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Electronics

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ABSTRACT

Electronics is one of the largest industries in the US and plays a critical role in almost every aspect of national security. It is directly responsible for the economic boom over the past ten years that propelled the US into an unparalleled superpower status. The US has capitalized on advancements in semiconductors, computing, storage, intelligent devices and sensors to achieve a competitive advantage. For example, the Semiconductor Industry Association (SIA) reported semiconductors as the number one industry in the US based upon its contribution to the nation's gross domestic product. Semiconductors are fundamental electronic components that transfer electricity as it passes through electronic circuits. Continued growth of this industry is a critical prerequisite to maintaining our technical superiority and leadership in this "Silicon Century."

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PLACES VISITED

Domestic

Virginia Semiconductor Company, Fredericksburg, VA

Oracle, Reston, VA

TRW, Reston, VA

Raytheon, Boston, MA

General Dynamics Communication Systems, Taunton RI

Lincoln Labs, Boston, MA

Applied Materials, Austin, TX

Advanced Micro Devices, Austin, TX

Dell Computer Corporation, Round Rock. TX

Dell Computer Corporation, Austin, TX

BAE Systems, Austin, TX

Fabless Semiconductor Association, Dallas, TX

Ericsson, Dallas, TX

Texas Instruments, Dallas, TX

Lockheed Martin Aeronautics, Fort Worth, TX

Sprint Advanced Technology Center, Dallas, TX

Northrop Grumman Corp, Electronic Sensors & Systems, Baltimore, MD

International

Acer Incorporated, Hsin Chu, Taiwan

Aerospace Industrial Development Corporation, Taichung, Taiwan

American Institute of Taiwan, Taipei, Taiwan

American Chamber of Commerce, Taipei, Taiwan

Chief of the General Staff, Taipei, Taiwan

Chip Implementation Center, National Science Council, Taichung, Taiwan

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Akihabara Electronics Area, Tokyo, Japan

American Embassy, Tokyo, Japan

Asian Technology Information Program, Tokyo, Japan

Exodus Communications, Tokyo, Japan

IBM, Tokyo, Japan

Intel, Tokyo, Japan

National Panasonic Systems Center, Tokyo, Japan

INTRODUCTION:

This assessment of the US electronics industry describes the current condition, challenges, industry forecasts, and its relation to our national security. Additionally, it discusses the government's role within the electronics industry and includes supplemental essays expanding on future technologies. The analysis is based on information gathered from multiple sources. Seminar members conducted extensive independent research in their industry-related topic of interest. These efforts were augmented by briefings from industry experts and three weeks of visits to domestic and international firms representing the major sectors within the electronics industry.

The electronics industry is the key enabler of the "Information Age" that spawned the "New Economy." This led the charge of increasing technical stocks and emergence of small and fast "Dot.Com" companies. However, this past year saw a significant downturn (or correction) and a movement back to traditional electronics business. Electronic systems have enhanced worker productivity, enabled the elimination of waste throughout the supply chain, and provided the tools to facilitate revolutionary advances in the more traditional industrial sectors. Electronics technology advancements have redefined the way we interact and communicate, conduct business, and seek entertainment. No other industry has had such a widespread economic and social impact.

THE ELECTRONICS INDUSTRY DEFINED:

Defining the electronics industry presents a difficult challenge. Electronics is represented across all industries and provides the stimulus for growth and survival. At one extreme, the electronics industry includes firms that design and produce high technology end-items from refrigerators, to automobiles, to sophisticated satellites. At the other end, it includes firms that design and produce sub-elements/components of those end-items. The first extreme leads to an overly broad assessment, while the second is too narrow and embedded in the products. Our definition is a hybrid of the two extremes. The first focus is on the building block of all electronics—the semiconductor. Second, the health of key industries that exploit the semiconductor for specific value-added applications is assessed, such as computing devices and telecommunications. Third, we looked at two specific customer applications—consumer electronics and defense electronics. Finally, the government's role for ensuring maintenance of a viable electronics industry to support US needs is addressed.

Semiconductors. The semiconductor sector is the core component of the electronics industry and produces the microchips, integrated circuits, and discrete electronic devices used in a myriad of products ranging in complexity from high-end super computers to simple watches. This sector is responsible for the dramatic cost decrease and performance increase of electronic systems in the past and for the foreseeable future. Success of the semiconductor industry underpins success in the electronics industry as a whole.

Computing and Storage Devices. The computing and storage device market consists of central processing units, data storage, and input/output devices. Silicon and transistors drive the speed, size and storage limits of current hardware. This sector is the largest

segment of the electronics industry ranging from individual diary devices to extremely large super computing mainframes. Additionally, the storage device market complements this increasingly powerful computing technology with flash memory storage, server farms of data, and enterprise data warehouses that integrate offices and organizations for information and knowledge management.

Telecommunications. The telecommunications sector comprises the entire range of devices and systems that enable people to send information back and forth, including copper wire and fiber optic cables, wireless systems, routing and switching systems, and input/output devices such as cell-phones and modems. The increasing importance of the Internet has produced phenomenal growth in telecommunications-based services. International Data Corp, a research firm, projects over 600 million Internet users worldwide by the end of 2003, up from 240 million at the end of 1999. [1] Demand for bandwidth and access to the "Internet Age" will increase 300-fold in the next eight to ten years according to RHK Inc., a California research firm. [2] Cell phones and personal digital assistants (PDA's) facilitate mobile Internet access, which will become the dominant means of access by 2003.

Consumer Electronics. The consumer sector represents some of the most advanced applications in electronics seen today. This sector covers a wide array of hardware and software products loosely categorized as home information systems, mobile electronics, video, and portable audio. Home information systems include personal computers, peripherals, and digital cameras. Mobile electronics consist of broadband access services, wireless telephones, pagers and radio service products. Digital TVs, DVDs, camcorders and personal video recorders are grouped as video products. Home theater systems and MP3 players are in the home and audio category.

Defense Electronics. The defense electronics sector encompasses two main areas: military unique electronic items (such as avionics and precision guidance systems), and commercial devices modified to meet military requirements (such as ruggedized laptops). DoD makes extensive use of electronics throughout all its activities, from combat, to logistics, to base operations.

CURRENT CONDITION:

Semiconductors. The semiconductor industry remains healthy with a global market topping $204 billion. [3] It is now the nation's largest manufacturing industry with over $102 billion in sales in 2000, employing over 280,000 workers. [4]

Two major themes shape the semiconductor industry. First, strong domestic and foreign competition has compelled many semiconductor companies to achieve economies of scale by consolidating. Second, the high capital costs of fabrication facilities have resulted in some semiconductor companies going "fabless"—retaining design work in-house and outsourcing some or all of the manufacturing. Many of the large-scale fabrication foundries are offshore in such countries as Taiwan, Singapore and Malaysia. [5]

The largest market for semiconductor products is the high technology consumer electronics industry that consumes up to 80% of all semiconductors produced. [6] World Semiconductor Trade Statistics show that in January 2001 the US semiconductor market of $5.23 billion was down 5.8% from December 2000. This downturn may reflect an excess inventory situation that has affected other electronics industry sectors in recent months. However, industry spokesmen are quick to point out that this still represents a 15.4% rise from the $4.53 billion reported for January 2000. [7]

Computing and Storage Devices. Computing devices continue to get smaller, more powerful and cheaper. The last 12 months has seen continued growth in PDAs, internet messaging devices like Blackberries, and intelligent phones in the consumer market. Several advances have been made in the individual computing arena, including the integration of software on high processing chips.

Desktop computers experienced a slow year, partially due to market saturation and limited new software. Significant offerings included: Microsoft's Windows 2000 operating system, Intel's Pentium 4 and Advanced Micro Devices' Athlon processors. Computing platforms at the server and enterprise level continued to grow with 14% increases over last year. Leading the growth were Sun Microsystems and Dell as the top vendors of 2000 with 61% and 42%, respectively. [8] 64-bit microprocessor architectures are becoming more common in all types of performance and Internet servers. For example, Intel's Itanium Xeon processor market grew by almost 50% last year. [9]

The worldwide storage market in 2000 was $29 billion with more than half of businesses estimating growth at 25-50% annually. [10] Heavy demand is likely to increase, and by 2004 companies will likely have to manage 10 times as much data as they do today. There is a greater dependence on storage technology/vendors as critical partners.

Telecommunications. The telecommunications industry has undergone a major transformation from copper wire to fiber optics, satellite communications, wireless services, and digital technology. The industry is in a high-growth period, driven by rapid advancements in voice, data and video communications technologies.

The wireless market is one of the fastest growing segments driven by an increasing demand for data communications, an expansion of wireless services, new technologies including smaller, more functional handsets, and increased industry competition. [11] As a result, prices are falling. Internet applications for cell phones and wireless PDAs are an emerging market and analysts expect it to have the largest share of industry infrastructure upgrade. PDAs and "smart" phones with built-in location capability (directions to nearest bank/restaurant) are ushering in mobile commerce.

The explosive growth in the demand for Internet access and remote access to corporate networks has driven a rapidly increasing demand for bandwidth, especially to end-users but also in the core of telecommunications networks. A major issue with today's networks is the limited bandwidth to service the "last mile" or "local loop." Although the core of the network uses fiber optic cables at the terabit-per-second range, the residential subscriber connects to that network by cables capable of only 64 kilobits per-second. Demand for faster speed is pushing the industry for solutions to the "last mile" problem. While cable modem and digital subscriber lines are leading technologies, direct satellite, fiber to the home and fiber to the curb are also potential solutions.

Consumer Electronics. The consumer electronics industry is growing at a phenomenal rate according to the Consumer Electronics Association. In 2000 the US experienced total sales of $90.1 billion, while sales for 2001 are forecasted to reach $95.6 billion. Advances in digital technology are pacing the industry's sensational growth. The products that gained the greatest benefit from digital technology were digital TVs, DVDs, MP3 players, wireless telephones and digital cameras. "Home information products," including personal computers, peripherals and digital cameras, will capture the largest share (41%) of consumer electronics sales. Projected sales for other categories are: mobile electronics (11%), video (DVD), camcorders, personal video recorders (21%), and home/portable audio (home theater systems and accessories) (15%). [12]

Defense Electronics. Once a driving force in the electronics industry, the defense sector has shrunk to less than 5% of the world market and under 1% for components. [13] As a result, during the 1990s consolidation wave, many firms exited the market, and most analysts expect mergers and acquisitions to continue among 2nd and 3rd tier suppliers. Today, Raytheon, Lockheed-Martin, Northrup Grumman, and General Dynamics dominate the defense electronics field with another 10-15 smaller firms as sub-contractors to the four major firms. [14] Defense electronics firms will increasingly focus on systems integration, modification of commercial products, and setting architectures and standards. Electronics continue to grow in importance to the DoD, with

components embedded in nearly every weapon system and piece of equipment. Spending on electronics now totals $51 billion, or 16.5% of the defense budget. [15]

CHALLENGES*:*

Technical Limits. Silicon chips, the basic component of electronics, are getting smaller, faster, and cheaper. Continuing this trend will require large investments of intellectual and financial capital to overcome technical challenges. The International Technology Roadmap for Semiconductors states that current lithography and thin film technologies used to produce transistors today are nearing their practical limits. However, there is promising research on near-term solutions to extend the ability to manufacture smaller transistors and fit more of them on a single chip. These include extreme ultraviolet lithography, X-ray lithography, and electron beam lithography. [16] In developing thinner and smaller transistors, several problems have developed stemming from the physical and thermodynamic properties of material. Electrical "static," electron tunneling, and heat dissipation problems all prevent the transistors from functioning as designed. [17] Research is being done in non-silicon technologies such as molecular electronics, nanotechnology, optical computing, quantum computing, and DNA computing. These technologies show promise for long-term technology advances. These breakthroughs will require continued funding from commercial and government sources.

Research and Development (R&D). The two main sources of R&D funds for the electronics industry are internal dollars spent by companies and government dollars spent on basic research. From the industry perspective, R&D provides the competitive edge and drives future profits. The Patent Intelligence and Technology Report of 2000 identified the top 53 companies receiving patents. IBM led the way with 2922 patents relating to network information processing, data storage and microelectronics. However, as DoD downsized and outsourced many activities, the government relied more on industry advances. Unfortunately, industry R&D focused on near term technology with short-term payoffs (i.e., winning the next contract), not the longer-term technology that puts leading edge defense at risk of not working toward the next breakthrough.

Since 1994, the US R&D investment trends have been on the rise for specific sectors. In 2000, R&D was 2.72% of the Gross Domestic Product, up from 2.67% the previous year. Additionally, R&D expenditures have steadily increased since 1995, with an average of 6%. Expenditures in 2000 were 7.9%, reaching $264 billion. [18] The 2001 appropriation bill continues this trend with significant increases for defense, health, and sciences. The government R&D budget was increased $7.6 billion to $90.9 billion, or 9.1% over requested amounts with defense accounting for an 8% increase to the Systems and Technology accounts and a 6.1% increase to all other DoD R&D. [19] This reflected a new upward trend in the defense related R&D sector. The government must continue this funding trend for both basic research and sponsorship of the commercial market for leverage into defense. An example of new basic research is the $500M initiative by the SIA that received funding from the US semiconductor industry (50%), the semiconductor equipment industry (25%), and the DoD (25%). [20]

Offshore Manufacturing/Capability. The design, etching, and intellectual property associated with silicon chip production are primarily done in the US. However, more of the actual mass manufacturing of the chips are done in Taiwan, Singapore, and Malaysia. A new semiconductor facility costs around $3 billion to build and takes about two years to become operational. Therefore, most of our capability to produce semiconductors will remain overseas for the foreseeable future. In addition, Japan, Taiwan, Korea, and China are challenging US market share. For the US to maintain its share of the world market, we must address issues such as intellectual property rights, restrictive import controls, and anti-dumping laws.

High-tech workforce shortage. The electronics industry needs a continuous supply of highly skilled engineers, software developers, and system integrators to sustain its growth and remain competitive in the global economy. Rapid growth in the industry, however,

has completely outstripped the supply of high-tech workers. The resulting tight labor market has affected virtually every company we visited, including those overseas. The US is not generating enough of these workers because our education system does not adequately prepare students in math and science. As a result, US companies are using H1-B visas to bring in foreign workers or they are sending work offshore. Without sufficient personnel, companies and the government will not be able to sustain growth, make innovations, or increase productivity. This could hurt us economically (through lower productivity) and militarily (through lack of innovation to stay ahead of competitors). In the short-run, raising the number of H1-B visas will help. However, in the long-run we must improve our education system. Industry must also provide continuing education so workers maintain skills in a rapidly changing environment.

Parts Obsolescence. Rapid advances in electronics technology now quickly make various parts and components obsolete. In fact, component life cycles are now less than 18 months. Since weapon systems last for several decades and even office equipment lasts at least three years, virtually everything has obsolete parts. Yet, under current market conditions, vendors do not produce or retain obsolete parts. DoD's long-lived weapons, unique hardware requirements, and complex budget and acquisition system make this problem particularly acute for the military.

Since DoD cannot replace its weapon systems rapidly or continuously upgrade its equipment, DoD needs these parts to maintain operational weapon systems. Currently, we do not address the problem efficiently, and waste large amounts of time and resources overcoming the problem.   Since obsolescence has become a feature of the landscape, we can't eliminate it. Therefore, the government must take steps to mitigate it. First, we must determine the size and extent of the problem. Second, we must budget for mitigation costs. Finally, we must build obsolescence mitigation into future systems.

OUTLOOK:

The electronics industry outlook is strong, spurred by the consumer's insatiable desire for faster, smaller, mobile, convergent capable communication/computing capabilities. The "Information Age," driven by the Internet, is in its infancy and will continue to grow in the foreseeable future. Electronics is pervasive in our society and impacts all industries. The highly competitive nature of the industry provides a breeding ground for new ideas and technology advancements.

Semiconductors. The outlook for the US semiconductor industry remains good.   Consumers, companies, and the government continue to demand technology enhancements. To remain in step with Moore's Law, semiconductor manufacturers are constantly developing innovations in chip design and size such as the transition toward 300mm/12 inch wafers, yielding about 240% more individual chips per wafer compared to the 200mm/8 inch wafer today. In addition, the larger wafers are expected to reduce die manufacturing costs by more than 30%. [21] The industry effectively allocates resources to near-term research problem areas. However, the Government must continue to fund longer-term research for the US to remain the technological leader in this sector. Focusing export rules concerning technology will allow US firms to expand market share and remain competitive with foreign companies. With continued research and innovation in manufacturing and design, the US will remain the world leader in this industry.

Computing and Storage Devices. The next 18-24 months will see continued proliferation of individual computing devices and specialized sensor computers. The electronics industry will target the telecommunications, automotive, and medical industries to receive these devices with specific intelligence and communications. Strong competition for operating systems (OS) will continue as Linux, Microsoft, Palm OS and phone-based systems compete for market share. Windows 2000 and XP will dominate the OS for

PCs and gain market share in the low-end server markets. This development is significant because Windows will provide the de facto standard for the processing environment and an overall integration of Microsoft's product line. The mid and high-end server line will meet the needs of e-business by providing high transaction rates and organizing companies' enterprise information. PC sales will remain stable, but information appliances will account for an increasing portion of their revenues. Studies indicate that consumers intimidated with using a PC will feel less threatened by an information appliance that is designed with fewer functions.

The booming Internet market is directly responsible for an expected growth in network attached storage (NAS) to $2 billion by 2003. The average NAS device shipped in 1999 had a capacity of 88 gigabits (GB) and that average will rise to 211GB by 2003. The SAN market share during this same period was $1.4 billion in 1999, and expected growth will be 66% by 2003. While SAN and NAS products represent about "7% of the overall storage market in 1999, it is expected that these products will account for 38% of the market in 2003." [22] See attached essays on "An Assessment of the Data Storage Sector" and "The Future of Computing."

Telecommunications. Digital convergence, enabled by emerging telecommunication technologies, is allowing Federal Government and private sector industries to realize unprecedented efficiencies. Strategic leaders who understand this potential can intelligently streamline operations and receive cost savings through implementing better business practices. Consumer demand for instant communications (unlimited bandwidth) anywhere and anytime (mobile capability) is the growth driver in the networking equipment market. To meet this demand, industry is emphasizing high-speed switching and routing. This will to continue to fuel the industry's growth through at least the next several years. Momentum is building for converged networks, which combine voice, video and data, wireless/wire-line, on a single network. This transformation is predicted to continue, as stated by the Standard and Poor's forecast of overall growth in the global communication network equipment industry of over 15% annually for the next several years. For example, according to Gartner Group, US satellite broadband users are expected to grow to 2.4 million by 2004. [23] Dataquest predicts that 863 million customers will use mobile phones by the end of 2003, up from 309 million at the end of 1998. [24] See attached essay on "The Future of Network Technology."

Consumer Electronics. The growing market trend is toward mobile computing capabilities provided by information appliances. International Data Corporation (IDC) reported that information appliances would be the emerging category of digital consumer electronics since they provide low-cost, easy-to-use, consumer-focused local access to the features and benefits of the Internet. IDC projected that 11.4 million "smart" hand-held devices were sold worldwide in 2000 with PDAs making up 70% of that market. [25]   This market is expected to grow to 61 million by 2004. Industry consultant, 4th Wave, predicts even more substantial growth, $5 billion by 2001 and $20 billion by 2008. The forecast from eTForecasts is even more aggressive considering all information appliances. The projected Compound Annual Growth Rate for shipment of all information appliances from 2000 to 2005 is 47.4% in the US and 59.8% worldwide. [26]   In terms of handhelds, Palm still maintains the predominant OS, which is also used by Handspring, Sony and TRGpro, although Microsoft has forged agreements with Casio, Compaq and Hewlett-Packard. Sharp selected the Linux OS. While the market provides strong competition, the lack of a single OS poses interoperability issues between some applications such as the Palm OS and Microsoft products. Flat panel/high definition displays and Secure-Digital devices are also predicted to have a major impact on future consumer electronics. See essays on "Flat Panels" and "Telematics."

Defense Electronics. Electronics will continue to grow in importance to DoD, enabling advances in military capability and efficiency that far outstrip today's. However, defense electronics share of the overall market will continue to shrink, and the trend towards fewer defense-unique electronics will continue. As a result, the defense sector will become more reliant on private sector products and advances. Since these commercial products will be available to everyone who can pay, the US military's ability to stay ahead of the competition will decrease. Therefore, rather than focusing on the impossible task of staying ahead in electronics technology, the military's ability to integrate and use electronics wisely will keep us ahead of any competitor.

Outlook Summary. The chart below summarizes the future industry outlook, the US position, key drivers in the market, and national

security implications of the industry.

Sector Outlook & US Global Position S= Short-Term L=Long-Term	Industry Drivers	National Security Implications
Semiconductors S L ? #1 design & IP, but ... assembly mostly Off-Shore (O/S)	- Consumer electronics - Demand for smaller/faster/cheaper - Long-term physics limits - New technologies (micro-machines, non-silicon)	- US leadership key for strong economy - Long-term R&D government funded - Defense does not drive the train - Defense uses commercial sector - High-tech workforce shortage
Computing & Storage Devices S L #1 developer & consumer, but ... reliance on O/S parts & manufacturing	- Demand for smaller/faster/cheaper - Industry convergence - Small mobile devices (PDA, Cell phone, Laptop) overtake PC market	- Reliance on industry and market forces - Leadership in creative designs and R&D spending for breakthroughs
Telecom S L #1 infrastructure but ... need wireless advances	- Demand for fast comm with all capabilities (convergence) anytime, anywhere (mobile) - Internet	- Realize unprecedented efficiencies - Streamlined operations - Better business practices, and overall savings
Consumer Electronics S L #1 consumption but ... still largely in foreign goods	- Entertainment - Telematics - Cost - Pervasive communications	- Driver of the electronic boom - Provider of high-tech breakthroughs - Increased vulnerability to supply disruption from O/S suppliers - Ability to maintain lead
Defense Electronics Dependence S L Sector #1 but ... competitors gaining ground	- Reduced budgets - Leverage COTS - Threat - Low R&D funding	- Leverage from commercial industry - Large amount of import products - Emphasis on dual-use applications - High-tech workforce shortage

Figure 1. Electronics Outlook Summary.

GOVERNMENT GOALS AND ROLES:

For many years, the US Government provided leadership in the electronics industry. It provided the "seedcorn" R&D, but also provided the policies and laws that limited the industry's growth. The Defense Advanced Research Projects Agency and Federally Funded Research and Development Centers, such as MIT Lincoln Laboratories, developed the technologies that enabled worldwide application of the Internet. Government leadership in the semiconductor industry in the early 90's helped the industry achieve its world premier role in chip design and processing power. However, trade policies such as, tight export controls, inability to enforce intellectual property rules, telecommunications laws and immigration policies, inhibited growth.

The commercial electronics industry grew at the same time the US eased controls in many of these areas. This is obvious in multi-lateral trade agreements such as the North American Free Trade Agreement and World Trade Organization rules. These agreements opened the door for tariff-free trade in high technology. They also made "Buy American" rules for high-tech products nearly obsolete. [27] The Telecommunications Act of 1996 assisted in creating more robust competition in the industry. The benefits of US policies that support industrial growth are recognized as the beginning of revised export controls. Intellectual property rules, particularly government sponsored R&D, have undergone changes that enable technology advancements to be widely disseminated while advancements developed in the private sector are protected. [28]   The US is slowly revising immigration laws for more flexibility.

More government involvement in the electronics industry was not generally advocated, however, firms expressed concerns with US export controls on high end computing technologies. Other than traditional defense firms, few companies expressed specific obstacles to growth caused by existing laws or US policies. The presence of robust competition and the aggressive pursuit of market share clearly drive corporate investment decisions and the overall growth of the industry. Innovation and competition contribute to increased earnings. While many firms wanted technical standards in segments of the electronics industry, they were confident that competition would give rise to market-driven, not government-driven, standards.

Such a minimal role for US Government sharply contrasts with the views of the traditional defense industry firms we visited. Many defense firms argued that the government has a distinct role in maintaining their ability to provide innovative technology solutions to meet national security needs. Despite perceived and actual obstacles embedded in the government acquisition and budgeting process, many electronics firms have developed ways to integrate product lines for government and commercial customers. Where DoD represents the primary source of a company's revenues, easing government laws, regulations and practices provide the sole basis for continued growth. In contrast, those firms that are not exclusively reliant on government funds are more focused on markets as the source of growth.

The contrast between the commercial and defense electronics markets creates an emerging and non-traditional role for government policy. That role involves policies that balance the industry's short-term desire for profitability with the longer-term prospects for leap-ahead technologies and their impact on US national security. Commercial electronics firms appeared to lack an understanding of the linkage between industrial/technological strength and its implications on national security – often associating national security exclusively with the military. Policies that would facilitate establishing this linkage should focus on encouraging competition at home and ensuring market stability and access abroad. Many of the recommendations outlined in this report facilitate achieving these goals. However, additional effort is warranted such as:

1) Technology Partnership Agreements – The Government and commercial firms would coordinate high-risk, high payoff R&D with the intent of making the results available to commercial firms for use in advancing state-of-the-art commercial applications. In exchange, the government would receive "most-favored-customer" status from the recipient commercial firms. [29]

2) Technology Refresh Designs – New government acquisition strategies should integrate technology refresh provisions early in the design process of major systems and components to allow upgrades during development, production and system operation. Such initiatives would eventually replace extraordinary actions required to maintain suppliers of obsolete parts and components.

3) Strategic Sourcing Initiatives – Promote cooperative projects with commercial domestic and foreign firms to recognize critical technology links to major systems and open global markets to the prospect of two-way trade in defense-related technologies.

4) Civil/Military Integration Incentives – Continue to reduce the perception that the government is a capricious customer when it comes to technology. This includes policies that support providing financial incentives to suppliers to use commercial technologies where feasible and cost-effective, and to market technological advances.

In the electronics industry, the US Government should promote competition and market stability at the broad strategic level. As a customer, the government's portion of the electronics industry market is so insignificant, it has no choice, but to stand in line with the rest of the world's customers when it comes to technology. At the strategic level, policies must focus on improving relationships with the industry at the enterprise level, not only to improve the government's position in line, but also to ensure scrutiny of capabilities most essential to the security and competitiveness of the US.

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CONCLUSION:

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The electronics industry is the key enabler of the "Information Age." It has provided the tools and technologies that facilitated revolutionary advances in more traditional industries and the productivity increases that drove our economic growth.

The electronics industry is healthy but requires ongoing monitoring to ensure the US does not lose its competitive advantage to its global competitors. New technologies are pushing the limits in ways that will dramatically transform the industry. As electronics capabilities increase, they will become embedded in more devices and more intertwined in our lives. Increased use equals increased dependence. This dependence introduces vulnerabilities such as an increased reliance on offshore manufacturers and the requirement for a highly skilled workforce. The government must take actions to mitigate the risks associated with our dependence on an information-based society.

Though defense electronics no longer drives the industry, it provides capabilities that are critical to our nation's defense. The effectiveness and lethality of our weapons systems are increasingly dependent upon the electronics subsystems they employ. The electronics industry is essential to our economy, our national security, and our way of life. Our vital dependence upon this industry is increasing. The government must foster an environment that enables stability and sustained growth of the electronics industry.

SPECIAL ESSAYS.

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An Assessment of Data Storage

One of the main challenges facing companies and government today is the need to store and maintain an increasing amount of data. As more businesses and government agencies move their computing and information processing requirements to the Internet, their computer data storage requirements will continue to increase exponentially. Expansion in the use and adoption of e-business and customer relationship management applications by corporations have also added to the demand for storage capacity. Similarly, as processing power of desktop computers has increased, so has the convergence of data, graphics, video and sound. Applications that integrate multimedia features are now commonly used in corporate enterprise data systems. These applications consume vast amounts of storage capacity.

This essay provides a brief overview of the state of technology in the storage sector of the electronics industry. In general, we find that the storage sector is still growing, that industry is spending a healthy amount of money on research and development, but that the U.S. government needs to allocate more resources to promote basic research in new and advanced technologies.

The Storage Sector Technology. The most popular enterprise storage architecture in use during the last few years has been the server-hosted storage approach. [30] However, there are a number of alternative technologies and services that provide more flexibility to organizations who store their growing data. The newest and most sophisticated storage solutions in use today are the network-attached storage (NAS) and storage area networks (SANs). NAS is a term used for disks, tapes and other mass storage systems that have an integral network connection such as Ethernet or fiber-channel. These devices can be connected as a network resource rather than just attached to a particular server. SAN, on the other hand, is a networking concept in which the software has knowledge of the quantity and value of data stored in mass storage devices and the characteristics of those storage devices. In SAN systems, it's not just enough to know that data is moving from A to B. The software also has to know about the backup strategy, data recovery and application software specific attributes to preserve and reconstruct the environment in case of a failure or system reconfiguration. This aims to automatically replicate many functions that were previously managed by systems administrators. While either method could be used as a stand-alone solution, they can also be used concurrently as part of an enterprise storage solution. However, experts believe that if a company's storage needs will continue to grow, particularly large corporations, they should adopt either a SAN solution or get the services of a storage service provider.

Outlook of Storage Sector. Anticipating a declining personal computer (PC) market in the U.S., a couple of years ago the major PC makers began to focus their resources in other areas, mainly services, storage and servers. Demand for computer storage has been growing steadily for most e-businesses. [31] According to Standard & Poors, the storage market is expected to grow 127% between calendar year 2000 and the year 2005 (from $44 billion in 2000 to $100 billion in 2004). [32] In the last two years alone,

IBM, Compaq, Hewlett-Packard, Dell Computer and Sun Microsystems have announced plans to offer new storage hardware, software and services.

An additional component of the storage sector of the electronics market is the storage service provider (SSP). These companies provide data storage services off-site or at the customer's facilities. They generally own and install the necessary hardware to provide the data storage services. It is predicted that spending in this once small niche market will jump at an annual compound rate of 134%, from $153 million in 2000 to $10.7 billion in 2005. [33]

At the other end of the storage technology spectrum, there has been an explosive increase in the use of flash memory [34] for the storage of data, graphics and digital music. Flash memory is a key component in the millions of mobile electronic devices being sold throughout the world today--from cellular phones to PDAs to digital cameras to MP3 players.

The opportunity to profit from the storage sector prompted Enron Broadband Services, to create a trading market of surplus storage capacity available from SSPs. The concept calls for storage capacity owned by SSPs to be pooled into Enron's hubs and then provisioned to create physical capability. StorageNetworks, Inc., is one of the first SSPs to partner with Enron to provide capacity and software technology services. Best Buy Co., one of Enron's customers, will use the storage capacity from Enron to support their customer relationship management application instead of their own dedicated data systems.

Conclusion. The storage sector of the electronics industry continues to grow at a healthy rate, in spite of the downturn in the PC market. Competition within the storage sector is providing a strong incentive for storage companies to continue investing in research and development. By leveraging the data storage services available today DOD should be able to increase efficiencies and save hardware costs.

Mr. Ramon Morales

The Future of Computing

Introduction – Setting the Stage - The evolution of computers since the 1970's has fallen into a predictable track characterized by Moore's Law of doubling the speed and transistor density on silicon as cost remains constant. [35] This model is largely responsible for the migration of many applications and data from large computer mainframes to smaller and faster servers at the office level and personal computers on every desk. As the computers and networks have become ubiquitous in serving data and applications across the enterprise the question now becomes, what is the next generation (or wave) of computers and how will they serve increasing user needs?

Background – The Race - In the early days of computers, extremely expensive mainframes drove the market with "Big Blue" IBM as "King of the Hill." While cost was a barrier for market entry the "IBM Mystique," a rare combination of fear, admiration, and mystery contributed to their monopolistic hold of the industry until 1984.

During the 1980's, the fruits of faster and lower cost semiconductors enabled the PC boom to dramatically change the landscape of the modern office. Punch cards, typewriters, paper filing systems and secretaries were on the decline. While IBM dominated this PC race early, their outsourcing strategy ultimately shifted power to Microsoft and Intel in 1981.

The 1990's saw two major changes in computing and infrastructure. First, continued semiconductor evolution created smaller and faster computers that could support an entire office or organization. These PCs became a more responsive and lower cost option to the traditional mainframes. Second, the computing environment became networked. Internet, Extranet and private net all experienced Metcalf's law, which holds that the increased value of networks is exponentially related to the number of users on the network [36] . This connectivity provided a "tiered" and distributed environment of PCs connected to office application/data servers and wider connections to global Internet and company enterprise servers. Advances in PC processor speeds from 25 to 500 Mhz during this time were a major contributor to the networking revolution.

Today's environment – Stabilizing forces - The computer environment today is not constrained by a structured "tier" company environment as faster PCs, servers, and other computing platforms exceed 1.5 Ghz with multiple shared and interleaving (or symmetrical) central processing units. Web-based computing and networked devices have become the standardized force for our future wave. Included in this stabilizing force is the demand for standards, open systems, common operating systems, and simpler programming languages based on object practices.

Objective – Direct Convergence and Context-based Information - The objective of new computing environments is to become universal and transparent to the work required. This means that work devices will have embedded processors capable of performing the necessary functions while automatically reporting their health and systems performance. Convergent and context-based information will use the equipment and networks to draw and transform from one functional area to another. Early examples are demonstrated by Web Portals, whereby companies are directly linked to suppliers, customers, and inventories to integrate the corporation. Future expansion will integrate phone, sensor, and individual mobile devices directly into the enterprise Portals.

Achieving this objective requires that the computing environment change. Although servers will continue to be part of the organization, they will serve more as a data warehouse and repository to be accessed by networked computing devices. From this perspective, applications will again be driven from servers and desktops to specialized and independent devices, sensors and multi-function phone-like devices.

Driving Factors – Computing Enablers - The most significant factor driving convergence and context-based environments continues to be the advancements in computing, networks, and storage. Silicon-based electronics currently dominate this industry however, emerging advances in molecular electronics and other non-silicon methods may provide the necessary breakthroughs to create the objective of a universal and transparent computing environment. [37] Molecular microchips promise transistors that can be produced cheaply in astronomical numbers, compute faster, remember longer without refreshment, and consume a trickle of power. This will transcend the limitations of silicon, magnetic and optical storage technologies while providing memory systems so powerful and small that the entire corporate database could be stored (or cached) on a single chip.

Other initiatives driving toward smarter and smaller computing is currently demonstrated by the convergence of cell phones, pagers, personal digital assistants, palm-based computers, and music devices. This year we have already seen several attempts to integrate these devices, set the standard and become the next major commodity with strong competition between Palm's M-series, HP's Jornada, Handspring's Visor and Compaq's iPAQ. This integration resulted directly from advances in electronics, semiconductors, power, and methods to integrate software on the chip. In this regard, electronics miniaturization provides a multi-function platform while new advances in regulating power and performance through embedded chip-based software creates integration [38] . Transmeta's Crusoe chip is a prime example of the innovative merger of software and transistor chip that now delivers up to 700 Mhz of software regulated CPU power on a single $119 chip. [39]

Conclusion - The future of computers is brighter than ever as they become smaller, more useful in our lives, and integrated with our job functions. Advances in technology will not see an end with silicon-based electronics, nor will we see an end to the computing platforms. However, as computing becomes more integrated with our jobs and lives, the current desktop and wired environment will all but disappear. Technology breakthroughs in devices are the first steps toward convergence and integration however, there are many challenges to upgrade the software applications and provide knowledge-based access to the information. We still have a long way to go.

Mr. Kenneth Loudon

The Future of Network Technology

Background. The communications equipment industry has undergone a major transformation, from copper wire, to fiber optics, satellite communications, wireless services, and digital technology. This transformation will continue, per Standard & Poor's

forecast of networking equipment growth of 15% annually over the next several years. This essay examines optical and wireless segments that are growing even faster.

Drivers. The coming of the modern information age has brought about phenomenal growth in telecommunications services, driven primarily by the Internet. There are two overarching drivers in network technology, the need for: 1) increased bandwidth and 2) convergence. International Data Corporation, projects over 600 million Internet users worldwide by the end of 2003, up from 240 million at the end of 1999. [40] In addition, the amount of time spent on the Internet is rising dramatically, and applications are becoming more bandwidth-intensive. This underlying driver of growth—demand for bandwidth due to "the Internet age"—will increase 300-fold in the next eight to ten years according to RHK Inc., a research firm in California. [41]

The second, equally strong, driver in the network technology area is the requirement for converged networks capable of carrying voice, data, and video on a single system. Convergence refers to a methodology where a variety of diversified technologies and equipment come together to offer a set of services to the consumer. An example is the integration of cable modems and television cable to carry data and other services from the Internet, viewed from any electronic device, not just a computer.

Optical networking. Driven by demand for more bandwidth and speed, optical networks will change everything. The clear growth enabler of the optical segment is a technology called Dense Wave-Division Multiplexing (DWDM), projected to grow 55% this year. DWDM is already eliminating long-haul bottlenecks and will soon do the same in regional and metro-area networks. DWDM allows service providers to add capacity without having to install new fiber-optic cable. DWDM uses lasers to divide traffic into separate colors or wavelengths of light, before sending it through fiber-optic networks. Some of the most advanced DWDM systems can split traffic into 80 wavelengths over a single strand of fiber. By contrast, the more common Synchronous Optical NETwork (SONET) equipment uses only one wavelength.

Optical Networking Technology Forecast
Within 5 Years
- Majority of homes will transition to broadband Internet access
- DWDM systems will be used to carry multiple SONET transmissions for backbone networks
- DWDM-based rings will become available allowing creation of ring-based and mesh-topology optical

Because the performance and capacity of optical technology is doubling about every nine months—twice the rate predicted by Moore's law—the long-term possibilities of fiber networks read like science fiction. [42] (see Table 1). In about 30 years, we'll have networks that, for the cost of a dialup connection today, will be able to deliver a believable telepresence—a visual communication so convincing you'll feel like you're in the same room with someone who's actually on another continent. [43] In just ten years, when every PalmPilot can display video, a webcam is built into monitors, and full-screen clips are sent as email attachments, the broadband metamorphosis will be complete.

Optical Networking Technology Forecast
Within 5 Years
- Optical wavelength switching will provide the most efficient use of bandwidth
- Optical switches will be proliferated
- Automated provisioning over

Optical Switching. Today, light wavelengths traveling through fiber optic cable must be converted to electronic signals to be processed and routed through current switches, then translated back to light form. This creates inefficiencies in the network. An all-optical switch could eliminate the conversion by directing a wavelength, or multiple wavelengths, through a network. The optical switch isn't readily available in the commercial marketplace today, but will be soon. Today, several companies have developed prototypes based on "micro-electromechanical systems" (MEMS). [44] These prototypes essentially use tiny mirrors that can reflect wavelengths. MEMS etches micro-mirrors onto silicon substrate to provide an optical cross-connect. Electronically steered mirrors reflect laser beams in different directions. Table 2 shows the future forecast.

Wireless technology. The wireless market is one of the fastest growing segments of the communications equipment industry driven by: increased demand for data services, increased demand for a mobile environment, new technologies including smaller, more functional handsets, and increased industry competition, which is causing prices to fall. [45] Dataquest predicts that 862 million

customers will use mobile phones by the end of 2003, up from 309 million at the end of 1998. [46] Wireless is moving to a worldwide 3G (data enabled) standard by mid 2002. Key enhancements of 3G technology include: increased efficiency and capacity, new services such as wide area networks, bandwidth on demand, increased flexibility, seamless roaming, and higher data rates. Even 3G may not be the ultimate solution. New generations of mobile technology emerge at intervals of 10 years. [47] (see Table 3). New technologies under development to help bring the Internet to a mobile environment are Bluetooth and Wireless Application Protocol (WAP). Bluetooth, a wireless technology, will enable a user to download data from a PC to a cell phone, or interface a headset with a mobile phone, without the use of wires. [48]

WAP enables mobile terminals to load and display information from the Web. It is an open standard which enables software developers to easily create applications for consumers and businesses. WAP will permit employees to access their e-mail, calendars, or address books stored on a company intranet. Future forecasts include technology that will enable people to use handheld devices that will deliver the same capability as their PC.

Think of a computing world that now has life outside the PC, including Internet screen-phones, wireless smart-phones, and intelligent refrigerators. We are quickly moving toward a world entirely different from today's computing and networks—a world in which all technologies will converge to provide a combination of services to the user.

Lt Col Dona Hanley

Wireless Technology Forecast
Within 5 Years
- Location and personal service based wireless devices are common
- Mobile phone use triples
- Wireless data rates increase from 3.3Mbps to 36Mbps by 2003
- 3G technology deployed
- WAP and Bluetooth technologies deployed integrating home and office
- Integration of mobile devices and internet applications includes voice

Flat Panel Displays

Visual displays provide the primary interface between information resources and the user. Described as "the window to the Internet" flat panel displays have demonstrated their utility as key enablers of a multitude of electronic systems. These displays are thin electronic devices capable of displaying images and textual information. Their superior physical, electrical, and performance characteristics have made flat panels the display of choice in an increasing number of commercial, industrial, and military applications.

Flat panel displays are emerging as ever more powerful devices.   Unlike the analog-based cathode ray tubes they are displacing, flat panels are not limited to functioning as passive receivers of information. They are state-of-the-art digital electronic systems that are rapidly evolving into interactive information interfaces able to perform more tasks and handle ever-increasing amounts of data.

These high definition displays are facilitating the wave of digital convergence and portability among a wide variety of electronic devices. Examples of the integration of flat panel displays into consumer electronic products include: notebook computers, internet-ready mobile phones, digital cameras, MP3 players, camcorders, personal data assistants, automobile navigation displays, medical devices, and head-mounted displays. Flat panels will play a fundamental role in shaping the future of the wireless communications and entertainment industries.

High definition display systems embody critical technologies within the electronics industry.   Some experts have described flat panel displays as the highest-potential, strategically significant competency in microelectronics. [49]   Technological advances have recently enabled manufacturers to fabricate integrated circuits directly onto the displays. [50]   The increased integration of system-board electronics onto displays will increase the power and utility of flat panel display systems. This increased power may result in a significant shift of the entire electronics industry infrastructure.

One dramatic example of the potential widespread impact of flat panels is in the area of energy conservation. Some analysts claim that if all of the cathode ray tubes in California (estimated at fifty million) were replaced with flat panel displays the state could reduce its electricity consumption by four gigawatts [51] . This amount equates to 9% of California's peak power use and would enable its infrastructure to avoid all rolling blackouts and Stage 1, 2, and 3 alerts.

The expanding market for flat panels will exceed that of the ubiquitous cathode ray tube-based displays.   DisplaySearch, a market research firm, indicated that flat panel deliveries achieved record unit and revenue highs during 2000. They also predict that the industry will experience a compounded annual growth rate of 21.5% and exceed sixty-three billion dollars by the middle of the decade. [52]

Active Matrix Liquid Crystal Displays (AMLCDs) currently dominate the commercial flat panel industry. Continued improvements in resolution, color viewing capabilities and power consumption will enable AMLCDs to maintain their 70% market share through 2005. [53]   The passive matrix variant LCD market share is projected to decline from 19% to 11% over the same period. The leading new display technology, embodied by organic light emitting displays, is expected to capture a 5% market share.

AMLCDs represent the technology of choice for most military and consumer applications. Though this technology was first developed in the United States, it was Japan's continued investment and development efforts that facilitated the acceptance of flat panel displays in the consumer marketplace. [54]   These initiatives allowed Japan to gain the extensive design and manufacturing expertise that enabled it to achieve early global leadership in the industry. Today, Japan, Korea and Taiwan-based producers dominate the flat panel display industry. [55]

By providing superior performance and capability, more efficient use of space, and improved reliability under harsh conditions, flat panels have demonstrated they are ideally suited for use in demanding operational environments such as aircraft cockpits, ground combat vehicles, ships, and submarines. These critical applications, required to support the military's expanding information dissemination capabilities, necessitate that the military must have ready access to a robust dual-use industrial base that is willing and able to produce customized flat panel display systems that incorporate the latest technology advancements at reasonable prices.

The primary components of an AMLCD display head are the display glass, driver electronics assembly, and backlight assembly. Domestic display manufacturers have demonstrated their ability to design and integrate the interface electronics, filters, software and mechanical packaging required to meet the stringent operational characteristics required of military weapon systems. However, they have not been able to establish an enduring industrial base capable of providing themselves or system integrators with a dependable and cost effective supply of display glass.

AMLCD display glass consists of a liquid crystal cell formed between two plates. The active matrix plate is comprised of a large glass substrate covered with a layer of thin film transistor switching elements. These elements control the optical performance of each pixel in the display.   The quality of the display depends on the ability to produce a near fault-free matrix of transistors across the entire substrate. The challenge of achieving near zero defects becomes greater as the size of the substrate increases. This inherent characteristic of AMLCD glass defines the economic reality of the industry—that production volume drives process yields, cost, and quality.

The Department of Defense recognized flat panel displays represented an emerging technology that would have widespread applications in the military's growing information processing requirements. Consequently, the government made substantial investments in the research and development of advanced displays to foster the establishment of a domestic design and manufacturing base capable of supporting the military's projected state-of-the-art high definition display technology requirements.

In spite of the government's efforts the military's flat panel display procurements remain problematical. The large public and private investments (in excess of one billion dollars) made during the last decade have not spawned the anticipated domestic AMLCD industrial base. Rather than having gained access to a stable and affordable source of supply, military customers have seen availability diminish as costs have risen. There is no AMLCD custom glass manufacturing capability within the United States able to support our national security display requirements. The military remains dependent upon foreign-owned offshore sources for all of its AMLCD glass requirements.

The economic and national security demands for flat panel display-enabled systems mean this industry has an increasingly

significant impact on our domestic industrial base. The flat panel display manufacturing sector will continue to be the focus of high-level commercial, strategic, and government policy interest.

Lt Col Walter Augustin

Telematics: The Convergence of Communications and Computing

Introduction - The Consumer Electronics Association reports that a small number of breakthrough technologies will soon fuel a rapid expansion of the already massive consumer electronics marketplace. One of those technologies is telematics. The *Oxford English Dictionary* broadly defines this relatively unknown term as the "long distance transmission of computerized data."   The consumer electronics industry more narrowly defines telematics as automotive electronics that converge a number of technologies to enhance safety, exchange information, and entertain the mobile user. While telematics has its roots in the defense industry, market penetration forecasts may soon reverse the technology flow. High profits and the desire to improve product performance could finance sophisticated research and development (R&D) initiatives in the consumer sector.   Telematics could become an industrial base "life preserver" for the engineering talent and manufacturing capacity needed in defense electronics. In the not too distant future, user interface designers for our most complex weapons systems may simply look to the latest model automobile for "state of the art" technology.

Market Outlook – Telematics is clearly gaining momentum in the commercial sector. At the close of 1998, only 56,000 US cars had any piece of telematic technology. That number is forecast to grow to over 30 million vehicles by 2005. [56]   By 2005, annual revenue streams from telematics will exceed $13 billion in the US alone. [57]   Q-PC Corporation, a leader in military telematic applications, has shifted its focus to the consumer sector envisioning a $400 billion market by 2015. [58]

Telematic System Components - A telematic system consists of five components. The Telematics Control Unit (TCU) integrates and stores system data. Global Position System (GPS) module enables vehicle tracking. A wireless communication device makes much of telematics possible. Third generation (3G) wireless communication, slated for world-wide introduction in 2003, will raise data transfer rates from the current 14.4 – 33.6 kilobits per second to 2 megabits per second. [59]   Available bandwidth clearly defines the realm of the possible for telematics.

The final components of a telematic system are the interface, the link between the whole system and the operator. The user interface is the most exciting part of the telematics system and the one most likely to generate dual-use technology breakthroughs for the defense sector. Telematic systems must improve, not detract from safety. Widespread acceptance of telematics will require a well-designed user interface.

Emerging Technology - The cutting-edge technology in development today focuses on improving driver safety and making commuting time more productive and entertaining. Ironically, the growing complexity of telematic systems demands increasingly simpler user-interfaces. Generally, the aim is to simplify the existing instrumentation to make "cognitive room" for well-designed telematic interfaces. Fingertip controls and voice recognition software will reduce distractions. Data displays will resemble a military aircraft heads up display. Muth Technologies, a maker of military forward looking infrared radar applications, has recently joined with GM to improve the display quality. [60]   EyeCue is another GM adaptation of military technology where image displays appear to float in midair at the front of the car. Speed, vehicle status data, navigation directions and even streaming e-mail are available with no need to look inside or even refocus your eyes. [61]

As a nation, we waste 500 million hours per week stuck in commuter traffic. [62]   Accidents are largely attributable to trying to make productive use of this wasted time. Productivity enhancements fall into two categories; those that increase data flow to the vehicle and those that reduce the requirement to pay attention while driving.

The first group refines existing tools. Motorola's iRadio, for example, adds Internet and email access to traditional wireless

communications service. GPS aided navigation eliminates wrong turns and makes driving more efficient. Additionally, systems will soon feed real-time accident and traffic congestion information and automatically calculate alternative routing.

The second group performs "auto-pilot" functions. In 2003, low speed, adaptive cruise control systems will appear in the European market. Using radar technology designed for the US Army's unmanned vehicle program, this allows "hands-off" driving in stop-and-go conditions under 30 miles per hour. "Close highway platooning" devices will improve highway throughput by reducing vehicle spacing on roads with "cooperative" sensors installed. [63]

Safety and productivity applications will largely drive demand for telematic devices but entertainment features will surely spark some interest. Satellite radio receivers will be dealer-installed equipment in the 2002 model year. For a subscription fee of ten dollars per month, a driver can have nationwide access to 100 channels of digital music and talk radio. [64]   Of course, with links to the Internet, downloading compressed music files from a "Napster-like" service is also quite possible. [65]

Government's Role - Sales of telematic devices will soon number in the millions and will likely continue to grow in a US market containing over 214 million vehicles. If the past is prologue, engineers and R&D resources will follow the money. The obvious question is will telematics drain the defense industrial base or help preserve it. Telematics will be a "life preserver" for the defense electronics sector, especially in the area of user interface design. While this dual-use technology precludes the need for direct preservation efforts, government still has a role to play. It must support the industry by nurturing complementary technologies such as a standardized 3G wireless communication protocol that is essential to the success of telematics.

Conclusion - Richard Mudge, of US Wireless predicts, "in two or three years telematics could be as big a factor in people's lives as the cell phone and the Internet are today." [66] It will unquestionably transform the way we interact with motor vehicles and holds out the potential for an improved quality of life for those burdened with long and tedious commutes. All will certainly benefit from the added safety that stems from a well-designed interface that keeps eyes on the road instead of on maps and Palm Pilots.

The projected demand for telematics will be quite a boon to the automobile industry. Fortunately, the growth of this technology has an added benefit; it keeps the engineering expertise, heretofore working on defense projects, gainfully employed. Profits will likely spur additional R&D efforts that will continue to have relevance in the defense sector. It appears that the growth of telematics will be one of those rare win-win situations.

Lt Col Matt Dapson

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