ELECTRONICS

ABSTRACT

Electronics is a robust, rapidly growing industry which outperformed the U.S. economy as a whole in 1996. The industry has, in fact, had an increase in factory sales each year for the last quarter century. This report confirms the strength of the industry's long-term outlook and its ability to support the national security strategy well into the 21st century. It also reviews recent trends in the industry's converging computer, telecommunications, and multimedia sectors—and predicts that a more unified electronics industry will be on the cutting edge of the future. The multifunctional high-tech products that this industry will design and produce in the coming years will revolutionize the way Americans live, work, and play. The U.S. electronics industry is poised for phenomenal growth.

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Domestic

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Defense Advanced Research Projects Agency, Arlington, VA
Dell Computer, Austin, TX
Harris Corporation, Melborne, FL
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INTRODUCTION

The breadth and pervasiveness of the electronics industry touches virtually every aspect of our lives. The speed with which the electronics industry has become such a major part of the global economy is illustrated by the advances of the computer sector. Moore's law postulates that semiconductor capability doubles every eighteen to twenty-four months. As chips grow in capability, we may soon each have our own Cray supercomputer equivalent on one Pentium-like chip for less than $100.

Electronics applications range from the dramatic to the simple. The industry includes the production of visually stunning high-definition television; the life-saving tools of microsurgeons; instant cellular voice communications to remote and isolated regions; dominant weapons to deter war or to end it swiftly if it begins; computers to explore the origins of life and to discover cures for man's maladies. The electronics industry has not only designed new, highly complex software to support the nation's air traffic control systems; it has also produced the simple digital watch, the reliable toaster, and the automobile ignition system.

This report presents the industry's statistics, describes and examines the structure and performance of its major components, and reviews various issues, including an assessment of industry challenges, outlook, and potential government roles. The report is based on extensive library and Internet research; industry and government presentations; and visits to domestic and international firms, trade associations, and government organizations representing different sectors of the industry.

THE INDUSTRY DEFINED

The electronics industry has five components: computers; semiconductors; consumer electronics; defense electronics; and software. Each is characterized by rapid technological change, capital- and labor-intensive production, and global competition. The electronics industry generates approximately 6 percent of the nation's gross domestic product (GDP). It is the largest basic industry and the largest industrial employer in the United States. In 1996, factory sales of electronics equipment, components, and related products generated over $409 billion—a 9 percent increase over 1995 (EIA, 1997), and the industry continued to outperform the U.S. economy as a whole—1996 being the 26th consecutive year of factory sales increases. In 1996,

industry distributors' sales grew by 14 percent and continued growth was expected in 1997 (Carbone, 1997).

Fortune magazine declared 1996 to be a surprisingly profitable year for the Fortune 500 companies, whose overall profits grew 29.3 percent. Led by a 32.3 percent profit growth in the computer software industry and a 29.9 percent profit growth for computers and office equipment, the electronics industry shared in the profitability of these 500 companies ("500 Medians," 1997a). The electronics industry's 1996 growth surpassed traditional manufacturing heavyweights, including automobiles, chemicals, and textiles.

Computers

Computer makers comprise 21 percent of the U.S. electronics industry in terms of 1996 factory sales (EIA, 1997). The electronics industry as a whole and the computer industry are critical components of U.S. national defense.

Structure. Major commercial computer producers include IBM, Hewlett-Packard, Compaq, DEC, and Apple ("Fortune One Thousand," 1997). Major suppliers to the defense sector include Raytheon/E-Systems, Texas Instruments, Westinghouse, Lockheed-Martin (LORAL), and Rockwell.

The computer industry's commercial and defense sectors differ structurally in fundamental ways. The commercial sector is characterized by many sellers and a huge number of buyers. The defense sector has relatively few sellers and *very* few buyers. In addition to the Department of Defense (DoD), other buyers in the defense sector include the U.S. Transportation Department, the Department of Energy, national communications companies, and foreign governments. Computer export sales exceed imports as the industry continues to maintain its strong position vis-à-vis international competition.

Current Condition. A comparison of U.S. factory sales for 1995 and 1996 shows that sales increased in computers and peripherals from $74.5 billion in 1995 to $84.3 billion in 1996—a growth of 13 percent. Although this rate of increase exceeds that of all other companies, it is merely "typical" of the computer industry's growth throughout the 1990s.

Similar growth is expected in 1997. The World Bank predicts a rapid expansion of the use of personal computers and the Internet. Based on

1994 data, the World Bank estimates that there are between 150 and 350 personal computers per 1,000 people in 14 countries, including Japan, Germany, Britain, Canada, and the United States. Between 100 and 530 computers per 10,000 people are linked to the Internet in the 11 countries that are the largest Internet users ("Computer Revolution," 1997). Electronics dealers and distributors expect no downturn in this solid demand for personal computers and other end products. Many are, in fact, forecasting a 20 percent growth in sales of personal computers and networking accessories in 1997.

Outsourcing has become an important strategy for the productive capacity of the computer sector. An estimated 43 percent of all outsourcing, or "contract manufacturing," in the electronics industry occurs in the computer and business/retail segment. In the computer industry, dependence on manufacturing as a core competency is not as predominant as in other parts of the electronics industry. When demand is erratic, the computer segment can spread its risk by outsourcing manufacturing—guided, of course, by cost pressures and time-to-market constraints ("Riding the Rising," 1997). It should also be noted that the U.S. computer industry is internationally competitive, with worldwide revenues expected to more than double by 2002.

Semiconductors

The semiconductor sector is often described as "packaging" and "manufacturing." Packaging is the creation of circuit interconnections and a fit operating environment for integrated circuits, and manufacturing is the semiconductor production process.

Structure. Major U.S. semiconductor and equipment manufacturers include INTEL, Texas Instruments, Applied Materials, National Semiconductor, Advanced Micro Devices, and LSI Logic.

The semiconductor industry has experienced a decade of remarkable change during which individual semiconductor firms shifted from a vertically integrated, monolithic, nation-based structure to a more horizontally integrated cooperative structure. Multinational partnerships and alliances now dominate the $100-billion global industry. The semiconductor sector varies: at the low end, simple commodity semiconductors are produced; at the high end, application-specific semiconductors. Each segment has specific, often different marketing demands and business traits. International alliances among semiconductor companies are common, especially between Japanese and

U.S. firms. U.S. firms were among the first to move production facilities offshore to take advantage of cheaper labor and facilities. The United States and Japan have, in practice, divided the semiconductor sector; the United States leads in microcomponents sales, the Japanese in memory. Their dominance is due in part to the high cost of entry into the technological realm. The United States is expected to continue concentrating on specialized, high-value products—microcontrollers, microprocessors, and integrated circuits—while the Japanese firms concentrate on commodities such as SRAMS and DRAMS ("Globalization," 1996).

To remain a world-class competitor, the U.S. semiconductor industry must maintain a full complement of capabilities, including leading-edge research and development, fabrication, equipment making, manufacturing, testing, marketing, and servicing. Because only volume production and sales across a number of product markets separate the front runners from the rest of the pack, the U.S. semiconductor industry cannot rely exclusively on the computer industry to drive its growth. The semiconductor industry must make its own timely response to the growth in consumer electronics (e.g., high-definition television); telecommunications; aerospace; and other end-user industries.

Current Conditions. The fastest-growing semiconductor segments are those in high-end, computer-based applications. Market penetration and growth will depend on the continued evolution of these end-use demands. The current major categories of semiconductors include microprocessors; logic; memory; bipolar digital; analog; and discrete chips. Major end-use semiconductor categories are consumer goods, for example, computers, automobiles, communications, industrial equipment, and other products ("Globalization," 1997).

The semiconductor business has historically been cyclical. Although the industry's Fortune 500 companies showed a bare 1.1 percent increase in profits during 1996, five of the top nine (i.e., Texas Instruments, National Semiconductor, Advanced Micro Devices, and LSI Logic) experienced double- and triple-digit profit *declines* compared to 1995, mostly as a result of significant unit price reductions. On the other hand, both Intel and Applied Materials (a semiconductor equipment manufacturer) showed substantial profit increases, and the forecast for 1997 is more optimistic (*Fortune*, 1997).

Consumer Electronics

The best description of consumer electronics items may simply be "anything that blinks, beeps, buzzes, or vibrates." An extensive list of such items can now be found in almost every American home. Three types of products account for roughly 25 percent of all sales, namely, audio products; television sets; and video recorders.

Structure. Considering sales by both foreign and domestic manufacturers, the consumer electronics market is expected to reach $70 billion in 1997 (CEMA, 1997). However, at $11.3 billion, the U.S. share of this market is only 16 percent, based on factory sales (EIA, 1997). Consumer electronics is, therefore, a low profit margin, mass-production industry whose products are viewed merely as commodities. Accordingly, many American firms are exiting the field. The resulting gap is being filled by imports.

Current Conditions. During 1996, consumer electronics sales increased by 6 percent over 1995. Consumer electronics exports have grown from approximately $2.8 billion in 1991 to $3.1 billion in 1993, to over $4.2 billion in 1995. Opportunities for growth are clearly manifest. Many Americans are buying third-and-fourth generation consumer electronics and are only interested in the newest technology, but opportunities to sell "older" models or current technologies abound throughout the world. The former Soviet bloc nations, China, and Central and South America are virtually untapped markets precisely as they push to improve their economies and the conditions of their people. U.S. manufacturers, sellers, and distributors of consumer electronic items have significant export opportunities.

Defense Electronics

As a customer, the defense industry's market share of the electronics industry has declined, yet its reliance on electronic components has increased. Electronic subsystems are critical components underlying the accuracy, maintainability, and reliability of national defense. They are a growing percentage of weapon systems costs. Defense electronics run the full spectrum, from microprocessors and information systems to communications and weapons-guidance devices, and from sensor-based systems to collection, recording, fusion, and analysis systems.

Structure. In the past, defense electronics was a monopsony market: one buyer, the U.S. government, and three categories of suppliers—the numerous sellers having been aggregated as hardware producers, systems integrators, or systems engineers. Today, as defense spending declines, the electronics industry has become responsive to, and more reliant on, commercial markets. This condition has forced the defense industry to consolidate and sellers to integrate, creating a small number of vertically integrated megacorporations. This development has been accompanied by a shift in focus, with the government looking to the commercial electronics industry for standards, growth, and viability.

Other characteristics also differentiate the defense electronics hardware market from the commercial sector. Procurements tend to be larger and less frequent, with fewer, costlier systems than in the commercial sector. The technology cycle of fifteen to twenty-four months is unequally matched with an acquisition cycle of eight to twelve years. The increase in vertical and horizontal integration, and a continued consolidation among larger companies, results in substantial barriers to new entries. Companies of less than $1 billion per year in revenues have difficulty competing with the merging companies. Smaller companies must either merge with others or exit the defense arena. Reduced domestic and international procurements require less capacity, leading to industrywide consolidations. Important mergers within the last year include Raytheon and E-systems, Lockheed-Martin and Loral, and the proposed McDonnell Douglas and Boeing merger. The resulting megacorporations are horizontally and vertically aligned to provide hardware, systems integration, and systems engineering to both commercial and government customers. No wonder that the smaller firms are having increasing difficulty in their bid to be prime contractors.

The defense sector maintains a favorable balance of exports over imports and continues to be a strong international competitor. Note, however, that this advantage faces a potentially serious challenge as NATO allies consider instituting a "buy-European" policy.

The commercial electronics sector and its growth are at the heart of the commercial off-the-shelf (COTS) concept of defense acquisition. This trend started in the early 1980s in response to the difficulty of finding electronic components for aging weapons systems. It has spawned a new acquisition strategy including COTS, the demise of military specifications, and an increased reliance on commercial standards. To a significant degree, the new strategy takes us from our previous monopsonistic relationship to a more commercial one. The government customer must rely on the technology and innovations of the

commercial market, right down to the planning and fielding of new weapons systems. Megacorporations are in fact a defensive response to this market change; their large size ensures their ability to respond to commercial customers and to satisfy defense requirements, thus ensuring their viability.

Current Conditions. Total defense electronics sales (estimated in 1989 dollars) are between $38 and $45 billion a year. This range reflects a significant decline in government expenditures since 1989, and procurement is likely to remain stable at these levels throughout the 1990s.

Revenues driven by foreign military sales will probably decline over the next five years as western European markets continue to wither. For the largest buyers of U.S. defense electronics in the Middle East—Israel, Egypt, Saudi Arabia, Kuwait, and Turkey—revenues are likely to remain flat or decline slightly (in constant dollars). However, in the Far East, gains are expected, particularly in Taiwan, Singapore, and China. In South Asia, primarily India and Pakistan, the industry looks for only modest increases.

Software

U.S. software firms represent one of the most productive, vibrant sectors of the electronics industry. Major firms comprising the software industry include IBM, Microsoft, Oracle, Netscape, Silicon Graphics, Computer Sciences, Novell, Intuit, C-Cube Microsystems, and Lotus. According to *Business Week's* assessment of the top 50 best performing businesses in all sectors in 1996, Microsoft and Oracle ranked two and eleven, respectively. The assessment was based primarily on overall sales, profit growth, and total return to shareholders. This outstanding showing attests to the incredible strength and vibrancy of U.S. software firms.

Structure. In 1995, computer software firms led all other categories of electronic industries with nine new start-up companies. This growth is indicative of the industry's low entrance barriers. Start up in the software business is made even easier by the proliferation of the Internet where new companies can easily make their software products available to the public. U.S. software firms had total sales in 1996 amounting to about $125 billion.

Current Conditions. The U.S. commercial software industry continues to ride the crest of the information tidal wave, robustly matching new and more enhanced software to every leap in hardware capability. In international competition, the U.S. software industry dominates the marketplace, with a significant 75 percent share of the world's market for prepackaged software sales. In Europe, U.S. software companies held 60 percent of the market last year (Mowery, 1996). More than half of all major U.S. software companies earn greater than 50 percent of their sales revenues in international markets. Although currently there is no credible challenge to U.S. domination of the software industry, foreign competition is growing. Some countries, for example, India, have built internal capabilities that make it less expensive for U.S. firms to obtain software coding for routine software designs developed from India. South Korea has also aggressively expanded its software production capability in recent years and expects to continue this expansion into the next century. This foreign competition raises a potential concern for the long-range future of U.S. programmers. Another important concern for the software industry stems from overseas piracy. Some analysts estimate that the United States loses about $9 billion in sales each year to software pirates.

CHALLENGES

The electronics industry will continue to be a major influence on the U.S. economy and defense in the 21st century. This period will be characterized by explosive technological changes and intense competition in an increasingly global economy. The challenge for the U.S. government and the electronics industry is to harness these technologies to increase productivity and competitiveness, while simultaneously retaining a military capability that can be used effectively (along with other instruments of national power) to pursue U.S. national interests.

The increased globalization of the market place combined with the galloping pace of technological change represent significant challenges. In its *Future Warfighting Capabilities*, the U.S. Department of Defense identified high-performance electronics as a key to modern warfare and conflict prevention. Clearly, the nation's defense strategy relies heavily on electronics. Yet defense makes up only about 2-to-3 percent of the electronics industry's total business. This decrease in market power means that military needs are no longer the primary driver for

technological progress in electronics. As industry's focus shifts to commercial markets, both government and industry will be challenged to ensure that the industrial base retains its capability (and if necessary, its capacity) to support defense surge and mobilization requirements.

Rapid advances in technology (e.g., increases in integrated circuit or chip density) have fueled tremendous growth in the electronics industry. However, such galloping technology presents major challenges in the form of reduced development time and briefer product life cycles. New, leading-edge technology becomes obsolete in twelve to eighteen months (if not sooner) as new advances are developed and introduced. Thus, a particular technology dominates the market only briefly, and the time available for recapturing initial investments is also shorter—with less return on investment (ROI). As this trend continues, industry will be challenged to provide a sufficient return on investments, notwithstanding the product's shorter life cycle. If ROI is not commensurate with the risk, either procurement prices will rise, or industry will retreat from defense involvements. Shorter product life cycles also create significant supportability challenges; long-lived defense systems may contain electronic components that quickly become obsolete and are no longer produced.

The electronics industry (in the United States and abroad) has addressed the ROI challenge by increasing collaboration among companies and research institutions (such as colleges and universities). Companies may try to increase ROI by decreasing their research and development (R&D) costs. Investors also identify R&D costs as an indicator for potential ROI. While the industry realizes the necessity for ongoing R&D, investors often penalize companies that invest too heavily in R&D instead of focusing on short-term maximum ROI. Maintaining a viable R&D base while satisfying shareholders will be a key challenge for the electronics industry in the 21st century.

A recurring theme in the electronics industry is the shortage of technically trained and well-educated personnel. Two specific concerns are the shortage of qualified personnel for semiconductor manufacturing and the dearth of academically qualified software engineers. At the same time, trends such as vertical integration and concentration, are increasing the complexity of electronic systems. These systems are also more likely to increase their capability through software upgrades than through new hardware. Therefore, a major challenge for this industry will be to retain access to the technical workforce and engineering expertise needed to cope with increasingly complex, software-intensive systems.

As electronic systems become increasingly more complex and interconnected, industry will need to ensure that products are useful and provide added value. Determining how to add value and in what features will require an understanding of the environment in which the customer operates. Thus, another key challenge for the electronics industry will be understanding the customer's requirements—getting people to focus on the customer versus the technology.

OUTLOOK

The long-term outlook for the U.S. electronics industry is good. Its strength should be sufficient to support the U.S. national security strategy well into the 21st century. The industry is, in fact, poised to grow even stronger as its major components—the computer, telecommunications, and multimedia industries—continue to "converge." Some analysts have labelled this convergence as the infocommunications industry, but firms in the electronics industry have also embarked on other strategies such as partnering with each other—teaming with academia, and consolidating—that should further enhance the industry's ability to support national security.

Convergence

The continued convergence of the telecommunications, computer, and multimedia sectors should result in multifunctional products of increased value to the user. Convergence has been and will continue to be driven by a number of advanced technologies, including digital and wireless communications, advanced fiber-optics technology, and smaller, more powerful computer chips. The combination of these and other technologies has created an infrastructure that greatly facilitates this.

As products that were once separate, physical items are consolidated, one product can suddenly perform multiple functions. The advent of digital communications, for example, will make the distinctions between computers and televisions irrelevant, since each will incorporate the other's functions. Consumers will be able to read electronic mail on television or watch a movie from a personal computer. Likewise, the replacement of traditional copper lines with fiber-optic telephone lines and cables will give consumers greater bandwidth, thus allowing vast amounts of data to be accessed simultaneously and quickly

through multiple media. Wireless communications, via satellite, are already being included in video cameras and display monitors to create "telemedicine." Thus, medical personnel transporting an injured victim to the hospital by ambulance can describe and even show the victim's injuries to a doctor at the hospital. The doctor can, in turn, transmit life-saving instructions to the medics long before the ambulance actually arrives at the hospital.

The Telecommunications Act of 1996 should promote further convergence in the electronics industry, as this Act virtually eliminates cross-market barriers and relaxes antitrust laws and other rules governing companies that provide telephone services, cable television systems, and Internet and online computer services. Competition has already intensified among these companies as they obtain entry to each other's markets, giving rise to a growing debate over whether the United States is headed for a computer or TV-driven world. Ultimately, this debate will be decided by consumers—the people who spent $19 billion on computers and $10 billion on TV sets last year.

Partnering

Precompetitive collaboration, or partnering, appears to be a growing trend in the electronics industry as companies seek to share the enormous costs of research and development and to reduce the cost of technology. This activity should be viewed favorably by the antitrust authorities. Although partnering is occurring in all sectors of the industry, it appears to be most prevalent among companies involved in the semiconductor sector. This sector, with the backing of federal funds, began a major partnering effort in 1987. Known as SEMATECH, this consortium currently has ten member companies—IBM, Intel, Lucent Technologies (formerly AT&T), Hewlett-Packard, Advanced Micro Devices, Motorola, Rockwell, Texas Instruments, Digital Equipment, and the National Semiconductor Corporation.

SEMATECH's primary mission is to solve the technical challenges that would otherwise prevent the United States from being first in the global semiconductor industry. Fiscal year 1996 marked the last year of government subsidies to SEMATECH. However, the consortium plans to continue its current arrangement because it has proven to be a cost-effective way for companies to share the risks and the rewards of developing semiconductor manufacturing technology. According to SEMATECH's 1995 annual report, industry and government have invested $1.7 billion in SEMATECH since its inception. Approximately

70 percent of those funds were reinvested in the companies that make up the U.S. equipment and materials supplier infrastructure.

Partnering to gain market share also appears to be a growing trend among electronics firms. For example, Motorola, IBM, and Apple are jointly funding a design center for the advancement of computer microprocessors. This design center is reportedly the largest of its kind in the world. In addition, Applied Materials, Intel, and Motorola have formed a partnership to develop improved semiconductor materials; and Dell and Unisys recently partnered to provide 1,600 new computer servers to the Social Security Administration. As companies aggressively compete for market share, it appears that the partnering trend will continue.

Teaming wth Academia

Electronics firms are continuing to strengthen their position in the marketplace by teaming with educational institutions. This initiative supports an ample supply of "knowledge workers" with the necessary skills to produce cutting-edge products. Currently, the electronics industry is having a hard time finding sufficient numbers of qualified "high-tech" workers. To deal with this problem, SEMATECH and the Austin (Texas) Community College are developing a two-year curriculum in semiconductor training with a goal of producing hundreds of qualified graduates to support the semiconductor field. Other firms are seeking to fill job vacancies by implementing various strategies to upgrade the skills of their existing work force. The Harris Corporation, for example, provides in-house training courses to employees who wish to upgrade their skills and compete for higher-level positions in the company. Harris also provides financial reimbursement and time off for employees to attend courses at the community college level. This trend of industry teaming with academia is critical to the industry's ability to compete successfully in the global market.

Consolidation

To remain profitable in the face of shrinking defense budgets, a number of defense electronics firms have consolidated, mostly through mergers. Another impetus to consolidation is the nonlinear cycling of technological advancements and defense acquisition schedules. There is a clear "disconnect" between the technology cycle (eighteen to twenty-four months) and an acquisition cycle of eight to twelve years.

Consequently, electronics firms involved in developing technology for major military weapons systems take longer to realize a return on their investments, an unappealing situation for their shareholders. As investments become more costly, smaller electronics firms must consolidate to survive. The future health of defense electronics depends on successful, efficient consolidation and, for many, expansion into commercial markets to ensure profits for investors.

GOVERNMENT GOALS AND ROLE

Because the strength of the U.S. electronics industry is expected to hold steady into the foreseeable future, we can anticipate a fairly limited role for government involvement. Government's role in the recent past was much stronger. The Telecommunications Act of 1996 dramatically changed the ground rules for competition among companies involved in telecommunications and, indeed, in all aspects of electronics.

With the Telecommunications Act, the government set a new course: it accepted competition as the basic charter for all involved in the telecommunications, multimedia, and computer markets. The Act unleashes competitive market forces that will provide electronic firms continued opportunities for success. On the international level, however, the government may still serve the electronics industry in two areas. It can help ensure fair and open trade policies, and it can help protect the industry's intellectual property rights.

Open Trade. The United States and many of its trading partners, for example, the European Union, have agreed on policy that allows mutual market access. However, further work is needed to ensure that the United States does not fall back on unnecessary protectionism. To the extent possible, all barriers that keep foreign companies from fairly competing for U.S. market share should be lifted. We should, for example, rethink the nation's "Buy America" policy, which appears to contradict U.S. efforts to support worldwide free trade. Major provisions of the Federal Communications Commission Act, which limit the amount of foreign participation in the U.S. electronics industry, may also need to be repealed. The Helms-Burton Act also appears to nurture protectionist sentiments overseas. Free and open trade with virtually no barriers to competition has contributed to the strong market position currently enjoyed by U.S. electronics firms and this policy should continue.

Protect Intellectual Property. The United States must continue to protect the intellectual property of the electronics industry, primarily copyrighted software, from international piracy. Dialogue with member nations of the North American Free Trade Agreement and the World Trade Organization make this challenge a high priority. Strong corrective action against countries that violate intellectual property rights is critical to maintaining an industry that today accounts for over 70 percent of the world's software market.

CONCLUSION

The electronics industry will continue to be a major contributor to America's military and economic power. This industry provides the value-added products and services that the United States and other nations increasingly rely on to improve productivity and raise living standards. In addition to physical products, the electronics industry spawns faster and more insightful problem-solving methods—for its own needs and across numerous other industries—all of which lead to more robust economic growth.

The rapid growth in technology that characterizes the electronics industry requires both government and industry to rethink the way electronic systems are acquired. Shorter development times and product life cycles also drive industry to rethink how it captures and retains market share. An increased focus on providing value-added products to the customer will require an increased understanding of the customer's basic needs. The convergence trend will continue to increase the functionality offered by electronic equipment and its ability to operate anywhere and to interact successfully with other producers' equipment. This trend (both in the commercial and government sectors) will increase the need for the industry's developers to understand customer requirements from a system-of-systems perspective. That is, we must treat products as interconnected systems rather than as stand-alones, with each component contributing to the overall performance capability defined by the systems architecture.

The products of the electronics industry will provide content as well as the ability to manipulate data and information. Therefore, the industry will continue to challenge America's educational system to provide a highly skilled and well-educated work force. Otherwise, companies will go elsewhere. The ability of the United States to pursue its national

interests effectively in the 21st century will increasingly depend on how successfully its industrial base can transfer the rapid advances in sensor, computing, and telecommunications technologies from the commercial sector to defense needs. This condition in turn will be largely determined by the nation's ability to use highly educated and trained people to maximum advantage in the workplace.

Today's electronics industry is characterized by explosive technological change and by intense competition in an increasingly global economy. The challenge for the United States is to harness these technologies to increase productivity and competitiveness while retaining an effective military readiness that can help influence the outcome of world events. Meeting this challenge requires the concerted effort of industry and government. The primary role of government should be to foster a domestic and global environment that allows the U.S. electronics industry to flourish.

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