ELECTRONICS INDUSTRY

ABSTRACT: The electronics industry is center stage in today's transforming and globalized market. As such, improving and even accelerating high-technology innovation, while ensuring its propriety, will be instrumental if the United States is to maintain its competitive advantage for continued economic prosperity and indispensable national security. Managing the electronics industry by government heavy-handedness is futile. The answer lies with creative and cooperative measures by government and the business sector. Challenges and opportunities exist in developing innovative human capital, keeping critical design and manufacturing thriving in the United States, altering defense electronic acquisition, modifying government policies, and enhancing and leveraging basic research.

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Virginia Semiconductors, Fredericksburg, VA
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AAI, Baltimore, MD
Sensytech, Newington, VA
Fairchild Industries, Frederick, MD
BAE North America, Manassas, VA
L-3 Electronics, San Carlos, CA
Advanced Microcomputer Devices, Sunnyvale, CA
National Semiconductor, Santa Clara, CA
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Savi, Sunnyvale, CA
Merit/Sensor, Santa Clara, CA
Analog Devices, Sunnyvale, CA
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International:
Aselsan, Macunköy-Ankara, Turkey
Havelsan-Aydin Aerospace Electronic Industry, Ankara, Turkey
Turkish Aerospace Industries Incorporated, Ankara, Turkey
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MEMSCAP, Oslo, Norway
SSPR, Oslo, Norway
NERA, Bergen, Norway
Kongsberg Defence and Aerospace, Kongsberg, Norway

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ABSTRACT: (60-100 words that detail the bottom line conclusions of the report)¶
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INTRODUCTION

The Electronics Industry Study focused its research on the semiconductor industry and its associated activities to gauge the state of the defense electronic industries and their ability to support the United States national security objectives during peacetime and war. Although the semiconductor is a commodity in today's market place, it remains the critical component of the commercial and defense electronic industries. The confidence, availability and health of the semiconductor market serves as an indicator of the ability of the United States to sustain economic growth, maintain competitive advantage and dominate the technological warfighting advantage over our adversaries.

The defense applications of electronics constitute a relatively small portion of the overall electronics industry. However, electronics applications within the Department of Defense (DoD) are critical to current capabilities and the transforming of the armed forces. This means that while DoD cannot assure the health of the electronics industry as a whole, DoD must ensure that defense applications are not put at risk by adverse electronics industry trends or arbitrary policy decisions, and must be vigilant in watching for opportunities that positive trends may herald. Risks as used here include both vulnerabilities within the electronics industry that may limit United States defensive and security capabilities and the proliferation of electronic technologies potentially able to nullify US defensive and security superiority.

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In the course of our studies, the electronics industry seminar visited semiconductor manufacturing, commercial electronics, and defense electronics companies; industry associations; and domestic and foreign military entities in the United States, Turkey and Norway. We met with small niche businesses as well as industry leaders to gain their insights and perspectives into the current condition, challenges, and future of both semiconductor and associated activities and defense electronics industrial capabilities.

This paper defines the industry, current conditions, challenges and the outlook for the electronics industry. Five key areas are discussed in detail, which include research and development, trust and availability of semiconductors for United States defense and security, human capital/resource issues, government policy impacts and organization of the defense industry.

Generally, the seminar is optimistic about the electronics industry and its ability to support US National Security interests. That being said, the industry is transforming and DoD is now an electronics market follower instead of the market leader it once was. This creates challenges for both the DoD and defense electronic industry.

Accordingly, this industry study was focused on the following question: Are there trends affecting the electronics industry that pose risks or opportunities for the national security strategy of the United States?

INDUSTRY DEFINED

Background

As the United States adapts to the many economic, diplomatic, and military challenges of globalization and world instability, our use of information technology is vital to assure continuing prosperity and security. A key reason for our dominance in the "cyber economy" has been the exceptional technological contributions of the semiconductor industry. This unrivaled military capability relies heavily on technology. "Semiconductors play a crucial role in ensuring our national security by allowing advances in the capabilities of new devices and new applications for national defense."[i] The industry centers on integration by "cramming millions of transistors and circuits onto increasingly dense chips. Each new generation of circuitry enables cheaper, if volume is substantial, better performing products."[ii] Today's devices are based on the metal oxide semiconductor field effect transistor (MOSFET), which consists of source and drain electrodes through which current can flow, and a gate electrode, which controls the current through the other two. Still matching Moore's contention of doubling the density of transistors in the semiconductors every 18 months, transistor designers continue to shrink the distance between the source and drain.

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Semiconductor and Defense Electronics

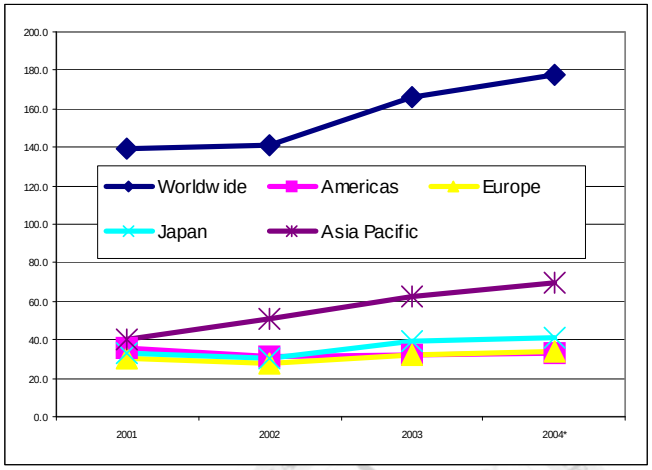
The current method of producing packaged integrated circuits is an expensive, complex, technology-driven endeavor. The sophisticated manufacturing process typically consists of hundreds of steps, during which many copies of an integrated circuit are formed on a single silicon wafer. The advances in manufacturing that have driven improvements in chip performance have also led to dramatic increases in the cost of new fabrication facilities (also know as fabs). It now takes about $2.5 to $3 billion to build a new "state of the art" plant.[iii] The huge cost of building semiconductor plants has resulted in a new business model – the foundry. Foundries provide relatively low cost, "mass production" of integrated circuits designed by someone else (mostly in the United States). Many new fabs are being built overseas in places like Ireland, Taiwan and China.

The semiconductor industry supplies microchips primarily to the computing (54%), telecommunication (26%), consumer (14%), automobile (5%) and military markets (<1%). The military's demand makes up approximately three tenths of one percent of the end-use market. That being said the dollar value of the defense contribution is still significant and has remained practically constant through the life of the industry. For the purposes of this study, the electronics industry that integrates semiconductors into defense related products is what we refer to as the defense electronics industry.

CURRENT SEMICONDUCTOR CONDITIONS

As seen in the below graph[iv], significant sales trends include relatively flat sales by the Americas, Europe, and Japan and sustained growth by Asia Pacific and Worldwide. Note: Sales are estimated based on January and February 2004 data; given trends in the news, this estimate is likely low.

Trends in Sales/Shipments (USD, Billions)



Subsidies, Quotas, Trade Restrictions, Calls for Protection

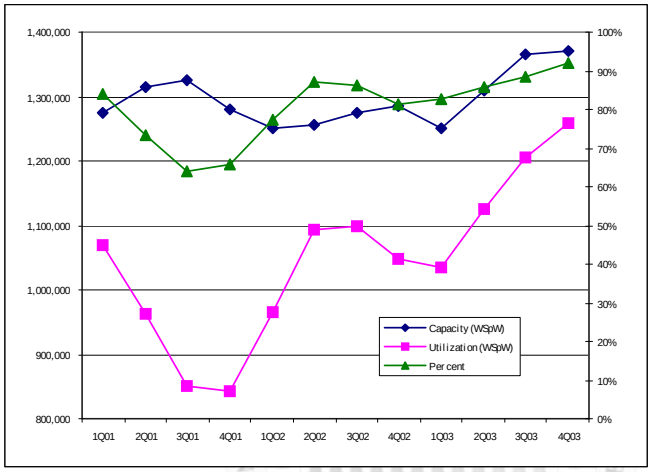
This subject area is dominated by concerns about market trends and policies in East Asia. A white paper by Senator Joseph Lieberman stated it succinctly: "East Asian countries are leveraging market forces through their national trade and industrial policies to drive a migration of semiconductor manufacturing to that region, particularly China."[v] An industry association that tracks these trends lists China's policies as: Value added taxes reduced from 17% to 3% for domestically sold semiconductors, five years without taxes, five years after that with a 50% reduction in taxes, establishment of seven government funded industrial bases, establishment of eight government funded training bases, free land for manufacturing facilities, and duty free treatment for manufacturing equipment imports.[vi] Senator Lieberman's white paper concludes by calling for the following actions: enforce General Agreement on Tariffs and Trade (GATT) rules with respect to subsidies and currency pegging; allow joint production agreements between companies; encourage tax incentives for US investment; increase the number of science and engineering graduates; increase federal funds for research and development; fund government-industry cooperative research programs; and support a semiconductor equipment and materials industry research consortium to maintain US mask-making capabilities.[vii]

A review of these trends and foreign policies by a prominent academic organization suggests the following: Establish three-way partnerships among industry, academia, and government; sponsor more initiatives that encourage collaboration between universities and industry; generate research interest in solutions to impending

and current industry problems; establish more incentive programs in order to address the undersupply of talented workers and graduate students in the industry; and augment federal support for programs to encourage research in semiconductors and attract professors and graduate students.[viii]

As seen in the graph below[ix], data on Wafer Starts per Week (WSpW) show that while capacity has been undergoing significant fluctuations, the trend since first quarter of 2002 has been a steady increase in percent utilization to above 90% of available capacity. Note that while this data set only goes through 2003, based on comments from our company visits, this trend likely continues through the present for both capacity and utilization.

Trends in Domestic and International Productivity (Units)



Industry International Competitiveness

Within the context of the electronics industry, if not most industries today, import and export ratios are no longer a viable metric. During the course of being manufactured, the components comprising finished consumer electronic end-items are exported and imported too many times for such ratios to have meaning. For example, a semiconductor design created in the United States is likely to be exported to Taiwan for production, followed by export to Malaysia for assembly, followed by export to Thailand for packaging, followed by export to China for incorporation into larger end-items, followed by multiple imports into the US or stay in China, where there is a growing consumer base.

Industry Profitability

The electronics industry is cyclical. Up to and including the first quarter of 2002, the electronics industry has been on the down portion of the most recent cycle. From the first quarter of 1999 through the first quarter of 2002, "The cumulative profit over the last 13 quarters is zero."[x] At the time of this report, industry profit data for 2002 and 2003

could not be ascertained, but, based on the capacity-utilization graph on the previous page, the industry is now on the up portion of the next cycle.

Impact of Information Technology

The performance increases and cost reductions achieved by the electronics industry have enabled the explosion in information technology. This in turn has enabled every industry, including the electronics industry, to achieve major increases in productivity.

Productive Capacity Impact of Outsourcing

Within the electronics industry, there are three business models: Vertically integrated, partially outsourced, and fully outsourced. The distinction between these models is the amount, if any, of outsourcing. In 2003, 15% of all integrated circuit revenue was from outsourced operations; by 2010, this will climb to 35%.[xi] While most of this outsourcing is companies using independent fabrication foundries ("fabs") to augment their in-house fabs or in-lieu-of owning in-house fabs, we also encountered companies who outsourced their design, assembly, and/or packaging operations. This outsourcing trend in the electronics industry is being driven by the enormous and growing cost of new fabs ($2.5-3 billion[xii]) and the per-chip cost reductions enabled by the newest fabs (5 times the chips at 1.8 times the cost[xiii]). Only the largest semiconductor companies can afford these expensive new fabs. The remainder of the industry cannot compete unless they have access to the newest fabs. Independent fabs provide that access.

CHALLENGES

The United States industrial complex, Department of Defense, Congress, are all faced with the current challenges of how to act and react in an information age that is becoming more uncertain and more globalized. The semiconductor industry is perhaps the leader in globalized industrialization. Innovators, producers, suppliers, markets and users of semiconductors truly span the entire globe and with this interdependence, new challenges confront the United States. Capturing market share in the semiconductor industry is still key. Competitive advantage was in the design, construction, packaging and selling of microchips, but now the paradigm has changed. Competitive advantage for semiconductors rests in the innovation, design and marketing of this technology, not necessarily in the production and packaging end of this now accepted commodity product. The key dimension to US competitive advantage has been the innovation and entrepreneurship brought to the semiconductor industry. The challenges we face are how to keep and maintain our innovative competitive advantage. Developing new technologies, new ideas and bridging basic knowledge into applied knowledge is critical. Consider the following challenges (many discussed in detail within subsequent essays) as perhaps the most important to address for both the short and long term:

- The remarkable scientific progress that has helped to define 20th century America is due in no small part to the unique characteristics of our basic research and development (R&D). At the peak of federally supported R&D expenditures around the mid-1960's, the government provided up to 68% of the

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allotted revenues. Now 40 years later, the government is investing in R&D at the mean low mark of 26% - a 42% decline. Regarding defense related investment, the government subsidizes 14% of the total expenditure, also down 42%. Even though non-federal support has increased to ensure an overall growth of about 5.8% per year these last few years, all of that growth has been towards other sectors, such as health. Industry has taken up the burden for conducting R&D, but in doing so, the emphasis has shifted from basic research and defense research to mainly that of applied research and consumer product development.[xiv] Turning away from basic, or "preemptive" research, that created and introduced to the world the life changing discoveries like the Global Positioning Satellite and the Internet, is a potentially huge loss for the US.

- The education system and the attracting, developing, producing and continuing to educate skilled engineers and scientists are issues for the United States and the Defense Department, if we are to maintain our competitive technological edge. US universities produce "barely enough" engineers, with the majority of advanced engineering degrees (42% masters and 52% doctoral) going to foreign students who now are tending to return to their own countries due to improving opportunities and lack of H-1B visas. Concurrently, universities in China produce six times the number of engineers than the US. The challenge will be to grow the US engineering talent pool while also ensuring attractive job opportunities in this new globalized economy.
- The emergence of large system integrators presents acquisition challenges. When the defense industry consolidated and mergers took place, the government offered up its system integrator position to industrial defense giants. These remaining defense industries restrict access to government contracts by smaller innovative firms, limit competition, and increase costs in defense electronics acquisitions. Although one-stop shopping is intact and technological burdens from government contracting officers are relieved to some degree, the best value and best technology may not be truly realized by the DoD.
- Trust and availability are key issues for DoD. Trust refers to the desire to have "nothing more or nothing less" in the semiconductors that are purchased. Also, whether availability of critical semiconductors will be maintained or overseas foundries will limit their distribution because of political or even environmental challenges.
- A combination of market forces, government policies, and foreign competition are shifting domestic production overseas. Foreign governments have implemented attractive initiatives to lure US electronics manufacturers offshore. They offer financial incentives, tax subsides, and lenient operating regulations to attract foreign capital and skilled workers. Issues such as the Buy American Act, Anti-Trust Laws, Export Controls, taxation, FMS improvements, etc. are examined in an included essay. A challenge for the US government will be to determine what, if any, intervention is needed to encourage companies to maintain domestic facilities.
- China and other countries are indeed a concern. Democratization of China's information technology, semiconductor business and financial markets is indeed in play. Markets abound in China, if free and fair access is permitted; however,

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China is positioning itself to dominate and eventually place itself into a monopolistic position concerning the electronics industry. Capital is plenty and subsidies encourage growth and production.

OUTLOOK

Short-Term (2005-2015) Outlook and Supporting Factors

During this period, some nations may catch up, but no one is likely to surpass the US with respect to state-of-the-art design and fabrication of semiconductors and related products. This assessment is based on (1) all US semiconductor firms visited indicated that they intend to maintain some or all design work in the US; and (2) most large US semiconductor firms have already started or announced plans to build at least one state-of-the-art next generation fab in the US.

Long-Term (2015-2025) Outlook and Supporting Factors

During this period, **some nations may surpass the US** with respect to state-of-the-art design and fabrication of semiconductors and related products. This assessment is based on the overseas migration trend for fabs coupled with foreign government funding and education incentives. Such market trends and government policies, if left unchecked or unmatched in the US, may allow foreign semiconductor firms to surpass the US in semiconductor research and development.

Political and/or Social Factors Impacting Short and Long-Term Outlooks

Foreign governments want the economic and military benefits of having their own semiconductor design and fabrication capabilities.

Positioning to Maintain a Preeminent Position in the Global Marketplace

US firms recognize that continuous innovation via R&D constitutes their competitive advantage in this industry. If foreign government incentives remain unchecked and unmatched, US firms may be forced to move even research and develop and design overseas to remain competitive.

Adequacy of the Industry's Response to the Previously Detailed Challenges

US industry cannot solve this alone. As long as foreign governments distort what should be a level playing field, US industry will need the US government to take actions to level the playing field. Various semiconductor associations continue to seek this assistance from the US government.

National Security Resource Requirements Supportability, Surge, & Mobilization

Because DoD requirements constitute an extremely small fraction of the worldwide or even the US semiconductor design and fabrication capabilities, short-term supportability, surge, or mobilization problems are unlikely. In the long-term, there is a potential for such problems if the overseas migration trend of semiconductor industry continues to the point where the state-of-the-art in design and/or fabrication moves overseas. Even then, such problems are likely to emerge only if these capabilities are concentrated in countries likely to oppose US interests.

GOVERNMENT: GOALS AND ROLE

Introduction

The semiconductor and defense electronics industries have taken new shape as indicated in previous sections. The semiconductor has become a commodity. Manufacturing has followed the path of assembly, testing and packaging of the semiconductor and other electronic products—shipped offshore. Other countries perform these laborious duties for reasons of profits and productivity for US businesses and their shareholders. One country may research and develop, another country designs the application, another manufactures the subassemblies, another assembles and tests and still another packages it. The economic, trade and labor models have drastically changed from the industrial age where products were almost wholly conceived, developed and produced in one country, then shipped to neighboring countries. Under this new era of a global economy, what are the roles and goals of the United States government?

Goals And Strategy

Many in the United States government embrace the notion that we are in a new era of global economic growth, and their goal is to embrace this new era. Specifically, that the United States and other countries need to leverage free markets and free trade. The National Security Strategy of the United States of America, September 2002, states, "A strong world economy enhances our national security by advancing prosperity and freedom in the rest of the world. Economic growth supported by free trade and free markets creates new jobs and higher incomes. It allows people to lift their lives out of poverty, spurs economic and legal reform, and the fight against corruption, and it reinforces the habits of liberty." Further, "market economies, not command-and-control economies with the heavy hand of government, are the best way to promote prosperity and reduce poverty. Policies that further strengthen market incentives and market institutions are relevant for all economies—industrialized countries, emerging markets, and the developing world."

Globalization: US Response And Roles

This new era of globalization (open, free exchange) is unstoppable and inevitable, but there is a role for governments. The benefits of globalization depend upon many things. First, the enforcement of fair-trading practices is paramount. These safeguards help ensure that the benefits of free trade do not come at the expense of workers, businesses or governments. Workers and businesses need to adapt to the change and dynamism of open markets, and in some instances governments made may need to lend a "short-term" helping hand. The United States government will need to economically engage with other countries to underscore the benefits of policies that generate higher productivity and sustained economic growth, but also create policy within the United States that does the same. Specifically, we need to review and revise their tax policies, fiscal policies, capital investment, defense acquisition organizational construct, investment in basic research and the education of those entering and those already in the electronic industry labor force. Later in this paper, we will provide specific recommendations to improve these areas.

ESSAY: IMPLICATIONS FOR CHANGING PRODUCTION BASE

Introduction

In 2003, the semiconductor industry will manufacture about 90 million transistors for every man, woman, and child on Earth, and by 2010, this number is expected to be 1 billion transistors.[xv] This bit of information illustrates how semiconductors have become an integral part of our everyday life. More importantly for the Department of Defense, our ability to continue to produce the highest technology semiconductors for defense purposes is paramount to our assured national security. Currently, the effects of globalization combined with semiconductors becoming a commodity product in their own right make it hard to develop and produce technology intended solely for proprietary use, such as in defense applications.

This section will briefly examine the basis of competition and performance in the semiconductor industry, with a focus on the trend of foundries-for-hire, especially overseas fabrication of semiconductors and the risk of technology transfer. It is important to discuss what the US must do to insure we maintain a viable semiconductor availability that supports our critical, low volume military unique requirements for semiconductors. Lastly, issues of trust within the scope of defense industry, including challenges faced in designing and producing low volume high technology weapon systems as well as supporting equally low volume, legacy weapon systems, will be examined.

Bases Of Competition and Performance

The US semiconductor industry accounted for 48% of the 2003 world market, with sales of approximately $80 billion dollars.[xvi] Over the years, as semiconductors have become an integral part of everyday life, the semiconductor industry has transformed from being almost exclusively captive manufactures to a majority being fabless manufactures. In this latter category American chipmakers do the majority of their high wage, high value added work here—design and research and development--in the United States, only to contract the manufacture to the foundries-for-hire. They face a serious challenge as foreign governments around the world are initiating policies to attract semiconductor fabrication facilities.[xvii] In the long run, use of offshore fabrication will undermine America's ability to source trusted, unique semiconductors required for military use.

Defense Industry

There are significant implications and potential repercussions for our national security resting in the decisions made by the US semiconductor industry. As mentioned earlier, since 1947, the semiconductor industry has evolved and transformed from a few highly vertical and fully integrated companies to a very large number of specialized companies and a disintegrated and modular value chain. During this same period, the US defense industry went from being originally the driver for semiconductor and computer technologies to mostly a technology follower over recent decades.[xviii] For example, the defense industry accounted for 100% of the US integrated circuit market in 1962, but had dropped to 4-6% by 1995.[xix] What are the implications of the ongoing transformation of the semiconductor industry to the defense industry?

Implications & Availability Issues Resulting From Industry Transformation

The implications for the defense industry concerning the transformation from captive to fabless manufacturers are two-fold. First, the maintenance of legacy systems becomes a serious challenge as once state-of-art devices in military equipment become obsolete and are no longer available and inventories of these devices are gone. The choices in this case are to either reengineer the device by accepting a more current commercial-off-the-shelf semiconductor or to find a company and foundry that is able to reverse engineer the obsolete device and make it anew. Foundries-for-hire are not an answer in this case as they focus on mass production of state-of-art devices for commercial uses. While there are a few companies that specialize in manufacturing obsolete semiconductors, often the costs involved in reverse-engineering obsolete devices far exceed the costs of adapting commercial off the shelf devices or engineering new products all together. The problem with trying to reverse-engineer devices is finding the specification/source control drawings specifications. Another problem is that the volumes of devices required rarely justify the costs of keeping the old technology alive.

Second, the defense industry has a serious challenge in finding "trusted" sources of manufacture for their most technological advanced semiconductor devices. Unless the defense contractor has the ability, financial resources, and human capital to operate and keep a foundry current in technology and in operation, it will have to default to commercial-off-the-shelf devices or try to find another trusted agent in the industry that has a foundry that can do the job. Only the very largest defense contractors would be able to fund the foundries required to produce the required state-of-art semiconductors designed specifically for innovative weapons systems. The low volume of production combined with extremely high cost of making the most advanced semiconductors will place a tremendous challenge before the defense industry in maintaining our country's edge in weapon systems in the future.

Offshore Fabrication: Challenges, Risks and Trust

The risks to the US defense industry in maintaining innovative technology in weapons systems come from three areas. The first risk is in the potential of technology transfer to foreign governments. A second area of concern is trust in the reliability of foreign made devices as well as availability of replacement spares and parts during times of conflict. Can the defense industry be assured of the reliability and quality of devices it receives from foreign sources? Is the device received actually what was designed and fabricated without intentional bugs, flaws, and other potential problems? The third concern is from obsolescence of system repair parts, whether manufactured in the US or offshore, and the ability to find trusted sources to make replacement parts once inventories are gone. **- By COL Ray Regner, USMC**

ESSAY: HUMAN CAPITAL CHALLENGES

Introduction

The electronics industry has had a dramatic impact on our society, and the invention of semiconductors enabled the leap into the information age. The semiconductor industry has provided the foundation for a range of technological

innovations, and the continuous development and fabrication of more capable semiconductors is now considered the main source for global economic growth. The basic challenge of a globalized economy to the US is the requirement to adjust and compete in a rapidly changing environment. Central to the effort to remain competitive is the preparation of a productive, competent, motivated, and reliable workforce. As electronics is used in ever more products, the demand for a US workforce capable of further innovation and development is increasing[xx], and it is in this environment the semiconductor industry has to compete for the most skilled engineers and scientists. This means the focus must begin in the elementary schools and continue until college. It will come at a big price tag and early commitment is important to prepare a technical workforce, which ensures that technology continues to be our competitive advantage and the source for a superior military.

Current State

The U.S. has seen a waning interest and performance among elementary and secondary level students in math related subjects, with a subsequent shortage of US students in engineering and science courses in colleges and universities.[xxi] According to 2001 Engineering Workforce Commission statistics for the US, 7% of Bachelor's degrees, 42% of Master's degrees and 52% of Doctoral degrees were granted to foreign students – primarily of Asian origin. For more than a decade, US graduate schools have depended on a substantial amount of foreign students and faculty for their programs.[xxii] The statistics shows a trend that could lead to less innovation within the US and further weaken the supply of the human capital required for solving the increasing complex technical challenges in the expanding electronics industry of the future. As the semiconductor and electronics industry have become global, countries report and view workforce shortages as the single most important constraint for the future.[xxiii] The need for engineers, mathematicians, and scientist is overwhelming, but the US is falling behind the Asian countries, which now produces six times more engineers than does the US.

Government Policies and Support

Given its positive spillover and the importance of the electronics industry to the economy, the government has to implement programs and allocate the necessary resources. In addition, it is imperative the electronics industry do its part. Both entities collaboration will ensure the interflow of the necessary talent.

The challenge of US human capital to the semiconductor and electronics industry is more than anything else linked to the volume of skilled workers. *The short-term issue*, therefore, becomes mainly a discussion of how to attract the currently available talents to the industry, and how to influence the most talented American students to choose math, engineering or science in colleges and universities. *The long-term challenge* is to ensure that elementary and secondary schools provide a sufficient number of quality students in math and science, thereby increasing the number of US students qualified for college and university level science and engineering courses.

- By BG Kjell Ove Orderud Skare and Mrs. Wanda Jones-Heath

ESSAY: DEFENSE INDUSTRY COMBINING, PARTNERING, & NICHE FOCUSING

Introduction

At the macro-level, the defense electronics industry has responded to the global strategic environment characterized by the collapse of the Soviet Union, military downsizing, globalization with the rapid flow of information and capital, and finally, the Global War on Terrorism (GWOT). From this environment, several trends have emerged in the defense electronics industry: consolidation of the industry, platform integration, "partnering" and the re-emergence of niche players. Unfortunately, this restructuring may lead to less competition, less innovation, and higher cost.

The Structure

The factors driving the consolidation of the defense electronics industry are market forces beginning with the collapse of the Soviet Union and the downsizing of the United States' Armed Forces. In essence, the market got smaller. The consolidation was initiated by the now famous, or infamous, "Last Supper." Secretary Aspin announced that defense spending, which was already on a five-year decrease, would fall much farther and faster. Industry leadership was already taking modest steps to consolidate, but Secretary Aspin urged that the defense industry take aggressive action to consolidate or go bankrupt. Secretary Gansler, noting international competition, wanted to see more "trans-Atlantic Alliances" and was not opposed to foreign ownership of United States' defense firms and warned against "Fortress Europe" and "Fortress America" and protectionism.[xxiv]

In the early 1980's there were 95 significant defense firms and by 1994 there were 53 corporations remaining, a 49 percent reduction. By 2000, the industry was down to six major corporations ("major" as defined by revenues in excess of $6 billion): Lockheed Martin ($23.3b), Boeing ($22.0b) Raytheon ($15.3b), BAE Systems ($15.0b), Northrop Grumman ($12.3b), and General Dynamics ($9.8b). In the twenty years from 1980 to 2000, the United States' defense electronics industrial base sustained a 95 percent reduction in the number of major firms.

In Europe, the consolidation of the defense electronics industry was not as dramatic as in the United States. In late 1980's, there were 16 defense corporations and by 2000, the industry had consolidated down to four significant corporations. The four remaining firms are Thales ($7.7b), Dassault Aviation ($4.42 b), EADS ($6.3b), and BAE Systems. BAE Systems established BAE Systems North American (a U.S. owned subsidiary) to make it more competitive with the United States' defense market. By 2002, BAE Systems ranked as the number four United States defense contractor, with $15.0 billion in revenue. Similarly in 2002, EADS established EADS North America to make it more competitive in the United States' market. EADS North America has revenues over $500 million and employs 2,000 people in the United States.

The United States is the world's largest purchaser of defense goods and services. In 2002, the United States' defense expenditures were $336 billion or 42 percent of the world's defense expenditures. In the 1990's, defense expenditures peaked in 1991 at $320 billion only to remain below $300 billion for the remainder of the decade. The

United States' defense expenditures for 2004 were $455 billion and they are projected to increase over the next five years to a high of $484 billion.[xxv]

The Conduct Of Business

The two most significant events that changed the defense industry concerning the supplier-customer (USG) relationship were the failures of F-20 Tigershark and the A-12 Avenger aircraft. On both programs, the USG changed direction, costing the contractors almost $3.0 billion in losses. By its actions, the USG demonstrated that it was not a reliable customer. The USG highly regulates the industry with the Federal Acquisition Regulations and the market is constrained by political forces and Congressional "power of the purse", specifically, annual appropriations for major weapon system procurements.

The major defense firms have moved to become system integrators. System integration is the production concept where corporations with very high levels of technical expertise and managerial skill assemble the "parts" manufactured by other firms and networks them into a coherent platform. Lockheed Martin is the systems integrator for the Joint Strike Fighter (JSF). They teamed with Northrop Grumman, BAE, General Electric, Pratt & Whitney, and Rolls Royce to integrate the airframe, avionics, propulsion system, hydraulics, and weapons systems to produce the world's most advanced tactical strike fighter aircraft. This concept provides the major defense firms flexibility and frees them from the risk of owning the entire value chain.[xxvi]

Partnering is another major trend in the defense industry. For most new weapons system procurements, firms partner to compete for the contracts. In addition to the JSF partnership, the Marine Corps' MV-22 Osprey is being produced by the Bell Boeing Tilt Rotor Team, and the DD(X) System was awarded to the Northrop Grumman-Raytheon team, including 30 of the nation's top engineering and maritime industrial companies.[xxvii] The advantages of partnering are shared risk and shared reward.

The expanding United States defense budgets, coupled with the major industrial firms acting as system integrators, are providing many medium and small firms "niche" opportunities in the defense market. The JSF, with hundreds of sub-contractors, and the DD(X), with 30 formal sub-contractors, are providing niche opportunities for many. Fairchild Controls Corporation (FCC) for example is a niche player in the defense market. FCC specializes in design engineering, test and evaluation for air-turbine machinery and vapor cycle cooling systems. In the last five years, FCC's defense market has increased by 25 percent. FCC is a sub-contractor to the Army's Apache Program and the Navy's Advanced Targeting Forward Looking Infrared targeting device.[xxviii]

Conclusion

The defense electronics industry has responded to the global strategic environment and market changes with mixed results. The industry responded by consolidating and adopting new business practices which have resulted in a few very large firms and many niche opportunities for the medium and small companies. Competition, innovation, and cost are great challenges for future weapon systems procurements. The USG, industry and allied countries need to work together to find the best possible solutions to keep the defense electronics industry viable for the decades to follow. **- By LtCol Bill Anderson**

ESSAY: R&D, THE LIFEBLOOD OF ELECTRONICS INDUSTRY

Introduction

Research and development (R&D) is the lifeblood of the electronics industry. Staying ahead of competitors is not only good business; it is the only way to survive. Innovation and creativity in research and development have fueled the race to increase processing speed while reducing scale. This in turn has enabled other industries to achieve previously unrealized efficiencies that have propelled quantum improvements in quality of life. Moreover, sustaining the leading edge through aggressive investment in research and development in the electronics industry is essential to sustaining a strong domestic economy; a world-class transformed military, and higher standards of living as the information age pioneers new frontiers. This essay will provide insights concerning the significance of R&D to the electronics industry, frame R&D investment, and describe the significance of R&D in the electronics industry to military transformation.

Significance of R&D to the Electronics Industry

It is hardly a novel concept that the only way to compete in the technology sector is through research and development. Even in these tumultuous times, you can cut people and you can cut budgets, but cut R&D and you are cutting the bloodline of the company. Nowhere is this more accurate than in the electronics sector. [xxix]

Technological innovation characterizes this industry more than most and, in fact, drives much of the industry's production. The rapid pace of innovation in electronics technology produces a constant demand for newer and faster products and applications. This demand puts a greater emphasis on research and development than is typical in most manufacturing operations. Being the first firm to market a better product usually determines the success or failure of the product and, often, the company. Even for many relatively commonplace items, R&D continues to result in better, cheaper products with more desirable features. For example, a company that develops a new kind of chip to be used in many brands of computers can earn millions in sales until a competitor is able to copy the technology or develop a better chip. [xxx] Therefore, significant resources are allocated to continually develop and improve products.

Research and Development – Who pays?

The semiconductor industry invests an average of 15 percent of sales in R&D each year and has invested nearly half a billion dollars in university research over the past two decades. [xxxi] Professional and related personnel account for about 3 out of 10 workers, reflecting the importance of research and development. Many employees are research scientists, engineers, and technicians, whose job is to continually develop and improve products. [xxxii] During 2002, industry continued to lead government in the number of dollars funding R&D with nearly $196 billion, which was an increase of 3.2 percent. [xxxiii] While the total amount was significant, the rate of increase was somewhat less than had been experienced in previous years and is a reflection of the economic factors that emerged in 2001. The economic downturn that was related to the stock market, to cash flow, to discounted interest rates, and to the perception and anticipation of difficult times ahead. All this had an adverse effect upon industry funding of R&D and the distribution of that funding across different performing sectors. Historically,

inflation-adjusted reductions in R&D funding have resulted in periods of retrenchment that have lasted a few years. However, in this case the change in industrial support was primarily a change in growth rate and a period of adjustment. [xxxiv]

Even though the electronics industry invests heavily in R&D, most of the money goes to applied research with commercial applications. [xxxv] As a result, the development of high risk, exploratory research is not resourced to sufficient levels. During the past several years, the government has significantly increased R&D spending. In 2000, expenditures were $78 billon; for 2004, the budget for R&D is expected to reach $117 billion – a 67 % increase. [xxxvi] However, only 22% is allocated to basic research. While renewed emphasis on funding R&D is important, the weighted allocation to applied research is not the best use of limited resources.

This is where the government can most effectively influence research and development. By reallocating government funding programs from applied to basic research, our nation can continue to nurture the creativity and innovation that is a trademark of our country. The consequences of the emphasis on basic research will also provide the underpinnings necessary to advance military technologies.

Enabling Military Transformation

Transformation has become the buzzword within the Department of Defense. Recent conflicts to include Operations Enduring Freedom and Iraqi Freedom, have served to propel the incorporation of human capital, organization, technology and concepts into a force that is transforming under fire. Precision warfare, space-based technology, and advancements in intelligence systems and procedures have enabled commanders to network and integrate joint battlefield operating systems to previously unachieved levels. Much of the required technologies used are based on those within the electronics sector. However, this is only a start. We will continue to face a threat that is non-nodal, more pervasive, and often non-state, non-deterable, and difficult to detect. [xxxvii]

Transformation requires the ability to acquire information and imagery; process information; make decisions; and distribute information over broad areas, at high data rates, on the move, and across all echelons. These capabilities are the enablers of network-centric warfare and effects-based operations. [xxxviii] Advanced technologies are key to the military's ability to continue on the transformation vector.

Several significant trends have developed which will impact the DoD's ability to ensure the development of technologies of operational utility to meet current and future needs.

First, military laboratories have been downsized over several decades. The labs have played a key role in transposing research advances achieved at universities by recognizing their applicability and translating them into military capabilities. Engineers and scientists within the labs have made significant contributions to technologies of little commercial interest, such as high-powered radar, stealth, and reactive armor. Reduced laboratory capabilities will result in reduced military capabilities. [xxxix]

Second, the industrial base shrank and restructured with the end of the Cold War. Through consolidation, the number of prime military contractors was reduced to about five. This limits the competitive base that drives innovation and risk-taking. [xl]

In order to bridge the gap to propel the required technologies, DoD leadership must develop strategies to capitalize on commercial research and development, and ensure that required technologies, which have little commercial utility, are resourced.
– By LTC Stephen Wood, USA

ESSAY: US POLICY IMPACTS TO THE ELECTRONIC INDUSTRY

Introduction

A combination of market forces, government policies, and foreign competition are shifting domestic production oversees. The risk of losing high-tech manufacturing is a national security concern; however, the potential loss of research and development (R&D) is a greater concern that could impact our defense and economic capabilities. The economic and security impact of losing the industry would be severe. Government intervention is needed to encourage companies to maintain domestic facilities, reinvest in future ones, and conduct R&D.

Implications to US National Security and Economy

The electronic industry's trend toward moving manufacturing offshore threatens US national and economic security. Studies show that advanced technology is necessary to provide the US with cutting-edge capabilities for defense requirements.[xli] The principal reason that high-tech companies are moving offshore is that foreign countries are taking advantage of opportunities to capitalize on US deficiencies to support its high-tech industry. In addition, existing laws, regulations, and policies are negatively impacting the US ability to maintain and expand its electronic industry base.[xlii]

Regulations/Laws

US laws and policies decrease domestic capabilities to compete in global markets. These laws/regulations limit the US ability to procure cutting-edge technological solutions, provide products at the lowest cost, and compete to sell high-tech solutions to foreign markets. Examples include:

Buy American Act: Buy America provisions are harming the industry they were supposed to protect. Existing laws and recently drafted bills negatively impact electronic manufacturers' ability to develop new weapon systems at the lowest cost and utilize the latest high-tech components. [xliii]

Anti-Trust Laws: Domestic manufacturers are not investing in new production facilities because of the upfront high investment, high risk, and global competition. Anti-trust laws prohibit companies from consolidating assets to establish jointly owned and operated production facilities.

Export controls: Export controls prevent domestic manufacturers from competing against foreign competitors for items that are considered dual-use technology and sensitive. The US errs on the side of caution when deciding on granting licenses. The procedures are slow and cumbersome and negatively affect domestic manufacturers' capabilities to compete with foreign firms.[xliv]

Foreign Military Sales (FMS): The Foreign Military Sales (FMS) program accounted for $13 billion in sales in FY2003, and is forecasted approximately $13.8

billion in FY 2004.[xlv] The United States Government (USG) benefits from FMS sales in the following ways:

- Lower unit costs from economies of scale,
- Means of recouping research and development (R&D) costs,
- Creates or sustains employment of American defense industry workforce,
- Key production lines will remain open.

However, due to the program's complexity, foreign governments and American defense contractors prefer to conduct business via Direct Commercial Sales (DCS). DCS sales tend to be more profitable, less paperwork, and usually comprise a larger portion of a defense firm's international revenue.[xlvi]

Taxation

Existing tax laws fail to sufficiently incentivize high-tech firms to conduct R&D, invest in new manufacturing facilities, or modernize existing fabrication centers.

Depreciation: Current depreciation methods do not allow domestic electronic manufacturers to utilize accelerated depreciation methods that better reflect their assets' useful life. Therefore, companies have higher taxable income in the initial year of investment when cash is most needed for operating expenses.

R&D Tax Credits: Congress extends R&D tax credits on short-term basis. The "credits are subject to expiration; thus are not as effective as they could be in promoting long-term investments" in R&D.[xlvii]

Stock Options: The US Financial Accounting Standards Board (FASB) is proposing changes that will reduce the attractiveness of stock options in the US[xlviii]. Changes to accounting methods will negatively impact the industry's ability to attract skilled technical personnel, while foreign competition continues to use them and offer favorable compensation packages.

Violation Of World Trade Organizations Agreements

US trade partners are violating World Trade Organization rules by providing indirect subsidies to domestic manufacturers. Value-added tax rebates are luring domestic manufacturers offshore and make it extremely difficult for domestic manufacturers to compete with foreign firms. **– By Mr Brad Williams, Dept of Defense**

CONCLUSIONS AND RECOMMENDATIONS

Arguably, the fundamental question that this paper addressed is whether the United States is losing its technological edge. Through collective research and analysis of the semiconductor sector and examination of the defense electronics industry, we determined that while there are areas for concern, opportunities do exist within this transforming and globalized market. Improving and even accelerating high-technology innovation while ensuring its propriety will be instrumental if the United States to maintain its competitive advantage for continued economic prosperity and indispensable national security. Attempting to control this market or business sector will prove impossible; managing this business sector through improvements with innovation will be key. Challenges and opportunities exist in growing the human capital, keeping

manufacturing thriving in the United States, modifying defense electronics acquisition; modifying government policies, and enhancing basic research. Consider the following recommendations:

Human Capital Recommendations

The answer for human capital lies with creative and cooperative measures by academia, government and the business sector. It needs to begin with our children, but also must extend to the current workforce.

The US needs lasting solutions to the country's workforce challenge which requires major national (K-12) education reform, better integration of technology into classrooms, and greater accountability for teachers, students and the communities that support them—beyond the "No Child Left Behind" act.

We need to introduce legislation similar to the National Defense Education Act of 1958 to increase the graduates of "hard" sciences and mathematics in our universities to facilitate innovative technology in both industry and government. In conjunction with the education act, the Federal government should consider channeling graduates for specific timeframe (4 – 6 years) to existing government labs or the next generation "Bell Labs" model to replace the loss of significant research and development assets as a payback for their education.

Successful US state agencies have initiated partnerships between their universities and industries to expand their universities' engineering departments to support local chip manufacturing and to enhance local workforce capabilities. This same partnership has been successful with industries in this country as well as others and must continue.

Businesses need to give their current workforce the opportunity and incentives to take advantage of continuing their education while on the job.

Policy Recommendations

The US must be proactive and assist its electronic industry in order to stay competitive in the global market. Initiatives must be adopted that promote competition, economic growth, and advances in electronics technology. Government, academia, and private industry must partner to establish pro-business policies to maintain the US technological leadership.

Adjust Government Controls: Existing laws, regulations, and polices should be reviewed to ensure that they are in the best interest of US national security and economy. The emphasis should be on national security, but have to pass a "common sense test" to determine if restrictions are effective or just an impediment to high-tech firms conducting global business.

Review Export Controls: Continual assessments of export controls are necessary to determine if the restrictions make sense and their goals are achieved. Export controls need to balance the need for national security and the interest of domestic manufacturers. The availability of comparable components from foreign competitors should be the determining factor on whether domestic firms sell their products in the global market. If comparable products are available, export controls should be loosened to encourage sales from domestic companies to "maintain the US as an export platform in the global economy."[xlix]

Relax Anti-Trust Laws: Joint ventures for trusted foundries should be encouraged to reduce the cost to a single organization and allow for better utilization of multi-billion dollar facilities.[I] Title 15 of the US code provides exemptions to anti-trust laws when domestic technology companies are facing foreign competition. The exemption allows for domestic firms to consolidate resources into joint centers that can be run in cooperative ventures. Utilizing existing exemptions and relaxing current anti-trust laws will allow manufacturing facilities to spread the cost and risk associated with large ventures to multiple investors.

Tax Incentives: Modern, state-of-the-art electronic manufacturing facilities cost in excess of $3 billion. Tax laws need to encourage the private sector to invest in facilities and conduct R&D. In addition to investing in physical assets, domestic manufacturers must be able to attract the best and brightest personnel needed to develop cutting edge technology. Tax credits, accelerated depreciation methods, and the continued use of stock options promote private industry to invest in R&D and capital facilities. The culmination of tax policies ensures domestic manufacturers maintain their competitiveness in the global market.

Establish Permanent R&D Tax Credits: R&D tax credits should be reformed and made permanent in order to allow domestic firms to take full advantage of R&D expenditures to include offsetting tax liabilities for income earned from foreign sales. The reformed credits will promote increased R&D and allow companies to conduct long-term planning.

Establish Accelerated Depreciation Methods: Accelerated depreciation methods should be adopted to expense high technology equipment with short useful lives. The accelerated depreciation schedules will bring depreciation in line with the economic life of equipment.[II] In addition, the accelerated method encourages companies to modernize and/or invest in new facilities since the increased depreciation will reduce their taxable income in the earlier years of assets lives.

Maintain Existing Reporting Procedures for Stock Options: Broad based stock options have been effective incentives to attract human capital to the semiconductor industry by allowing companies to reward employees for the risk they take and the technology they develop. Continuation of stock options and current reporting methods is necessary to allow domestic manufacturers to attract high-tech personnel and compete with foreign competitors.

Enforcement of World Trade Organization (WTO) Rules

"Global trade rules prohibit a WTO member country from engaging in activity that treats domestic producers and products more favorably then imported products."[III] US trade representatives must work with the WTO to enforce trade agreements and eliminate disadvantages imposed by foreign countries that harm US sales. Representatives must ensure that US manufacturers are playing on level ground to compete with foreign competitors.

Defense Acquisition Strategy on Risk Mitigation

Both DoD and the National Security Agency (NSA) require access to semiconductor foundry capabilities for classified semiconductors. Only the NSA

currently has such a capability and the NSA has deemed it economically infeasible to upgrade its capability to the next generation semiconductors. Conference Report 107-732 accompanying the 2003 Defense Appropriations Bill directed the consideration of establishing a national foundry to address this. The DoD Industrial Capabilities Report describes the results of a study initiated to consider a national foundry. Those results indicate that as long as US capacity exists, our vulnerability and cost concerns can be addressed by a prepayment arrangement known as a "take or pay" wherein we buy a portion of an existing foundry's output. In such an arrangement, we would pay the costs to certify the foundry for classified work and we would pay for a certain amount of capacity whether we use it or not. The report goes on to indicate that DoD is implementing a long-term strategy to address this under the Department's Defense Trusted Integrated Circuit Strategy. Subsequent to this report, IBM has agreed to provide "trusted foundry" capacity in a joint arrangement with DoD and the National Security Agency. Government officials are working diligently to find others to be part of the national foundry to reduce the risk of a single supplier of these unique, critical semiconductors.

Along the same line, acquisition personnel, specifically program managers, need to reduce the risk to their platforms and weapon systems by maintaining availability of semiconductors and associated electronic components. Eventually weapon systems age and replacements/upgrades are required; program managers at the beginning stages of their programs need to assess the availability risk of their critical components and possibly buy additional inventory for the life of systems, keep a warm production line open, or plan to have the critical components reengineered.

Bottom Line:

If the United States is to maintain its competitive advantage for continued economic prosperity and indispensable national security, this country needs a national competitive strategy that addresses the improvement and acceleration of high-technology innovation. The answer lies with creative and cooperative measures by academia, government and the business sector.

A prime example of this is the Research Triangle Park, a public/private, planned research park, in Raleigh, North Carolina, where industry team with the state government and three major research universities. Together, they provide unparalleled resources to North Carolina companies, the universities, and area entrepreneurs. All of these institutions work together with the Park companies, reflecting a special spirit of cooperation and learning within the scientific and technological community. The Park encompasses 7,000 acres of North Carolina pine forest and has approximately 1,100 acres for development. It currently houses more than 100 research and development facilities, which employ over 38,500 Triangle residents. The combined annual salaries in RTP amount to over $1.2 billion dollars.

Although this is just an example, it is critical that we foster something of this nature on a national level and further address this industry in the areas of altering defense electronic acquisition and modifying government policies. **– By CAPT Matt Blizard, USCG, Lt Col Jim Appleyard,USAF, and LTC Jerry Glasow, USA**

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