0.03		SMT	Capacitor, small 0805	0.16	0.15	0.15
CD-ROM Drive	Capacitor		31	0.03		SMT	Capacitor, small 0805	0.81	0.80	0.78
CES	Crystal/Osc		1	1.24	RC67.73 JVC 4J	SMT-5	Oscillator, 67.73, SMT-4	1.24	1.22	1.19
Graphics	Crystal/Osc		1	1.28	JC53.69 JVC 4J	SMT-6	Oscillator, 53.69, SMT-4	1.28	1.25	1.23
CES	Crystal/Osc		1	1.26		SMT-6	Oscillator, 4000, SMT-6	1.26	1.24	1.21
CES	Diode		2	0.01		SOT-23	Diode, small, SOT-23	0.02	0.02	0.02
CES	Diode		22	0.01		SMT	Diode, small	0.19	0.19	0.18
Graphics	Diode		7	0.01		SMT	Diode, small	0.06	0.06	0.06
CD-ROM Drive	Diode		7	0.01		SMT	Diode, small	0.06	0.06	0.06
Graphics	Ferrite		2	0.18		SMT-6	Ferrite, small 2012	0.35	0.34	0.34
Graphics	Ferrite		2	0.04		SMT-4	Ferrite, small 1210	0.09	0.09	0.08
CES	Ferrite		4	0.04		SMT	Ferrite, small 1206	0.18	0.17	0.17
CES	Ferrite		10	0.04		SMT	Ferrite, 0805	0.44	0.43	0.42
CES	Header/Conn.		1	0.64		PIH-64	Header, card-edge type, 2x34, shrouded, right-angle	0.64	0.63	0.61
CES	Header/Conn.		1	0.08		PIH-8	Tab connector, 8 leads, shrouded, right-angle	0.08	0.08	0.08
Graphics	Header/Conn.		3	0.04		PIH-2	Connector, coaxial RCA-type	0.11	0.10	0.10
CES	Header/Conn.		1	0.19		PIH-2	Connector, mini-DIN mono jack	0.19	0.19	0.18
Graphics	Header/Conn.		1	0.11		PIH-4	Connector, round DIN, 4-pin	0.11	0.11	0.11

(Continued)

Table B-1 (Continued)
Bill of Materials Model: Sony Playstation
(Custom MIPS RISC Processor, Double-Speed CD-ROM)
Cost in Dollars

Subsystem	Type	Manufacturer	Qty.	Best 1995 Cost	Part #	Package	Description	Best 1995 Cost	Best 1996 Cost	Best 1997 Cost
Graphics	Header/Conn.		1	0.12		PIH-12	Tab connector, 12 leads, shrouded, right-angle	0.12	0.12	0.12
CES	Header/Conn.		1	0.39		SMT-10	Flex cable connector, 10 leads, locking tab	0.39	0.39	0.38
CES	Header/Conn.		1	0.07		PIH-7	Header, 1x7, 0.08 pitch, shrouded	0.07	0.07	0.07
CES	Header/Conn.		1	0.04		SMT-4	Header, 1x4, 0.08 pitch, shrouded	0.04	0.04	0.04
CD-ROM Drive	Header/Conn.		1	0.16		SMT-16	Flex connector, 16 wide, locking tab	0.16	0.15	0.15
Graphics	IC	Toshiba	1	11.28	CXD8514Q	PQFP-160	Graphics controller, custom	11.28	10.72	10.18
CES	IC	Sony C.E.	1	2.94	RS53430F	SOIC-40	ROM, 4Mb	2.94	2.79	2.65
Audio	IC	AKM	1	5.03	AK4310VM	SOIC-24	16-bit stereo DAC, 92dB dynamic range	5.03	4.93	4.83
Graphics	IC	Sony	1	1.15	CXA1645M	SOIC-24	NTSC/PAL encoder	1.15	0.92	0.73
Graphics	IC	Sony	1	2.98	CXD2923AR	TQFP-64	Triple RAMDAC ASIC	2.98	2.83	2.69
Audio	IC	Sony	1	11.73	CXD2922Q	PQFP-100	Sound chip ASIC	11.73	11.14	10.58
CD-ROM Drive	IC	Sony	1	7.63	CXD1199BQ	PQFP-100	Sea-of-gates ASIC	7.63	7.25	6.89
CD-ROM Drive	IC	Sony	1	11.24	CXD251Q	PQFP-100	Processor ASIC	11.24	10.68	10.14
CES	IC	JRC	1	0.23	2904	SOIC-8	Op amp, dual, 15mV offset	0.23	0.22	0.22
CES	IC	JRC	1	0.21	082B	SOIC-8	Op amp, dual, 6mV offset	0.21	0.21	0.20
CES	IC	JRC	1	0.21	2100	SOIC-8	Op amp, dual, 6mV offset	0.21	0.21	0.20
CD-ROM Drive	IC		1	0.18	LC46 XJKB	SOIC-8	IC	0.18	0.18	0.18
CD-ROM Drive	IC	Sony C.E.	1	6.90	E35D 424666	PQFP-80	CD controller ASIC	6.90	6.56	6.23
CES	IC	JRC	1	0.64	2903	SOIC-8	Comparator, dual, 6mV	0.64	0.63	0.61

(Continued)

Table B-1 (Continued)
Bill of Materials Model: Sony Playstation
(Custom MIPS RISC Processor, Double-Speed CD-ROM)
Cost in Dollars

Subsystem	Type	Manufacturer	Qty.	Best 1995 Cost	Part #	Package	Description	Best 1995 Cost	Best 1996 Cost	Best 1997 Cost
CD-ROM Drive	IC	Rohm	1	5.41	BA6398FP	SOIC-30	Compact disc driver	5.41	5.14	4.88
CD-ROM Drive	IC	Sony	1	4.09	A1782BR	TQFP-48	CD player component (motor controller?)	4.09	3.89	3.69
CES	IC	JRC	2	0.21	2100	SOIC-8	Op amp, dual, 6mV offset	0.42	0.41	0.40
CES	Inductor		4	0.18		SMT	Inductor, EIA size B	0.70	0.69	0.67
CES	Inductor		2	0.13		SMT	Inductor, EIA size A	0.26	0.26	0.25
CD-ROM Drive	Inductor		4	0.13		SMT	Inductor, EIA size A	0.53	0.51	0.50
Audio	Inductor		1	0.13		SMT	Inductor, EIA size A	0.13	0.13	0.13
CES	Inductor		6	0.20		SMT	Inductor, small, EIA size C	1.21	1.18	1.16
CES	Inductor		5	0.07		SMT	Inductor, EIA size B, labeled CCP	0.35	0.34	0.34
Memory	Memory	Samsung	4	12.36	KM48V514BJ-6	SOJ-28	DRAM, 512Kx8, 60ns	49.45	45.49	41.85
Graphics	Memory	Samsung	2	21.54	VR256KX16, 60NS	SOIC-64	VRAM, 256X16, 60ns	43.08	38.77	34.89
Audio	Memory	Toshiba	1	7.08	TC51V4260B	SOJ-40	DRAM, 256Kx16, 80ns	7.08	6.37	5.74
CD-ROM Drive	Memory	Hitachi	1	2.65	HM62W256LFP	SOIC-28	SRAM, 32Kx8, 70ns, 3.3V	2.65	2.38	2.15
Processor	IC	LSI Logic	1	21.11	CXD8530AQ	PQFP-208	32-bit MIPS RISC processor, JPEG decoder, 3D graphics	21.11	17.94	15.25
CES	Resistor		1	0.20		SMT-3	Variable resistor, screwdriver controlled	0.20	0.20	0.19
CD-ROM Drive	Resistor		2	0.20		SMT-3	Variable resistor, screwdriver controlled	0.40	0.39	0.39
CES	Resistor		54	0.01		SMT	Resistor, small 1206	0.47	0.46	0.45
CES	Resistor		145	0.01		SMT	Resistor, small 0805	1.02	1.00	0.98
Graphics	Resistor		10	0.01		SMT	Resistor, small 0805	0.07	0.07	0.07

(Continued)

Table B-1 (Continued)
Bill of Materials Model: Sony Playstation
(Custom MIPS RISC Processor, Double-Speed CD-ROM)
Cost in Dollars

Subsystem	Type	Manufacturer	Qty.	Best 1995 Cost	Part #	Package	Description	Best 1995 Cost	Best 1996 Cost	Best 1997 Cost
Audio	Resistor		24	0.01		SMT	Resistor, small 0805	0.17	0.16	0.16
CD-ROM Drive	Resistor		54	0.01		SMT	Resistor, small 0805	0.38	0.37	0.36
CES	Resistor		10	0.08		SMT-8	Resistor network, 8 pins, 1405	0.78	0.70	0.63
CES	Transistor		1	0.15	78MO5P	TO-220	VR, 5V, fixed, pos	0.15	0.14	0.14
CD-ROM Drive	Transistor		1	0.07		SOT-223	Transistor, SOT-223	0.07	0.07	0.07
CES	Transistor		14	0.04		SOT-23	Transistor, small, SOT-23	0.49	0.48	0.47
Audio	Transistor		4	0.04		SOT-23	Transistor, small, SOT-23	0.14	0.14	0.13
CD-ROM Drive	Transistor		2	0.04		SOT-23	Transistor, small, SOT-23	0.07	0.07	0.07
PC Boards	System Raw Card		1	12.50			System raw card	12.50	12.25	12.01
Card MVA	System Card MVA		1	15.00			System card MVA	15.00	15.60	16.22
							Subtotal—System Card:	244.77	228.63	214.07
Others										
CD-ROM Drive	CD Mechanism		1	13.80			CD spindle, laser, and motors, with ball bearings on spindle for disc retention	13.80	13.38	12.98
Power	Power Supply	Matsushita	1	8.00			Power supply, 100V in, 15W	8.00	8.00	8.00
CES	Header/Conn.		1	1.65			Handset connector module	1.65	1.62	1.58
Controller*	Handset controller		1	5.24			Handset controller, 14 buttons*	5.24	5.14	5.03
Mechanical	Mechanical		1	3.60			Case top, with button covers and CD door/mechanism, ABS	3.60	3.67	3.75

(Continued)

Table B-1 (Continued)
Bill of Materials Model: Sony Playstation
(Custom MIPS RISC Processor, Double-Speed CD-ROM)
Cost in Dollars

Subsystem	Type	Manufacturer	Qty.	Best 1995 Cost	Part #	Package	Description	Best 1995 Cost	Best 1996 Cost	Best 1997 Cost
Mechanical	Mechanical		1	1.80			Case bottom, ABS	1.80	1.84	1.87
Mechanical	Mechanical		1	1.45			Upper EMI shield/CD mechanism support, CRS	1.45	1.48	1.51
Mechanical	Mechanical		1	0.28			Lower EMI shield, 0.009 brite	0.28	0.29	0.29
Mechanical	Mechanical		1	0.15			Connector module EMI shield, 0.009 brite	0.15	0.15	0.16
Mechanical	Mechanical		1	0.15			Expansion connector cover, ABS	0.15	0.15	0.16
CD-ROM Drive	Cable		1	0.15			Flex cable, 10 leads	0.15	0.15	0.16
Publications*	Publications		1	0.25			Manual, other publications*	0.25	0.25	0.25
Box MVA	Box MVA		1	2.10			Box MVA	2.10	2.18	2.27
Freight/Duty	Freight/Duty		1	6.00			Freight/duty	6.00	6.00	6.00
							Subtotal—Other:	44.62	44.30	44.00
							Total:	289.39	272.93	258.07

*Not included with evaluation unit; costs estimated; details not confirmed
Note: CES = Central Electronics System; MVA = Manufacturing Value-Added
Source: Dataquest (July 1995)

Appendix C
Pricing Assumptions

- All costs are based on Dataquest's pricing databases, discounted catalog, or discounted vendor quotes.
- 100K unit production pricing is employed. NRE charges are not included.
- Final assembly and test are included in Box MVA (manufacturing value-added).
- MVA analysis includes assumptions about where the process is done so appropriate labor rates can be employed.
- Only freight charges to the final assembly point are included.

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