INFORMATION TECHNOLOGY

ABSTRACT: The US Information Technology (IT) industry is a critical enabler of all major US industries and their ability to support the US National Security Strategy. As a crucial element of US Government and Department of Defense transformation efforts, the US IT industry must overcome several challenges if it is to retain its lead in the world market. These challenges include maintaining a strong IT workforce, addressing growing foreign competition, developing critical infrastructure protection, balancing spectrum allocation, ensuring interoperability and interconnectivity, and controlling intellectual property rights. The health of the US IT industry must remain a vital interest of industry leaders, academia, and US policy makers alike.

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Information Technology Association of America, Roslyn, VA
Lockheed-Martin, Information Technology, Arlington, VA
Microsoft, Bethesda, MD
National Cable and Telecommunications Association (NCTA), Washington, D.C.
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INTRODUCTION: The purpose of this study was to develop a strategic perspective of the Information Technology (IT) industry and its ability to support the US National Security Strategy (NSS). Over a five-month period, through seminar discussions and visits with trade organizations, industry associations, government officials, and domestic and international industry leaders, this seminar measured and evaluated the status of the US IT industry and its central role as an both an industry and an enabler for other industries to support US defense, political, and economic objectives. This seminar's members benefited greatly from their experiences in a broad array of subject matter areas ranging from profits to policy and gained significant insight into the current conditions of the industry, its future direction, and the global challenges it faces.

The IT industry led the way for other industries to transition from the "industrial age" to the "information age." At the beginning of the 21st Century, however, the IT industry is moving industries into the "Broadband Age" or the "Age of Convergence," providing additional growth opportunities for US industries and commercial ventures. The growth and proliferation of cheap and abundant IT is inspiring worldwide changes in defense, politics, and business, fostering the growth of e-commerce and leading to a more integrated world economy. IT is the main driving force for the increasingly globalization of world economies and industries.

This study examines the IT industry, specifically the current condition, and the industry's short and long-term outlook and discusses the most timely and pertinent challenges confronting the industry today and in the future. Additionally, this study examines the role of the private sector, academia, and the government in overcoming these challenges to ensure the US retains its IT competitive advantage. Finally, the seminar provides recommendations.

THE INDUSTRY DEFINED: Defining IT is relatively easy and straightforward. The Department of Defense (DoD) provides the following, ample definition:

> ***Information Technology (IT):*** *Any equipment, or interconnected system or subsystem of equipment, that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information… The term "IT" also includes computers, ancillary equipment, software, firmware and similar procedures, services (including support services), and related resources.*[1]

On the other hand, defining the IT *industry*, and identifying its scope and boundaries, can pose a significantly greater challenge. IT is at once an "industry" and a "revolution". Information technologies and information systems are the key enablers of the so-called "information age," just as industrial technologies and processes were for the industrial age. A primary difference, however, is that information technologies, unlike industrial technologies, comprise a considerable and direct market force across all facets of commercial industry, the private consumer sector, and all echelons of the government.

Another challenge lies in defining the individual sectors within the IT industry. This problem is exacerbated by the continuing "convergence" of digital content (audio,

video, text, etc.), technologies (e.g., telecommunications and computers), and services (e.g., telephony and the internet) that blur the lines that distinguish where one IT sector ends and another begins.

Yet one thing is certain. The IT Industry is a major force in the US economy. The US Department of Commerce (DOC) estimates that IT-producing industries supplied about 8% of total US GDP in 2003, or more than $870 billion.[2] The IT industry, its workforce, and its markets are truly global. The impact of the IT industry and the technologies and innovations associated with it have far-reaching implications for a broad range of governmental policies on topics including education, immigration, import/export regulation, technology transfer, national security, and privacy.

The US Census Bureau's North American Industry Classification System (NAICS) lists more than 40 separate industry sectors within the areas of IT manufacturing and IT services, and shows that more than 3.7 million Americans were employed in those sectors in 2002.[3] For the purposes of this industry study, we will limit the scope of the "information technologies" industry to the following major categories identified by the DOC as the "information technology producing industries."[4] Those are:

A. Hardware Sector: Includes sub-categories such as computers and equipment; wholesale and retail trade of computers and equipment; printed circuit boards; semiconductors; and magnetic and optical recording media, just to name a few.

B. Software/Services Sector: Includes computer programming; prepackaged software; wholesale and retail trade of software; computer processing and data preparation; information retrieval services; computer services management, and information security services, amongst others.

C. Communications Sector:

1. Communications Equipment: Includes household audio and video equipment, telephone and telegraph equipment, and radio and TV communications equipment.

2. Communications Services: Includes wireline and wireless telecommunications and television services (including cable).

CURRENT CONDITION: The onset of the "Broadband Age" or "Age of Convergence" at the beginning of the 21st century ushered in an age of access to information with incredible speed from widely dispersed locations. This has created an "always on environment" that is expected to shore-up growth of up to 5% in some sectors.[5] Several areas of the IT industry have been identified as growth sectors including: supercomputers, electronic games, Internet advertising, Voice-Over-Internet Protocol (VoIP), computer network security, advanced storage, voice recognition, Wireless Fidelity (Wi-Fi), Radio Frequency Identification (RFID), smaller laptops, open operating systems, distributed computing, supply chain management (SCM), online collaboration, and Web services. For online shopping alone, Neilsen/NetRatings reported

expenditures of $18.5 billion in online shopping during the 2003 holiday season, a 35% increase over 2002.[6] The Age of Convergence is big business.

From a global perspective, the US is still the major player across the entire IT field, albeit its lead has diminished, and in some areas its, lead has been completely supplanted. The US IT industry is by no means in crisis, but a few well-thought out policy decisions in the areas of opening immigration, spurring technology education, and protecting intellectual property rights can ensure its future strength.

A. Hardware: The worldwide Personal Computer (PC) market finished 2004 on a strong note, but growth is expected to slow in 2005. According to the research firm IDC, global PC vendors shipped 177.5 million units during 2004, up 14.7% from the 154.7 million units shipped in 2003. This number represents the peak of a worldwide recovery following the decreased shipments of 2001.[7] After a 4.8% gain in 2004, worldwide sales of PCs, servers, storage, networking, and peripherals should tick up modestly by 6.2% in 2005, to $386.6 billion. Mobile PC shipments will continue to drive the market, Gartner Research says, increasing by 17.4% over 2004. Desktop PCs, meanwhile, are forecast to grow by only 6.1%.[8]

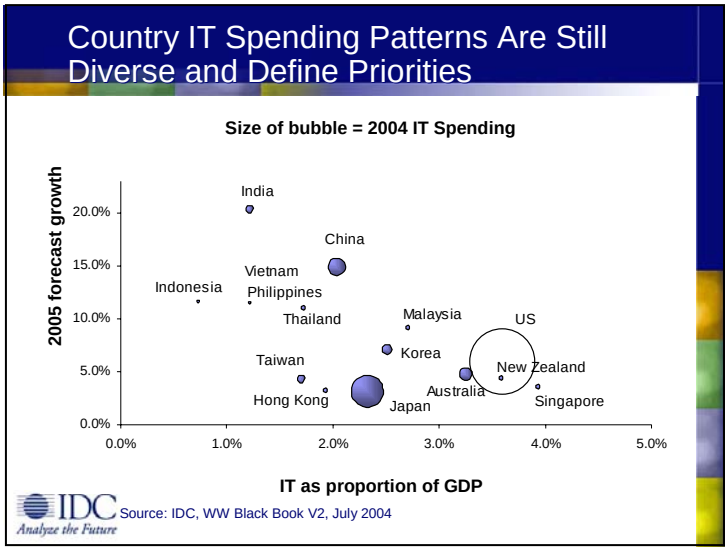
B. Software: Sales of new software licenses and technical support will increase just 6% in 2005, to $152 billion, predicts Gartner. While slightly higher than in the last couple of years, it does not compare to the roaring 15% growth rates of the late 1990s. Sales of software that helps companies deal with paperwork and business processes -- a must-have in the new regulatory environment -- are forecast to increase 15.5%, to $875.4 million and security software is projected to increase 13%, to $5.6 billion.[9]

C. Communications: Revenues from all US communications services are expected to climb 6%, to $347.5 billion, in 2005, according to Gartner. This is despite a decline in traditional voice service to $131.1 billion from $133.5 in 2004. Emerging services will drive spending, with wireless revenues forecasted to rise 11% to $122.5 billion, while revenues from broadband and other data services are projected to rise 12% to $93.9 billion. Moreover, IDC states customers will dole out $83 million -- a 28% jump over last year -- to purchase advanced technologies to wirelessly transmit photos/video clips, surf the Net, and send e-mail messages. Furthermore, the overall telecom equipment market is expected to rise 11% in 2005 to $84.6 billion, and then to $102.4 billion by 2007, according to Synergy Research Group.[10]

The US dropped from first to fifth place in a recently released Global Information Technology Report 2004-2005 that assessed the state of the networked readiness of 104 economies worldwide. Although it still ranked highly in most sectors, the US fell in several areas relating to the quality of its education system, its administrative burden, and individual telephone and Internet use. Simply put, the improved performance of other countries overtook the US.[11] This decline is especially troubling in light of some additional indications that the US is falling behind in high-tech development and infrastructure. For example:

- Approximately 19.9% of US households have broadband access, compared with 30% in Korea, 20% in Japan, and 70% in Singapore.
- US investment in research and development (R&D) dropped sharply following the end of the Cold War and has remained flat. However, investment has grown significantly in competitor nations such as Brazil, India, China, and Israel.
- US students are behind their counterparts in other countries in math and science. For example, some Asian countries are graduating five times as many engineers as the US.[12]
- Post September 11, 2001 fears have resulted in government policies that limit foreign student and IT worker access to studying and working within the US. US policies have forced this talent-rich pool to move to competitor countries. Additionally, top-name universities are setting up branches or campuses in competitor countries, enabling them to draw the very best students.
- Gartner predicts that US corporations will relocate 25% of traditional IT jobs to developing countries by 2010 due to lower labor costs.[13]

The good news is that the US still maintains a sizable lead in IT spending as a percentage of GDP as shown in the following IDC chart.



COUNTRIES VISITED: As part of the IT industry study, this seminar visited China, Thailand, Singapore, and Japan to assess the state of their IT sectors and the potential implications for the US. Several themes emerged from these visits. First, the nations that are furthest along in IT development are also the countries that have the most robust national infrastructure. China and Thailand are striving to develop the IT infrastructure necessary to become global IT powers but are hampered by the significant economic disparity between the rural and urban areas of the two countries. Second, all four countries are struggling with issues relating to Intellectual Property Rights (IPR). Singapore and Japan have the most stringent IPR regulations and have been fairly successful in enforcing the rules. China, followed closely by Thailand, has significant problems with IPR. Some estimates indicate that over 70% of the software used in these

countries is pirated. Third, Japan, Singapore, and to a lesser extent Thailand are transferring their lower-end programming functions to China with the strategy of maintaining higher-end functions domestically. Fourth, the governments in all four countries place a high priority on growing their respective IT industries and are expected to continue to play a significant role in the future of the global IT industry. If the US wants to maintain its dominance in the global IT market, it should look for opportunities to form strategic partnerships with these countries.

A. Singapore: According to the Global Information Technology Report 2004-2005 Singapore is the most successful country in the world at harnessing the Internet revolution and new technology. This small Asian state garnered high marks for its technical infrastructure, government policies on IT, the quality of its education system, and the affordability of telephone and Internet services. Singapore's goal is to be Southeast Asia's financial and high technology hub. Although the Singaporean economy is heavily dependent on exports, particularly electronics and manufacturing,[14] it is an excellent example of a country that has been able to make enormous progress exploiting IT to improve its citizens' living standards.[15]

B. China: China/Hong Kong is the world's largest market for semiconductors used in manufacturing data processing products; its market expected to grow 18.2% through 2008. Although China is a fast-growing IT market, enterprises based in China spend less on IT products and services than enterprises in more-developed economies. China is the world's leader in the mobile handset market, the world's largest PC market; and by 2007, China will become the world's largest Internet subscriber market.[16] The enterprise IT market is relatively unsophisticated and products that rely on a solid technology base and sophisticated management disciplines are unlikely to be successful before 2009.[17] Intellectual property rights continue to be difficult to enforce and may have long-term impacts on direct investment as companies become more wary of losing intellectual property and their competitive advantage. China has the largest labor pool in the world, and both local and international companies have employed this relatively cheap labor to yield successfully large sustained output. Chinese labor is also considered increasingly sophisticated and educated. A number of foreign IT companies, including IBM, Microsoft, and others have established operations in China to take advantage of the talent and relatively low cost of its labor pool. This direct investment, coupled with government actions to promote their IT industry, have allowed the Chinese electronics industry to account for 30% of Asia's total exports in this sector.

C. Japan: An overall assessment of the current Japanese market shows a shift from hardware and network infrastructure to software and services, with the Japanese heavily dependent on US imports for software and some hardware. The current outlook for the Japanese IT economy predicts a moderate decline driven, in large, by a predicted slowdown in the US. The Japanese are trying to offset this downturn by increasingly relying on the Chinese export market. Additionally, Japan is starting to take a leading position in several arenas such as developing the next generation Internet protocol (IPv6),[18] exploring the use of remote sensors to monitor climates and disasters, developing computerized language processing, conducting nanotechnology research and development, and developing application software for the next generation Internet.[19]

D. Thailand: Thailand is eager to increase foreign investment, especially in the semiconductor and electronics areas. Gartner believes that Thailand provides a safe and attractive location for foreign semiconductor companies looking for a lower-cost production alternative.[20] Piracy and concerns over government transparency are significant problems, and a recent survey published by the Business Software Alliance estimated that 77% of all software in Thailand is pirated.[21]

GLOBAL DIGITAL DIVIDE: Access to information and network connectivity are major requirements for full participation in the global economy.[22] Underdeveloped and developing countries lack access to information and communication technologies (ICT) which in turn contributes to the growing digital divide between these countries and the more developed countries These nations are characterized by corrupt governments, wholesale poverty, instability, terrorism, pandemics, civil wars, and human rights violations. The lack of emphasis and involvement in e-ready initiatives in these countries contributes to the ever-widening gap.[23]

INDUSTRY OUTLOOK: The US remains the world's IT innovation leader but faces significant challenges to its position. Other nations are working hard to advance their position in hardware, software, and communications equipment and services areas.

A. Hardware: The quest for faster access to information is driving the hardware sector to improve its ability to make data and information available more and more quickly. Data storage and processing power improvements are two key areas for making this goal a reality.

1. Data Storage: The production of data is growing exponentially and as a result, demand for storage solutions will continue to escalate. Driving this growth is compliance legislation such as Sarbanes-Oxley and increasing corporate governance over information security such that businesses are on the brink of a "data tsunami." Not only must companies be able to store petabytes (2^{50} or 1,024 trillion bytes) of data, they must also be able to retrieve this information instantly and affordably.[24] The sales forecast of disk-based storage systems alone is expected to hit $23 billion this year, up from $22.4 billion last year.[25] The massive amount of data also creates a major challenge in managing and administering it. Without enhanced storage processes, management, and automation, effective utilization of storage assets will remain a major data-center issue.[26]

Historically, companies addressed demand for storage capacity by purchasing hardware and software separately. However, the situation is changing, and CIOs and IT managers are becoming more interested in solutions to manage their storage in a more cost-effective and efficient manner.[27] Furthermore, these managers have demonstrated their willingness to incorporate new technologies as exemplified by the rapid adoption of Advanced Technology Attachment (ATA) disk and e-mail archiving technologies.[28] Replication technologies and disk-to-disk backup will displace traditional recovery techniques.[29] Finally, industry consolidation will continue due to the need for vendors to offer a broad portfolio of solutions.

2. Supercomputing: Supercomputing, also called high performance computing, is simply utilizing the fastest and most powerful computers available to solve complex computational problems. Typical supercomputers are up to 10,000 times as powerful as a desktop PC[30] and fill uses across a wide variety of disciplines, such as weather forecasting, data mining, genome research, nuclear engineering, and many others. Two of the most important uses of supercomputers within the US government are signals intelligence (DoD) and nuclear stockpile stewardship (Department of Energy, DOE).[31] Supercomputing has also helped our automotive, aerospace, medical and pharmaceutical industries remain economically competitive in the global market.[32]

The US is the unquestioned leader in the supercomputer industry, with over 90% of the market share.[33] The world's fastest and most powerful supercomputer is the Blue Gene/L built by IBM for the DOE at Lawrence Livermore National Laboratory.[34] It has a processing speed of approximately 70 Tflops (trillion floating point operations per second).

America's supercomputing dominance forms the basis for science and technology (S&T) breakthroughs that are foundational to a healthy US economic climate. Retaining that dominant S&T role will require the US to invest in critical supercomputer technologies such as custom high-bandwidth processors, architectures, software, and algorithms.[35] Even though there are many commercial applications, the US government is the single largest supercomputer consumer. Maintaining our militarily dominant role on the world scene relies on continued R&D in high performance computing technologies.

B. Software: In addition to hardware storage improvements, software innovations such as IPv6 and Open Standards are required to ensure cutting-edge performance.

1. Internet Protocol Version 6 (IPv6): IPv6 is the next generation of internet protocol. IPv6 greatly increases the number of internet addresses available and incorporates advancements that enable better mobile capabilities, quality of service, and end-to-end security. On June 9th, 2003, DoD announced that the Global Information Grid (GIG) will fully transition to IPv6 by 2008. The memorandum also mandated that all new capabilities being developed, procured, or acquired after October 1, 2003, will be IPv6 capable.[36] For the commercial industry, this timeline may be faster than normal market conditions would ordinarily push it.

2. Open Standards: The software standards that apply to the IT industry have been both a problem and solution. After fifty years of IT evolution, we are finally reaching the conclusion that it is in everyone's best interest to have standards that provide good communication and compatibility among vendors, suppliers, and users. An *open standard* is a published standard that is owned by no one and used by all.

Open standards have almost reached a critical mass in the mainstream world market. Companies such as IBM, SAP, Sun, Intel, Hewlett-Packard, and Silicon Graphics are committed to using open standard software as a core part of their business

models and are investing significantly in enhancing its already impressive capabilities. The way ahead is toward more open and unified systems. It makes good business sense. Simply put, open standards convert technology into the universal world of business.[37]

Open standards address long-term, strategic business/industry issues, not simply the short-term, tactical or technical objectives of a single segment or company within the industry. Successful open standards expand the opportunities for the entire industry while providing users with long-term stability. Such standards also provide a sound foundation on which users can base strategic decisions.[38]

C. Communications: To take full advantage of the advanced hardware and software solutions, faster communications networks are required, providing users with the fast, ubiquitous access to data and information that is required for the "Age of Convergence".

1. Equipment--Optical Networking: Optical networks provide high-capacity telecommunication transport and switching services using optical fibers and high speed optical components. Fiber optic cable began replacing conventional copper cable as the preferred telecommunications medium during the 1980's. The increased bandwidth resulting from the move to fiber optic cable fueled the dramatic growth of the internet and offered, for the first time, the potential for high-speed telecommunications applications. As demands have continued to increase, so has the need to develop higher speed optical components that can take full advantage of optical fiber bandwidths.

Present day optical networks transmit information in the tens of gigabytes per second range. To meet future demands, experts believe that speeds of terabits per second, or even higher, will be required.[39] To accomplish these speeds, R&D is underway on parallel optical processors, optical switches, dense wavelength division multiplexers (DWDM), holographic storage devices, optical amplifiers, and ultra narrow line width lasers.[40] Although the consolidation of all these devices into an integrated all-optical network is years into the future, scientists are making great progress.

With the burst of the "telecom bubble" between 2001 and 2003, the global market for optical networks fell to about 30% of its 2000 peak.[41] With this burst came a slowdown in R&D investments by private industry. However, despite the slowdown, the global forecast from 2004 to 2008 predicts an annual growth rate for optical networks of 13%, with North America and Asia expected to grow at a slightly higher rate of 15%.[42] Still, even with this double-digit growth, the optical network market will be slightly less than 60% of its 2000 size by the year 2008.[43] However, the pace of growth in the out-years should continue to accelerate as countries like China become more interconnected.

2. Services:

a. Wireline: Although the wireline sector provides voice transmission service as its primary product, this industry is undergoing transformation that makes it more and more difficult to define. Regulatory reforms have increased the competition within this $200 billion industry, and technology has introduced new

industries as direct competitors within the marketplace offering value-added telecommunications services.

b. Wireless: The wireless sector of the IT industry is comprised of two major categories: wireless devices (such as wireless/cellular telephones, wireless PDA's, etc.) and wireless infrastructure (wireless network equipment, transmission equipment, etc.).[44] Following the February 2004 "mega-merger" of Cingular and AT&T Wireless, there are currently five US-wide wireless carriers: Cingular, Verizon (in a joint venture with Vodaphone), Sprint, Nextel, and T-Mobile. There are more than 160 million wireless telephone customers in the US today, and total industry revenues were more than $87 billion in 2003 (a figure estimated to have exceeded $100 billion in 2004.)[45] Current trends suggest growth in the wireless sector will continue into the near future, although at a slightly slower level, as market penetration rates are currently climbing above the 50% mark.[46]

Additionally, Wireless Fidelity (WiFi) provides secure Internet connectivity for mobile computer users. WiFi's bandwidth and connection distance limitations will be solved with the employment of a new technology called Wireless MAX or WiMAX.

The wireless sector of the IT industry is heavily dependent upon a limited national resource, radio frequency spectrum, for the growth of business. On January 26, 2005, the Department of Commerce announced that another 90 megahertz of radio spectrum currently reserved for federal use would be auctioned to private users as early as June 2006. This additional spectrum is intended for use in Advanced Wireless Services (including Third Generation or "3G" wireless.)

c. Broadband: Broadband technology is defined as a "communication network in which the bandwidth can be divided and shared by multiple simultaneous signals (voice, data, and video). The network can carry multiple signals by dividing the total capacity of the medium into multiple, independent bandwidth channels, where each channel operates only on a specific range of frequencies."[47] Broadband transmissions can occur over a variety of media, including both wireless and wireline (copper, fiber optic cable, etc.). According to the US DOC, 19.9% of US households had broadband internet access at the end of 2003.[48] The federal government is advancing broadband infrastructure initiatives such as "broadband over power lines", increased spectrum usage, and simplification of "rights of way" access procedures to make broadband more readily available.

d. Third Generation (3G) Technologies: "Third generation" (or "3G") wireless equipment and services are bringing broadband capabilities to wireless devices. 3G capabilities support circuit and packet data bit rates up to 2 megabits/second, sufficient for multimedia services/capabilities. 3G standards continue to evolve, and rapid growth in 3G equipment and services is anticipated.[49]

D. The Department of Defense's Global Information Grid (GIG): The DoD defines the GIG as "[t]he globally interconnected, end-to-end set of information capabilities, associated processes, and personnel for collecting, processing, storing,

disseminating and managing information on demand to warfighters, policy makers, and support personnel."[50] The GIG, along with the operational and technical architectures that define it, the core enterprise services being designed to operate on it, and the governance structures established to manage it, comprise the lens through which DoD will view its IT operations. Commercial IT businesses seeking to do business with the DoD must understand this framework in order to be able to meet the department's requirements and to communicate effectively with it.

1. Network-Centric Operations Industry Consortium (NCOIC): The NCOIC was established on August 27, 2004, to serve as a forum for the commercial IT industry "to accelerate interoperability in systems that support military, homeland security, civil and commercial users."[51] Its goal is to better equip commercial IT businesses to work with government customers to analyze, develop, and improve net-centric architectures, capabilities, and mandated open standards. NCOIC membership is open to all interested domestic and foreign companies, and serves as a valuable asset for achieving the GIG vision.

2. Net-Centric Enterprise Services (NCES) and the Core Enterprise Services: The Defense Information Systems Agency (DISA) states "NCES will empower the edge user to pull information from any available source, with minimal latency, to support the mission. Its capabilities will allow GIG users to task, post, process, use, store, manage, and protect information resources on demand."[52] So far, nine "core enterprise services" have been identified that will provide common capabilities to all GIG users. Those services include collaboration, discovery, messaging, and storage, among others. Interoperability with these GIG services will be fundamental for all commercial developers of capabilities that will reside on the GIG.

3. Interoperability with the Intelligence Community: The GIG is designed to extend across the DoD, including the DoD intelligence community (IC), and interface with the national-level IC. Historically, interconnectivity with the national level IC has been limited by its higher classification of IC networks, as well as by the fact that its IC capabilities are procured under different acquisition authorities and programs than standard DoD systems, exempting them from many of the processes DoD uses to certify interoperability and GIG "net-worthiness."

CHALLENGES: The US is facing enormous IT challenges including IT workforce issues, increasing foreign competition, critical information infrastructure protection (CIIP), interoperability, spectrum shortages, and a lack of R&D funding. Additionally, the US government must consider its roles and goals in areas such as the universal broadband policy, the global digital divide, the sale of critical infrastructure to foreigners, and intelligence reform.

A. Challenge: IT Workforce

1. Education:

Issue: The US is not producing sufficient numbers of math and science majors to support US IT workforce requirements.

Discussion: In 2001, a bipartisan group, the Hart-Rudman Commission on American National Security, concluded that the greatest threat to America is the attack of terrorists with weapons of mass destruction. The second greatest threat to national security is the failure of math and science education.[53] "In fact, in a unanimously approved provision, the Commission stated that the failure of math and science education is a greater threat than any conceivable conventional war in the next quarter century."[54]

Statistics show that changes in US demographics will exacerbate America's education challenges. The size and composition of the labor force is changing, becoming more racially and ethnically diverse and with many older workers facing retirement.[55] Many students in these minority groups, especially Hispanic-Americans and African-Americans, often come from low-income backgrounds and do not receive sufficient preparation to pursue technical degrees. However, these groups, whose enrollment rates in technical degree areas are less than half that of white students, will comprise an increasing larger percentage of America's college and university students in the near future.[56] IT firms and US universities must develop a means to attract these "disinterested" minority groups into technical fields.

American students are increasingly turning away from relatively high-paying technical careers because of concerns about future employability. Many college students remember the "dot-com bubble burst" of the late 1990s and they buy into the hype over the offshoring of IT jobs to India, China, and other low-wage countries. They worry about their futures and are choosing majors that may provide them with more options and greater flexibility.[57] Many experts, however, believe the demand for graduates with technical skills and backgrounds will continue to grow.[58] This is in contrast to those who anticipate little growth in the US IT industry due to offshoring and general market-nervousness.[59]

Additionally, many believe there is an overall decline in quality of American education at the K-12 grades, especially in the areas of math and science. "The US is turning out students who, by and large, aren't qualified in science."[60] This is true not only in the absolute, where only 2% of America's twelfth graders scored an "advanced" rating in science, but also when compared to other countries. America's children are falling further and further behind.[61]

The Computing Research Association (CRA) completed a study that indicated "colleges and universities face a shortage of applicants for faculty positions in computer science and IT because too few students are graduating with doctoral degrees in those fields. According to the report, 880 IT and computer science doctoral degrees were awarded by colleges and universities in the United States in 2000, the lowest number since 1990."[62] This continuing decline in training and educating new professors and teachers, combined with the low performance of America's elementary and high-school children in technical subjects, will make it more difficult for US IT industry to hire

skilled US workers. "The IT personnel of tomorrow will be groomed in today's education system. The challenge is to better align the curriculum and the constantly changing business environment, because the quality of our workforce is directly proportional to the quality of the education received."[63]

Recommendations: After the Russians beat us into space, President Kennedy challenged the nation, and there was an ensuing surge in math, science, and engineering that ultimately took the US to the moon. It is time again for America's leadership to inspire educational growth in these areas.[64] The government should inspire America's youth with a similar challenge today.

The future of the IT industry depends on America's ability to inspire learning and innovation in future generations. This inspiration requires a cadre of teachers who are not only well-qualified, but also highly motivated and highly regarded by society. "Not having enough technology workers in the workforce is not the most serious threat facing the long-term continued prosperity of American businesses around the world. Not having enough qualified computer science and IT in higher education classrooms is."[65]

2. Foreign Workers:

Issue: The US is facing a labor shortage in certain skill areas. Those areas include those upon which the IT industry depends.

Discussion: According to the Information Technology Association of America (ITAA), the IT workforce was over 10.5 million strong in 2004.[66] While US citizens comprise some of the world's top engineers and scientists, many of our IT workers come from foreign nations. These foreign citizens provide significant contributions to the US economy because they often provide unique talents not available in the US. The H1B Visa is the primary immigration tool enabling foreign IT, telecommunications, and engineering professionals to live and work in the US. These visas enable US employers to hire foreign professionals for a specified period. One significant advantage to the H1B Visa category is that the employer need not demonstrate a shortage of qualified American workers, thus avoiding a labor certification process. The terrorist attacks of September 11, 2001 brought about legislation that reduced the number of H1B Visas, restricting the number of foreign IT workers allowed in the US. Since US firms cannot hire enough American workers or immigrants on H1B Visas, the US IT industry increasingly resorts to offshoring to fill workforce requirements.

Recommendations: The US government should work more closely with the private sector to determine the number and skills of foreign workers needed in the US IT industry and revise its visa policy accordingly.

3. Offshoring:

Issue: The US IT industry is turning to offshoring (moving operations overseas) for a variety of reasons. This shift has many ramifications including US job losses (and the resulting political fallout), technology transfer (i.e. Intellectual Property Rights or IPR) concerns, and homeland security issues.

Discussion: Offshoring is the permanent or long-term relocation of operations to lower-cost countries and regions such as India, China, and Central America.[67] Offshoring, especially of higher-paying IT jobs, is a major political issue. While offshoring results in the transfer of jobs overseas, there are obvious advantages for IT firms to include lower operational costs due to lower local wages, availability of a well-educated and skilled workers, and the potential to move operations closer to suppliers and emerging markets.[68]

The Institute for Electrical and Electronics Engineers (IEEE) claims offshoring of high-wage jobs from the US to lower-cost overseas locations is contributing to unemployment among American electrical, electronics, and computer engineers. Although these skills are essential to a strong US IT industry, a study by McKinsey Consulting, shows that 30% of all of the new IT work being generated by US companies is being done overseas[69] and Forrester Research estimates that outsourcing will cost the US 830,000 white-collar tech jobs by 2005.[70]

In addition to the US not developing essential job skills in its IT workforce, some critics are also concerned about the longer-term implications to the US industrial base, national security, and the role of the US as an innovation leader. "Offshoring poses a very serious, long-term challenge to the nation's leadership in technology and innovation, its economic prosperity, and its military and homeland security."[71] A June 2, 2004, Congressional Research Service report addressing outsourcing concerns states that, "An increase in offshore outsourcing of high-tech jobs, including computer programming and chip manufacturing, may enable a transfer of knowledge and technology that may eventually threaten US global technical superiority and undermine current [network-centric warfare] advantages."[72]

These concerns are in direct contrast to other organizations' much more optimistic views. The ITAA claims that by 2008, "Information Technology offshoring annually will account for roughly $125 billion in additional US gross domestic product, a $9 billion jump in real US exports, and, most importantly, 317,000 net new jobs in the United States."[73] Furthermore, the US Bureau of Labor Statistics reported that less than 2% of mass layoffs in the first quarter of 2004 were the result of jobs relocating to a foreign country.[74]

Until the US takes action to increase the output of its educational system in math, science and computer science majors, the US IT industry must rely on immigration or outsourcing to make up for the labor deficit. Outsourcing has become one of the hottest political, business, and IT issues today – one that will remain so for the near future.[75] With the advent of Global Sourcing, US employers must have the freedom to hire, promote, and relocate IT professionals throughout the world. In the end, limiting an IT company's options will undermine US firms' global competitiveness.

Recommendations: It is crucial that US firms compete globally. To that end, the US government should carefully consider any restrictions to offshoring except in areas where the nation must retain security superiority. Additionally, the federal government, collaborating with the IT industry and academia, should ensure US

technological leadership and innovation in the IT industry by developing a national long-term plan to address IT offshoring and America's competitiveness in the global economy.

B. Challenge: Foreign Competition

Issue: US preeminence in the IT marketplace is no longer guaranteed. There are indications in several sectors that reveal the need for the US to take decisive action in order to maintain its current position or regain the global lead. When considering the IT environment, readiness of the community, and usage among stakeholders, the US has fallen from its perch as the number one ranked IT country to fifth in 2004.[76]

Discussion: Last year the Asian and Nordic regions showed the most improvement in their IT standing while Western Europe was a "mixed bag" but with an overall downward trend. The IT industry is moving to a period where the development of ways to access information and utilize applications will surpass the need to update constantly hardware. Given these realities, "the United States must be proactive on innovation, investment, and improving education for American workers in order for US companies to compete successfully in today's global marketplace."[77]

The primary impacts of the current trend toward outsourcing IT software and services on the US economy and national security are the transfer of intellectual property and capability to potential competitors and the loss of US capability in these areas.[78] While there is some disagreement as to whether the current trend of transferring IT software and services to other countries will have an adverse impact on the US economy; there is near unanimous agreement that this trend is increasing the economic prospects of several current and future competitors, and increasing the military capability of some potential adversaries, namely China.

Recommendations: The US government should create a consortium of government and commercial sector professionals to set guidelines for exportable technology with measures to ensure compliance. Additionally, the Director of National Intelligence should address the sale of CI to foreign entities.

C. Challenge: Critical Information Infrastructure Protection (CIIP)

Issue: The US relies on various infrastructures (transportation, energy, financial, and communication) that are increasingly dependent on networked information systems for their continued operation.[79] The protection of our critical information infrastructure has national security and economic implications.

Discussion: Fifteen years ago, the Computer Science and Telecommunications Board noted that computer systems "control power delivery, communications, aviation, and financial services."[80] Little, however, was done to protect our critical infrastructures until President Clinton signed Executive Order 13010, "Critical Infrastructure Protection," in 1996 to establish an interagency commission (the President's Commission on Critical Infrastructure Protection) focused on assessing the

issues and challenges. Of key concern are networked information systems because they are used to control the other infrastructures and these information systems have unique vulnerabilities. In addition to being physically vulnerable to attacks, the US information systems are unable to tolerate environmental disturbances, human user and operator errors, and cyber attacks by hostile parties.[81] Recognizing the need to protect its $60 billion investment in IT, the federal government has placed an emphasis on combating IT crime by prioritizing information security.[82]

The National Cyber Security Partnership Task Force on Technical Standards and Common Criteria released a report in March 2005, recommending strategies to reduce security vulnerabilities through standards-based solutions and enhancements to existing development, deployment, and testing processes. The Task Force report reflects the significant progress that can only be made when industry, government and other security experts work together.[83]

Recommendations: CIIP should be a high priority. The federal government should continue its policy of encouraging partnerships with industry and academia to define and execute critical CIIP measures. The US should develop a next-generation IT infrastructure, with compatible laws and policies, and a broad-based national strategy that develops a trained work force and creates cyber-awareness at all levels of the general population. Lastly, the US government should work with industry and academia to resource a truly comprehensive and effective plan, to include R&D, because recovering from cyber attacks will always be more expensive than preparing for them.[84]

D. Challenge: Heavy Demand for Additional Spectrum

Issue: Spectrum allocation has security and economic impacts. Striking the right balance between public and private sector spectrum allocation is critical for American economic and security success.

Discussion: Recent years have witnessed enormous growth in spectrum-based technologies and uses of wireless voice and data communications systems by businesses, consumers, and government.[85] Spectrum contributes to significant innovation, job creation, and economic growth and is critical to the ability of first responders to react to natural disasters and terrorist attacks. Spectrum is also essential to the military's ability to train its forces and fulfill its mission of protecting our nation. The Federal Government makes extensive use of spectrum for radars, communications, geolocation/navigation, space operations, and other national and homeland security priorities.

In today's era of modern communications, proper allocation of radio frequency spectrum is vital to our nation's economic growth, security, public safety, law enforcement, federal infrastructures, and scientific research. To ensure our spectrum management policies are capable of harnessing the promise of new technologies, yet able to meet our nation's security goals, President George W. Bush established the "Spectrum Policy for the 21st Century – The President's Spectrum Initiative."[86] The goal of the

Initiative is to promote the development and the implementation of a policy that will foster economic growth; ensure our homeland security; maintain U.S. global leadership in communication technology and services; and satisfy other vital U.S. needs in areas such as public safety, scientific research, federal transportation infrastructure, and law enforcement.[87]

The Federal Communications Commission (FCC) and the National Telecommunications and Information Agency (NTIA) are both charged with "managing the nation's radio spectrum resources in the public interest", and must work together "ensure that spectrum policy decisions promote efficient use of the spectrum consistent with both the economic interests and national security of the nation."[88] The NTIA manages spectrum policies for federal government users. The FCC, manages spectrum policy for all other users.

Recommendations: The government should work with the private sector to determine spectrum requirements and auction additional spectrum as needed. Additionally, national security organizations (DoD, DHS, etc.) as well as state and local agencies, must remain actively engaged in the spectrum allocation process, leveraging the newly created Federal Government Spectrum Task Force, to ensure critical national security resources are not sacrificed simply to meet the growing spectrum demands of the commercial telecommunications sector.

E. Challenge: Interoperability and Interconnectivity

Issue: The execution of the US National Security Strategy (NSS) and America's ability to succeed in today's global business environment depend on its ability to effectively and efficiently manipulate and process information. One of the primary challenges in today's information revolution is how to achieve information system interoperability and interconnectedness to produce actionable information.

Discussion: President George W. Bush voiced concerns that affordable high-speed Internet access must be available across the US. Today's bandwidth, however, is insufficient for future requirements, analogous to the plight of rural residents of the 1930's when rural electrification was being discussed as part of the New Deal. A disjointed national strategy and subsequent policies are the most significant broadband issues facing the US today.

Significant advances in IT offer the government a tremendous opportunity for reengineering inter-agency and intra-agency information processes and implementing the technical infrastructure and systems technology to execute processes more effectively and efficiently.[89]

Recommendations: An overarching Presidential policy initiative, similar to the "Spectrum Policy for the 21st Century", should be implemented to coordinate a strategic network centric framework and infrastructure.

F. Challenge: Research and Development (R&D)

Issue: Historically, the R&D funding model for the US has seen the government provide robust R&D funding for military and space applications, and then the commercial sector apply this knowledge to produce commercial products. However, as the Cold War ended, we saw elected official decrease government R&D investments to fund other programs and business executives reduce R&D funding to improve their bottom line. This collective drop in R&D investment may have significant economic and national security impacts.

Discussion: The government considers certain R&D areas important; however, the combination of finite resources and the multitude of research opportunities require a prioritized approach. The updated R&D budget priorities reflect an extensive, continuous process of consultation with the President's Council of Advisors and collaboration with the interagency National Science and Technology Council.[90] Homeland Security R&D continues to be among the highest of the national priorities with an emphasis on applied technologies to address our Nation's ability to prevent, detect, treat, remediate, and attribute acts of terrorism.[91]

As corporations continue to watch the bottom line, the pressure has led to a reduction of corporate R&D spending. The long-term impacts of this reduction will be a loss of competitive advantage as other countries invest more in R&D. US corporations face the continuing unknown factor of the temporary annual R&D tax credit. Since this tax credit is temporary, corporations cannot figure it into their long-term plans and causes robust R&D investment becomes a risky proposition.

Unfortunately, the R&D tax credit is set to expire for the 12th time on December 31, 2005. While the tax credit intends to maximize private sector investment in US research, its repetitive, limited extensions have made it difficult for the tax credit to fulfill effectively its intended purpose.[92] Corporate research projects generally require five to ten years from planning to completion. The credit must extend consistently through the multi-year effort to be effective. The 1998 Coopers & Lybrand study highlights this requirement. It estimates, "US companies would spend an additional $41 billion (1998 dollars) on R&D during the period 1998-2010 as the result of permanently extending the credit. Additional R&D spending will raise productivity, adding more than $13 billion/year to the economies productive capacity by 2010 and generating a 31% annual rate of return to invested R&D."[93]

Recommendations: The government should incentivize commercial R&D investments by making the R&D tax credit permanent. A permanent and enhanced R&D tax credit policy is essential to the long-term health of the US economy and vital to the inherently research-intensive IT industry. It should also encourage international cooperation with our allies to cost-share the R&D burden.

G. Challenge: Innovative Leadership. To maintain global IT leadership, the US industry requires innovative leadership in many sectors. The following paragraphs discuss two important cutting-edge areas where progressive, visionary leadership is required to ensure the US leads in these promising frontiers.

1. Nanotechnology:

Issue: Nanotechnology promises to be one of the next great technological breakthroughs with significant economic impacts. The country that is first to bring this new technology to market will have a significant global comparative advantage.

Discussion: Nanotechnology is a rapidly growing field of science and engineering that involves the control and manipulation of matter on the atomic and molecular levels. Typically, nanotechnology refers to working on a scale less than 100 nanometers, where a nanometer is 10^{-9} meters (one billionth of a meter)[94]. A human hair, for instance, is approximately 100,000 nm wide. Innovations in nanotechnology have broad applications in the healthcare, manufacturing, materials, and electronics industries.

While modest efforts have been on going since the mid 1980's, it has only been in the last five years that the field of nanotechnology has exploded and shown great promise.[95] For the IT industry, nanotechnology holds the promise of significantly higher density memory devices, greatly miniaturized computers and a host of other applications.

The US has established a federally funded R&D program called the National Nanotechnology Initiative (NNI). Funding from the NNI, plus separate DoD nanotechnology efforts, accounts for almost two-thirds of all US nanotechnology spending. The US National Nanotechnology Initiative (NNI) has estimated that the global market for nano-based products will grow to $1 trillion within the next 10 years.[96] Computer chips based on nanotechnology have the promise to potentially increase computing power and reduce size by potentially orders of magnitude.[97]

The success of US universities and industries in developing leading edge nanotechnology solutions is critical to the economic future of our country. Further, the promise of nanotechnology in military related applications is also vital to our national security. The US cannot afford to be anything but the world leader in this critical technology.

Recommendations: The government should double the NNI budget within the next fiscal year and double the DoD programs funding nanotech R&D. Additionally, a joint NNI-DoD working group should be established to ensure proper sharing of data and information and to prevent unnecessary duplication of efforts.

2. Quantum Computing:

Issue: Although still largely experimental in nature, quantum computers offer the promise of significantly improved performance over classical computing methods.[98] The country that leads in this technology will have a significant comparative advantage in the global market.

Discussion: Quantum computing represents a completely new way of processing information. Unlike conventional digital computers that process information according to "1's" and "0's", the secret to quantum computing lies in the

realm of theoretical physics. The fundamental unit in a quantum computer is a quantum bit or qubit. Unlike its binary counterpart in classical computers, the qubit logical state can be one of four possibilities: 1, 0, or simultaneously 1 and 0.[99] Though not intuitive, except possibly to a quantum physicist, this concept allows for massive parallel computations achieved through the superposition of qubit states.[100] In simpler terms, a quantum computer will be able to perform certain types of calculations billions times faster that today's silicon-based computers.[101]

Quantum computing R&D is still in its infancy. Experiments to date have confirmed the basic theoretical underpinnings of quantum computing. However, the most advanced quantum computer built can manipulate only seven qubits. To overtake conventional computing, the ability to process several hundred qubits will be required.[102] To achieve its full potential, quantum computers will require advances in the development of control systems (error correction) and quantum communication protocols.[103]

The most talked about application for quantum computing is factoring very large numbers in a matter of seconds. When this becomes reality, all encryption codes (e.g. RSA) will be easily broken as these codes rely on the relative inability of current computers to factor large numbers into their primes in any reasonable period.[104] However, on a positive note, quantum computing also provides the potential for a theoretically unbreakable communication system.[105]

Recommendations: The government should create a government, commercial, and academic consortium to provide resources and information sharing capabilities in this area.

H. Challenge: Intellectual Property Rights (IPR) Enforcement.

Issue: The US has invested billions of dollars in R&D to produce its IT intellectual property and it, therefore, stands to lose its investment as other nations ignore IPR laws.

Discussion: The US loses billions of dollars in the international market each year as other nations ignore Intellectual Property Rights laws. Although these nations benefit in the short term from their actions, over the long haul enforcement is important for any nation that wishes to do business in the global community. The World Trade Organization requires nations to enforce IPR if they wish to be a member, and the US requires strict IPR enforcement for any country that wants to enter into a free trade agreement. Additionally, foreign investment will not be forthcoming to nations who do not protect the considerable R&D investments of other nations. Nevertheless, poorer countries see it in their best interests to ignore the IPR issues as they strive to create industries and jobs for their people.

Recommendation: The US should work with international organizations to apply pressure on nations that do not abide by IPR laws. This fight should be waged in the political realm, the commercial sectors, and in the various court systems.

CONCLUSION: Over the past five months, the fifteen members of this seminar studied the IT industry to ascertain its ability to support the US National Security Strategy. Using seminar discussion and visits with domestic and international officials, trade associations, industry representatives, Chief Executive Officers, Chief Security Officers, and government officials, to include a member of the Japanese Diet, this seminar observed first hand the conditions of the IT industry. A complex and ubiquitous industry, IT influences, affects, and enables all of the instruments of power: diplomatic, informational, military, and economic. The availability of inexpensive and readily available IT is the major force driving the globalization of world economies and industries, embedding IT into all aspects of our lives. This pervasiveness of IT, however, has caused many problems and concerns relating to the protection of our most critical infrastructure and personal information.

The US IT industry, while still the world-leader, is slowly losing ground to IT industries in other nations. This has significant implications for the IT industry's ability to support US national objectives. As a crucial element of US Government and DoD transformation efforts, the US IT industry must overcome several challenges if it is to retain its lead in the world market. In this seminar's opinion, the most noteworthy challenges and specific policy recommendations to overcome those challenges are:

Education: While the US is not producing enough math and science majors to support US IT workforce requirements, the governments of the countries visited place a high priority on developing education systems tailored to support their IT industries. Fueling the low production in the US is the overall decline in America's math and science education systems and the waning interest of America's youth in math and science. Of the four countries visited, China has the most aggressive math and science education program, while Singapore is attracting students who would have previously studied in the US but are unable to do so in our post-911 security posture. Japan is facing a demographic challenge with an aging population that stresses their entitlement programs, potentially reducing education resources.

Recommendations: The future of the IT industry depends on America's ability to inspire learning and innovation in its future generations. Federal and local governments must inspire America's youth with a challenge and establish a national goal toward which they can strive, similar to President Kennedy's challenge to put a man on the moon in the early 1960's. A coordinated effort between the private sector, academia, and government organizations will ensure America's children develop the necessary skills.

Visa Restrictions: The US is facing a labor shortage in certain skill areas, to include those areas upon which the IT industry depends. While US citizens comprise some of the world's top engineers and scientists, many US IT workers come from foreign nations. These foreign citizens provide significant contributions to the US economy because they often provide unique talents and services. However, the September 11th terrorist attacks brought about legislation that reduced the number of H1B visas, restricting the number of foreign IT workers allowed in the US. Universities and IT companies in China, Thailand, and Singapore are profiting from the reluctance of US policy makers to eliminate the visa restrictions. While the best and brightest students from these countries used to study at

US universities, more are now choosing to attend universities in their own countries. Singapore, in fact, is opening up its education system to foreign students, attracting many students from Australia and Europe who previously would have attended US universities.

Recommendations: The US government should work with the private sector to determine the number and skills of foreign workers needed in the US IT industry and revise its Visa policy accordingly. The US Congress should also readdress its restrictions on student visas.

Intellectual Property Rights (IPR): All four countries visited are struggling with issues relating to IPR. Singapore and Japan have the most stringent IPR regulations and have been the most successful in enforcing the rules. However, the US loses billions in the international market each year as other nations ignore IPR laws. Although these nations benefit in the short term from their actions, over the long haul enforcement is important for any nation that wishes to do business in the global community. The WTO requires nations to enforce these rights if they wish to be a member and the US requires strict IPR enforcement for any country that wants to enter into a free trade agreement with the US. Additionally, foreign investment will not be forthcoming to nations who do not protect the considerable R&D investments of other nations. However, poorer countries see it in their best interests to ignore the IPR issues as they strive to create industries and create jobs for their people so the IPR war rages on.

Recommendations: The US must continue to work with international organizations to apply pressure on nations that do not abide by IPR laws.

The US government must aggressively work with the private sector to answer growing foreign competition challenges and undertake initiatives to ensure the US remains the worlds' leader in IT innovation and competitiveness. In our estimation, the US IT Industry is well positioned today to support the National Security Strategy. This situation, however, could very easily, very quickly, and very realistically change if national policy makers do not address the challenges outlines in this study.

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