



INSTITUTE FOR DEFENSE ANALYSES

**Export Controls and the  
U.S. Defense Industrial Base**

**Volume 1: Summary Report  
Volume 2: Appendices**

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## **PREFACE**

This document reports the work performed by the Institute for Defense Analyses for the Office of the Deputy Under Secretary of Defense for Industrial Policy in fulfillment of the task entitled “Export Controls and the US Defense Industrial Base.” US defense industry and industry association representatives have asserted in various public forums that the capabilities of the US defense industrial base are being negatively affected by export control policy and its implementation. In particular, it is claimed that export controls as currently conceived and implemented result in economic impacts detrimental to the US defense industrial base, particularly on suppliers of dual use technologies, without a concomitant benefit to US national security. This report presents analysis of whether and to what extent the US defense industrial base has been negatively affected by export control policy and its implementation in four major areas: satellite manufacturing, semiconductors, machine tools and advanced materials.



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## I. OVERALL SUMMARY

### A. TASKING AND BACKGROUND

This is a summary report of the Institute for Defense Analyses task, “Export Controls and the US Defense Industrial Base.” This report addresses the following issues:

- What are domestic industrial perspectives and concerns regarding the effects of current and proposed export controls on US defense industry capabilities?
- To what extent are data available to evaluate industry contentions and quantify claimed negative economic impacts?
- Based on available data and other analyses, what conclusions may be drawn, quantitatively and qualitatively, as to the impact of current and proposed US export controls on key industry sectors?

The State Department administers the International Traffic in Arms Regulations (ITAR), which regulate exports of “defense articles:” weaponry and items closely related to weapons production. The United States Munitions List (USML) identifies the items controlled under ITAR.<sup>1</sup> The Commerce Department administers the Commerce Control List (CCL), which is used to regulate “dual use” technologies and equipment: i.e., items that are primarily used for commercial purposes but also have significant military applications. The Commerce Department also administers “deemed exports” regulations, which control the transfer of technical information to foreign nationals. Both agencies obtain input from the Department of Defense on licensing decisions. US export controls are coordinated with foreign governments through the “Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies,” which came into force in 1996.<sup>2</sup>

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<sup>1</sup> ITAR rather than USML will be used in discussing military controls because that is the common reference used by industry.

<sup>2</sup> Wassenaar members include Argentina, Australia, Austria, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Poland, Portugal, Republic of Korea, Romania, Russian Federation, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, United States.

**US industry concerns regarding the economic impact of export controls pivot on (1) regulation under ITAR as “weapons” of items that should, it is argued, be more loosely controlled under the CCL as commercial items, and (2) less stringent application of the Wassenaar Arrangement by other signatories, which “tilts the playing field” against US-based companies by allowing foreign firms to export equivalent equipment and technologies more quickly and reliably.** US industry has also raised concerns regarding the speed and predictability of license application processing, especially by the Department of State, as well as the increasing impact of controls on the exchange of technical know-how on international manufacturing supply chains and R&D enterprises.

Industry concerns were investigated in four industry sectors that are prominent in export control discussions: satellite manufacturing, semiconductors, machine tools, and advanced materials.<sup>3</sup> These sectors were selected in conjunction with the project sponsor, taking into account the salience of concerns raised by the industry, the industry’s importance to the defense industrial base, the expected availability of data to evaluate industry concerns independently, and the representativeness of these concerns within the broader export control debate. The primary economic impacts of concern were revenues, profits and market share (due to lost sales), competitive position, costs to suppliers and users, reduced technology investment and innovation, and workforce impacts.

The remainder of Section I summarizes overall findings, sector findings and overall conclusions. Section II contains executive summaries of the four sector reports from which the conclusions were largely drawn. A separate volume of appendices contains the full sector reports as well as additional detail on international export controls and proposed changes in US export controls for dual use items going to China.

## **B. OVERALL FINDINGS**

Quantitative assessment of export control impacts is inherently difficult. Export controls are only one of a number of factors impacting the competitive position of companies, and typically they are not the most prominent factor. Competitiveness is more directly impacted by firm-specific issues such as R&D investment, manufacturing

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<sup>3</sup> The study plan included a review of the Infrared Sensor / Night Vision sector as well. However, due to a concurrent study being undertaken by the Department of Commerce on this sector it was decided that IDA should wait for the results of this study before proceeding. That study, which was released in mid-October, is briefly summarized in section II on page 29.

efficiency, and market strategies, as well as macroeconomic issues such as skilled labor availability and cost, exchange rate policy, tariffs and legal barriers. Industry cyclicality can also mask—or mimic—export control effects. Hence, even in those industries where export controls appear to play an important role, it is difficult to prove that they actually cause lost market share. The best economic studies satisfy themselves with “sizing up” the problem as opposed to making definitive quantitative estimates.<sup>4</sup> By the same token, it is typically impossible for individual firms to “prove a negative”—i.e., that particular sales were lost due to export controls.

**In those areas where the study team was able to collect and analyze quantitative data on an entire industry—satellites and machine tools—a compelling case could not be made that differential application of US export controls account for loss of US market share.** Rather, rising foreign competency and natural cyclicality seem to better account for the drop. Similarly, with the exception of a few specific and important cases, **companies contacted by this study and published reports cite only a handful of instances where sales were lost to a foreign competitor due to delays or conditions in US export licensing.** Unilateral costs to US-based firms associated with export control compliance are relatively small in direct, quantitative terms.

This being said, **the absence of definitive quantitative evidence should not be interpreted as evidence that US industry’s concerns are unfounded.** For example, the large backlog and long processing time for ITAR cases and potential “ITAR-tainting”<sup>5</sup> of their R&D are serious issues for the satellite and advanced materials sectors. The processing time impairs the ability of US firms in these sectors to conduct global business relative to foreign competitors, which are able to be much more responsive to potential and actual customers throughout the business cycle from initial marketing to product development and delivery. Because these delays are relatively recent they may not be explicitly visible in market data. Moreover, such delays are essentially part of an overall mix of factors that companies bring to the table in negotiations, along with price, product offering, financing, etc. Thus, the increased processing time creates a risk factor that US

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<sup>4</sup> This wording is suggested by the most recent and thorough economic analysis of export controls: J. David Richardson, *Sizing Up U.S. Export Disincentives* (Institute for International Economics, October 1991).

<sup>5</sup> Technologies originally developed or qualified by industry with DoD funding are typically considered ITAR classified (tainted), which inhibits firms from commercializing them. The US aerospace industry and related suppliers, such as advanced materials companies, are increasingly performing non-DoD funded R&D abroad to help ensure that future dual-use developments escape ITAR tainting

firms must contend with in their negotiations with satellite service providers that their foreign competitors do not face.

The “ITAR-tainting” issue creates a different type of problem. In this case US firms—such as advanced material developers—find themselves reluctant to engage in R&D activities funded by the Department of Defense because this raises future prospects that the products based on this R&D—although intrinsically commercial—will be saddled with ITAR controls due to the link to defense-funded R&D. The impact on firms is that it reduces the sources of R&D funding, if firms see the ITAR constraints as excessive, and even has driven firms to conduct their R&D abroad. The impact on DoD is that it discourages potential partnerships that might provide advantages for future defense applications.

The increasing intrusiveness and implicit distrust conveyed by US export control implementation with respect to China—a market that is expected to fuel the next stage of growth and development for semiconductor and machine tool firms as well as other high technology industries—threaten to make US companies unattractive business partners. The costs of compliance, particularly with some of the proposed measures aimed at China, are becoming a matter of concern for US firms and represent a unilateral disadvantage to US-based firms in increasingly competitive international markets. For example, the risk and difficulty of complying with “deemed exports” regulations—a license that must be obtained before providing to foreign nationals information related to controlled technologies—has led some US companies to no longer hire foreign nationals, thus restricting their access to talented scientists and engineers.

These qualitative factors—unreliability in supply, the unilateral nature of export control measures, restricted access to foreign talent, and barriers to developing a foothold in emerging markets such as China—could eventually be reflected in diminished competitiveness of leading-edge US industries. In order to take advantage of global talent and develop customized offerings for foreign markets, industrial enterprises around the world are increasingly distributing globally and becoming intensely interactive throughout their supply chains. If US export controls inhibit US firms from competing in the changing global business environment, this may disrupt US industry’s supply chain and technology development strategies, and choke off promising market expansions and diversification opportunities. In interviews with individual firms it is apparent that US companies are already being constrained in supply chain choices by export control restrictions. In some cases export control measures are actually encouraging R&D and capital investment overseas, as well as discouraging R&D partnerships with US firms and

the DOD. (These ideas will be developed in more detail in the “Overall Conclusions” subsection.)

Furthermore, **certain near-term issues, if unaddressed, could lead to additional problems for the US industry.** Proposed changes to Department of Commerce rules for dual use exports to China, if adopted, would cause currently decontrolled items to come under tighter scrutiny. The new rules would require US firms to confirm the commercial nature of customers and end-users in China, with potentially severe penalties for exporting equipment or technology that was found to have a military end-use. For companies producing general purpose equipment or materials, such verification could be impossible, conferring potentially open-ended liability on US firms. (This problem could be mitigated by the “Validated End-User” provisions of the proposed rules—which would provide a blanket license for the export of specifically approved items to specific foreign entities—though it is unclear how readily that designation will be given and how much of the export control burden it will relieve.) Also, the prospective shift of controls on semiconductors from the CCL to the much more restrictive ITAR, due to outdated criteria for radiation tolerance of microelectronics, could make their products non-competitive—products that today are essentially uncontrolled.

### C. SECTOR FINDINGS

In the four industries studied, the study teams found the following:

- **Satellite manufacturing:** There is little quantitative evidence that export controls have diminished US satellite prime contractors’ success in international markets. However, because state-of-the-art communications satellites and components have become available from multiple global sources, specific technical criteria related to military criticality should be used to determine when the ITAR needs to be applied to these exports. Otherwise, US industry runs the risk of being impaired, if not disadvantaged, in the future satellite market, without achieving any national security benefit. Moreover, the large backlogs and long processing times for processing ITAR cases have become a serious issue for satellites (as well as for defense-related trade overall). This issue needs to be addressed. In addition, for satellites, the value and costs of requiring detailed monitoring of meetings with foreign satellite customers and partners should be reconsidered.

- **Semiconductor Industry:** Semiconductor device firms and semiconductor materials and equipment firms did not report significant lost sales or competitive impacts from application of US export controls. However, the proposed CCL rule changes involving China and expansion of deemed exports controls could have significant impacts on the competitiveness of the industry going forward, including foreign migration of manufacturing capabilities and technical talent. A critical issue on the horizon is the potential shift of control of semiconductor integrated circuits from the CCL to the ITAR due to the increasing radiation tolerance conferred by modern manufacturing methods. Under current “see through” rules, systems containing controlled integrated circuits would be considered controlled items as well, which, if not addressed, would create a serious impediment to the US export market for electronic goods as well as integrated circuits themselves.
- **Machine Tools:** Data going back more than a decade suggest that declining US machine tool exports are due to the loss of competitiveness of US machine tool producers, not due to unilateral US export controls. US industry made strategic decisions back in the 1980s to focus on the US automobile industry and cede other segments of the business to foreign firms. Those decisions, along with changes in the composition of US automobile manufacturing, account for the current state of the industry. However, for firms in certain advanced technology areas—critical to both defense and commercial markets, particularly aerospace—differential US application of export controls is leading to product development being moved overseas, as well as dampening global sales to China, the fastest growing market.
- **Advanced Materials:** Advanced materials, such as carbon-fiber polymer matrix composites, CF-PMC, are employed in an increasing variety of products, from tennis rackets to auto bodies to missiles and aircraft. Commercial aircraft are the fastest growing market for this material. The burgeoning market for these materials is encouraging new production facilities worldwide. Employing CF-PMC requires considerable interaction throughout the value chain from the fiber producers up through intermediate materials suppliers to the integrated product producers, making the industry increasingly affected by export controls. (Materials themselves, e.g., fibers and the prepregs, are largely not controlled; rather, controls apply mainly on

the technical know-how for employing them in integrated products.) The US CF-PMC industrial base today is robust and growing, but the major US firms are concerned that inhibiting their relationships with downstream integrators will encourage these integrators to develop alternative foreign sources and shift advanced R&D offshore.

Executive summaries of the reports for these four industries appear in Section II. The full reports are published in a separate volume of appendices.

#### **D. CONCLUDING OBSERVATIONS**

The current US export control system appears to be out of step with today's world of global manufacturing, technology development, and capital flows. Technology products often use components or manufacturing services from a variety of countries based on competitive advantages in niche areas. Countries that buy technology products from the US typically do so because US firms offer the best value, not because the country could not obtain the products from a variety of sources worldwide or produce the necessary technologies domestically. Selling, sourcing, and teaming internationally are increasingly important for competing as a global technological enterprise. Inhibiting these international business relationships makes enterprises more insular and less responsive to customers. When US export controls interfere with foreign partnering in high tech systems development, they encourage advanced technology and manufacturing investment to take place overseas. This practice has already begun in the machine tools and the advanced materials industries and is likely happening in the semiconductor industry as well. In the satellite industry, the increasing number of foreign components advertised as "ITAR free" testifies to the perceived advantage to satellite developers of avoiding US export controls.

Quantitative analyses on historical data miss these emergent trends and dynamics. In sectors such as integrated circuits and advanced materials, US producers still have a reservoir of intellectual property, product capabilities and process know-how built over several decades. These historical advantages naturally dissipate as global capabilities rise and need to be replaced with new competencies tightly linked with global supply chains in order to maintain US firms' market position and technological leadership. This erosion is hard to perceive clearly until it shows up in hard data, at which point it may be impossible to reverse.

These increasingly global dynamics of the high-tech industrial sectors make it more difficult to implement export controls effectively. With Europe, Japan, South Korea and Taiwan having become highly competitive across the range of advanced technology sectors, and China and India not far behind; global firms are seeking to access global markets through joint ventures and partnerships. With multiple potential sources dispersed throughout the globe, the ability of governmentally-imposed controls to limit technology transfer and development is becoming increasingly difficult. Boeing, the US-based leader in commercial aircraft, and US-based Hexcel, the largest advanced composite materials producer, are in partnership with China's leading commercial and military aircraft producer, AVIC-1, to produce composites structures for the 787 and a host of other commercial aircraft. At the same time, its main competitor, Airbus, as well as several other lower-tier aircraft makers, such as Embraer of Brazil and Bombardier of Canada, have set up extensive production facilities including final assembly lines, in China.<sup>6</sup> Major microelectronics firms based in several countries—Motorola, Intel, Samsung, Toshiba, TSMC and others—are undertaking Chinese joint ventures. Microsoft's advanced technology research center in China pursues world leading research in self-forming, self-healing, distributed communications networks, a capability also being pursued avidly by the US DoD.<sup>7</sup> This dispersion and interconnectedness of technology development and production creates a fundamental challenge to the ability to effectively implement export controls.

Moreover, there are potential impacts on future US defense capabilities in instances where US export controls have interfered with international defense cooperative programs, through their effects on domestic suppliers of US foreign military sales and associated export trade offsets. Of particular concern in an age of increasing coalition warfare are the impacts of controls on DoD development and acquisition with close allies, through their impedance of foreign partnerships necessary to major new defense programs such as the F-35 Lightning (Joint Strike Fighter). There are similar impacts on offshore manufacturing partners of America's legacy military systems for DoD's own use.

Given this rapidly transforming world of global enterprise, it may be time to assess more broadly how these global economic dynamics impact the effective

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6 "Lofty Ambitions: China Hopes to Build Wide-bodied Airliner to Challenge Boeing and Airbus," *The Economist*, February 8, 2007.

7 George Leopold, "Microsoft to locate wireless research center in China," *EE Times*, January 21, 2001.

implementation of export controls. Some questions for such an assessment could include: What is the role of technology exports in supporting emerging coalition warfare needs and how do export controls affect these? Are unilateral export control measures damaging the economic competitiveness of US firms and allowing others to expand their market positions, without achieving our security goals? Given the access to global networks of technology and supply, how do controls on advancing economies such as China or India, as the US is currently employing and implementing them, serve US security interests? Despite the global economic patterns discussed above, have controls had positive effects on slowing access to key technologies for such countries as North Korea and Iran?



## **II. SECTOR SUMMARIES**

### **A. SATELLITE INDUSTRY**

This sector study focused on the impacts of ITAR on the US satellite industry. The study considered quantitative metrics such as lost revenues and unilateral costs, metrics on competitiveness, as well as qualitative impacts such as access to international talent. Data were collected via (1) interviews with industry, academia, and government officials; (2) government and industry reports; and (3) various open publications. From these sources, IDA constructed a database of global satellite sales, launches and subcontracts by region and by type for the period 1995-2006. This database was used to analyze the market position of US satellite prime contractors and subcontractors over time and to discern any changes in that position due to changes in export controls.

Today, all satellite and satellite component exports are licensed through the ITAR process, administered by the US Department of State (DoS). Related services and technical data transactions must also be licensed under a Technical Assistance Agreement (TAA). A representative from the Defense Technology Security Administration (DTSA) must be present at all meetings with foreign persons (with exemptions possible for NATO and other major allies), and Congress must be notified of all contracts valued at more than fifty million dollars. Between 1995 and 1999, export of commercial satellites, components and services were regulated under the Commerce Control List, administered by the Department of Commerce. The CCL regulates exports of “dual use” technologies and equipment: i.e., items that are primarily used for commercial purposes but also have significant military applications. CCL controls generally are significantly less stringent and more transparent than ITAR controls.

Throughout the period from 1997 to today foreign governments have regulated commercial satellite exports under their commercial export control regimes based on the “Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies,” while in 1999 the US controls on satellites were moved by Congress to the ITAR from the CCL. Commercial satellites have become a global commodity with little difference between products offered by US and European primes in terms of performance, reliability, or ease of use. By applying ITAR controls to satellites, the US seeks to control technologies that are not tightly controlled by foreign

governments and are widely available from foreign sources. The changeover in US satellite export controls from CCL to ITAR in 1999 provides a basis for comparison of the impact of the US export control regime on the competitive position of US industry relative to their foreign competition—a concern that has been raised frequently by the US satellite industry.

The Department of State is currently overwhelmed by the quantity of ITAR applications—an increase of more than fifty percent since 2000—with processing delays often reaching several months. The backlog of cases is massive and growing as of this writing. In one instance, consideration of a satellite company’s license application did not begin for six months after submission. License applications are processed case-by-case, with little transparency or predictability. The impact of processing delays and uncertainties is particularly acute for TAAs, directly affecting business development and execution of contracts.

Because foreign suppliers do not face similar controls, US export controls and their implementation impose unilateral hurdles on US satellite makers and suppliers and risk creating dissatisfaction among foreign customer with US suppliers. Industry representatives cited specific cases in which contract awards were lost due to ITAR processing delays or the inability to share technical data to back up a US company’s offering. Additional licenses are required for failure investigations, and a foreign subsystem that is sent to the exporting country for repair must be licensed for its return to the customer, meaning that US firm importing that subsystem cannot respond rapidly to urgent customer needs. One US subtier supplier indicated that it might exit the international marketplace if a “solution to export controls (is) not found.”

The precise economic impact of such delays and additional constraints on US satellite firms on the overall US satellite industry is difficult to discern against broader trends in the satellite industry, which is cyclical and “lumpy” due to the small number of launches in any given year. The transfer of export controls on satellites from CCL to ITAR in 1999 corresponded with a major downturn for the worldwide industry. Satellite manufacturers faced significant overcapacity due to the development of larger, longer-lasting satellites, and more efficient use of spectrum.<sup>8</sup> The combination of growth in power, size, and design life make the average satellite of today approximately nine times more capable than the average satellite launched in 1990. Additionally in the mid-1990s,

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<sup>8</sup> Futron Inc., “How Many Satellites are Enough? A Forecast of Demand for Satellites 2004-2012,” 2004.

the European firms EADS and Alcatel aggressively entered the satellite market. Given these trends, US satellite revenue hit an all time low of \$3.2 billion in 2005, and overall US market share decreased as well.

The global export market is comprised primarily of commercial geosynchronous (GEO) satellites, and US commercial GEO satellites are the predominant US satellite export. From 1995-2006, export revenue from commercial GEO programs was about half of US firms' total GEO revenues. The US has historically dominated the global GEO export market. However, US market share for satellite prime contractors between 1995 and 1999 (under CCL control) was 68% compared to 58% between 2000 and 2006 (under ITAR), while EU firms' market share increased from 19% to 28% during the same periods. US industry cites this shift as evidence of the impact of tighter export controls. For example, Canadian TELESAT bought fifteen satellites from US vendors prior to 1999 but acquired the last three from Astrium, stating to the US vendor, "We will not buy from US due to export controls."

Nevertheless, analysis indicates that changes in US GEO market share have been consistent with trends in the global GEO and domestic US satellite markets. Due to the small number of launches, market share can vary widely by manufacturer and by region from year to year. For instance, US market share in 2005, measured in revenues, was 37%, but in 2006 it was 75%. Thus, while the entry of European firms into the satellite market clearly created additional options for the satellite telecommunications service providers, the data is not conclusive that export controls have had a major impact on the competitive position of US satellite makers and subtier suppliers. Major telecommunications service providers represent a large share of the commercial GEO market. These customers tend to purchase from companies from a specific region. Eutelsat, a European intergovernmental organization, has always purchased from European companies. Similarly, many US companies only buy US-made satellites. Moreover, customers switch manufacturers within a region: Data show that customers will often change prime contractors, even within major constellations. Viewed from the perspective of customer buying trends, **Canadian TELESAT is the only example of a major customer permanently moving away from US manufacturers after the change in export jurisdiction from CCL to ITAR.** Arabsat, while blaming ITAR for not buying US satellites, has actually never purchased a US satellite. ITAR controls may have contributed to a drop in US sales to European customers, but the US presence in Europe was small to begin with.

While China has never been a large GEO customer, those satellites it has imported have been mainly from the US. However, since 1999 a European firm has won a few contracts. Over the next decade the Teal Group forecasts sixteen Chinese satellite programs scheduled with all of these being indigenous. With the Chinese seeking to produce satellites for themselves, there are no major market opportunities in China for ITAR to impact. China claims to be achieving “many important technology breakthroughs through independent research” and, as in other technology areas, is pursuing increasingly sophisticated indigenous capabilities. This raises the prospect that in the future China may be a competitor in satellites rather than a customer.

Satellite component markets tend to be linked to the prime contractors and hence show the same regional biases: European primes tend to use European subcontractors, and US primes buy from US firms. Because US component manufacturers did not have a large share of the European market before 1999, US firms did not appear to lose market share abroad following the 1999 ITAR change (though the study’s data on this was limited). Outside Europe, the US component manufacturers have increased their foreign market share. Recent moves by European firms, which sometimes advertise their offerings as being “ITAR-free,” may erode the small foothold US component manufacturers have in emerging foreign markets.

Universities have claimed that export controls make US graduate school less attractive relative to their foreign competition, inhibit their foreign faculty in their research, interfere with cooperative research with foreign nationals, and force universities to decline certain research grants. Analysis of the data did not confirm any of these effects, though data specific to the satellite industry was not readily available.

In conclusion, export controls are only one factor in the buying decisions of satellite customers. European capabilities and presence were growing relative to the US before the shift from CCL to ITAR, and all existing manufacturers can expect to lose market share as emerging countries develop indigenous capabilities. **All in all, there is little quantitative evidence that export controls have diminished US prime contractors’ success in international markets. This being said, strong and increasing foreign availability raises strong doubts as to whether US export controls have any benefit for US national security that would justify stringent ITAR controls.** If the intent of US export control policy on satellite technology is intended to keep China behind the state of the art, to keep US firms ahead of rest of world, or to sustain US industrial capabilities, these policies have failed. If anything, export controls have likely

spurred foreign governments to develop their own industrial capabilities and avoid use of US technology.

**The study team recommends that the US adopt specific technical criteria related to military criticality, via the Commodity Jurisdiction Review process, in order to determine whether ITAR controls should be applied to particular satellites and components. The value and need for detailed DTSA monitoring of satellite-related meetings with foreign customers and suppliers should be reconsidered. Moreover, the serious breakdown in ITAR case processing should be rectified.**

## **B. SEMICONDUCTOR INDUSTRY**

For the purposes of this sector study, the “semiconductor industry” comprises firms producing semiconductor materials, semiconductor manufacturing equipment (SME), and semiconductor integrated circuits (ICs).<sup>9</sup> Worldwide revenues in 2005 were \$31 billion, \$34 billion, and \$227 billion, respectively. The semiconductor industry is widely viewed as “strategic,” supporting economic growth through innovative clusters of electronics and broader information technology (IT) firms (such as in “Silicon Valley”), as well providing high value-added exports and high-wage employment. Beyond the economic importance of the semiconductor industry, today’s dominant US conventional military capabilities derive from the US Department of Defense’s relative success in fostering and exploiting semiconductor-based computer, communication and sensor networks for military purposes. Advantages in “network centric warfare” based on advanced electronics, is assumed in much of current US defense strategy and planning.

**While electronics and IT are critical to US military capabilities, the most advanced ICs today play a relatively small role, and the US Department of Defense (DoD) is a niche player in the market.** With a few exceptions in areas such as sensors and intelligence systems, the ICs embedded within today’s most advanced military systems tend to be far from commercial state-of-the-art. Nevertheless, the US government has sought to prevent adversaries from accessing the most advanced ICs, SME and materials through the CCL, administered by the US Department of Commerce. Radiation hardened (RADHARD) ICs used in nuclear and space systems are controlled by the Department of State through the ITAR. US export controls are coordinated

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<sup>9</sup> The industry includes numerous major suppliers and subcontractors to these firms, such as computer aided design and other software companies. These firms were not contacted for this study.

internationally through the “Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies,” which came into force in 1996 as successor to the Soviet-era “Coordinating Committee for Multilateral Export Controls” (CoCom).

**US-based IC, SME and materials firms depend on exports.** For US-based IC firms, much of their market is serving electronics products manufacturers (both US and foreign-owned) located outside of the US. For SME and materials firms, this is due to rapid growth of advanced IC manufacturing in Taiwan, China and Korea (a significant portion of which is due to foreign direct investment by US-based firms). Some observers of the US semiconductor industry are concerned about this migration as well as the loss of US commercial participation in certain SME segments. Disparities in application of export controls by the US relative to its Wassenaar partners is said to exacerbate the problem by restricting US industry in accessing rapidly growing Asian markets, without conferring any national security benefit, due to the ability of the Chinese to access comparable technologies from Europe and Japan. Semiconductor industry leaders have called on the US government to address these disparities as part of a broader effort to respond to purported unfair trade practices by foreign governments, organizations, or firms.

**This study found that, since the inception of Wassenaar, US-based IC, SME and materials companies have not been severely impacted by export controls, but this may not be the case going forward.** US implementation of semiconductor export controls burdens US semiconductor companies with more conditions on foreign sales and longer and less predictable waiting periods for license approval than that faced by competitors in Europe or Japan selling comparable products, but licenses are rarely denied. Companies contacted by this study and published reports cite only a handful of instances where sales were lost to a foreign competitor due to delays or conditions in US export licensing. However, staffing requirements and the administrative burden of export controls represent a unilateral cost to US industry relative to its foreign competitors. The costs of compliance are rising and threaten to become a competitive disadvantage to US-based firms in the increasingly competitive international semiconductor industry. More importantly, licensing delays and uncertainties threaten to give US suppliers a reputation for being unreliable partners in the lean, “just in time,” worldwide supply chains that increasingly characterize high technology industries. Implementation of “deemed exports”—a license that must be obtained before providing to foreign nationals information related to controlled technologies—has led some companies to no longer hire

Chinese researchers and other controlled foreign nationals due to the risk and difficulty of complying with these regulations. Many of these talented individuals are doubtless hired by foreign competitors.

As of this writing, unilateral costs to US-based semiconductor firms are relatively small in direct, quantitative terms. Qualitative factors—reputation for unreliability in supply, diversion of R&D funds to export control compliance, restricted access to foreign talent, barriers to developing a foothold in emerging markets such as China, etc.—are hard to assess but could soon be reflected in lost sales and competitiveness. Furthermore, certain prospective issues, if unaddressed, could lead to severe if not debilitating problems for the US semiconductor industry:

- Proposed changes to Department of Commerce rules for dual use exports to China, if adopted, would cause currently decontrolled SME and materials to come under tighter scrutiny. The new rules would require US firms to confirm the commercial nature of customers and end users in China, with potentially severe penalties for exporting equipment or technology that was found to be supporting the production of Chinese military systems. For SME and materials companies, such verification could be impossible, since they produce general purpose equipment that could be used to build any type of ICs, which themselves are general purpose devices. (This problem could be mitigated by the “Validated End-User” provisions of the proposed rules—which would provide a blanket license for exports to certain foreign entities—though it is unclear how readily that designation will be given and how much of the export control burden it will relieve.) The ambiguity of the proposed rules confers potentially open-ended liability on US firms, based on subjective application by the Department of Commerce. This expansion of export documentation, investigation requirements for China, and potential liability would likely be unilateral, as other Wassenaar signatories have shown no interest in similarly tightening their implementation.
- Continued unilateral application of deemed exports regulations could inhibit US companies in hiring top foreign talent from controlled countries, beyond the limitations imposed by immigration policy. In the case of China, this burden adds to the incentives for top Chinese technologists to stay in country or leave the US. This disadvantages US companies relative to foreign competitors, which do not face such hiring restrictions. Deemed export regulations could also inhibit US companies from performing joint research

with leading Chinese institutes, some of which are approaching world-class standing in semiconductor technology.

- The criteria for control of radiation hardened ICs in Category XV (d) of the ITAR could, within a few years, encompass most ICs and any electronics products incorporating them. This would make standard commercial ICs of all types subject to intensive control as “military items” regulated by the Department of State. The reason is that continuing miniaturization of IC circuits, introduction of low-power materials, new design techniques and improving error correction software are conferring inherent radiation hardness to all ICs—enough to possibly meet the ITAR criteria for being controlled, even if these ICs were not designed for use in nuclear or space systems and would be unreliable in such applications. Under ITAR’s “see through” rules any system containing a controlled part is considered a controlled item, which could lead to the perverse outcome of subjecting Japanese video games and European cell phones to US ITAR controls, which would effectively destroy the US IC export market. ITAR controls on ICs would doubtless be unilateral, as it is quite unlikely that the US would persuade foreign sources to treat all ICs as though they were weapons.

In the final analysis, for such a dynamic and globally dispersed technology as microelectronics it is very difficult for any control regime to be effective. As the locus of advanced IC consumption and production moves to Asia, including China as well as Taiwan and Korea, the underlying rationale for controlling microelectronics technologies appears to be negated. Today US IC manufacturers are little affected by export controls, although they have to maintain the processes required by the government. What is worrisome is that in the near future there will be unintended consequences seriously impacting US IC manufacturers if either the China Catch-All comes into effect as proposed or if changes are not made to the ITAR RADHARD provisions.

### C. MACHINE TOOL INDUSTRY

The machine tool industry is interesting and important to an examination of the economic impacts of export control for three reasons:

- Machine tools have traditionally been an important export control concern. The 1976 Bucy report <sup>10</sup> emphasized that controlling manufacturing technology (the ability to make weapons) is more important than controlling weapons system operational technology. Machine tools embody manufacturing technology. The 1987 Toshiba affair (in which several advanced machine tools were exported from Japan to the Soviet Union to manufacture propellers for submarines) and the 2003 Mitutoyo debacle (Japanese Mitutoyo exported coordinate measuring machines without a license and wound up in Libya helping to make uranium refining centrifuges) are among the most significant export control violations, and they both occurred within the machine tool industry.
- Export control restrictions on machine tools have been significant and very consistent over the last half century, making the sector a good case for study of the long term impact of export controls on an industry.
- Today, China is the largest buyer of machine tools in the world and is the country to which most machine tool export restrictions apply. China buys about one-quarter of the world's tools. The current impact of export controls should be apparent here, if anywhere.

Machine tools have been vital to the nation's warfighting capability since the Civil War. Machine tools build the composite surfaces of modern aircraft, which confer light weight and, for military aircraft, stealth. Machine tools mill the titanium frames that

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<sup>10</sup> "In 1976 a Defense Science Board Task Force issued a report, commonly called the Bucy report [*Defense Science Board Task Force on Export of U.S. Technology, An Analysis of Export Control of U.S. Technology--A DOD Perspective* (Washington, D.C.: GPO, 1976)] suggesting that the export control system should shift from a focus on products to a focus on critical technology. Basically the Bucy task force argued that, with the exception of technologies of direct military value to potential adversaries, effort to control exports should not focus on the products of technology but on design and manufacturing know-how. The report recommended that primary emphasis should be placed on (1) arrays of design and manufacturing know-how; (2) 'keystone' manufacturing, inspection, and test equipment; and (3) products requiring sophisticated operation, application, or maintenance know-how. The Bucy task force concluded that the preservation of the US lead in critical technological areas was becoming increasingly difficult but could be achieved, first, by denying the exportation of technology." p. 31, *Scientific Communication and National Security*, NRC Report (1982) by the Committee on Science, Engineering, and Public Policy of the National Academy of Sciences.

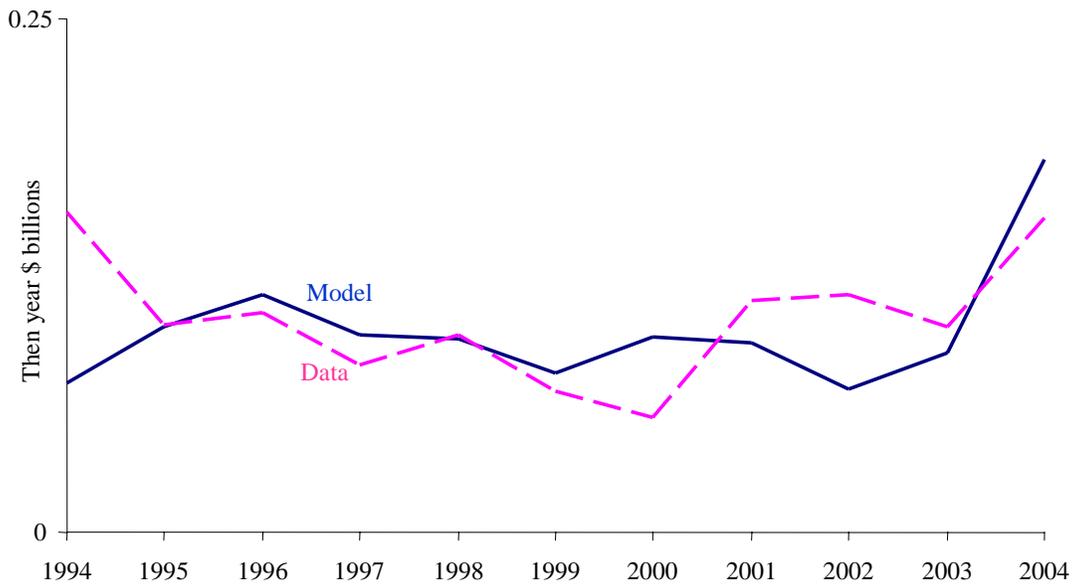
provide the structure for these same aircraft. Complex parts such as centrifugal compressors in turbine engines, and precision parts, such as germanium lenses in infrared vision systems, all depend on specialized high technology machine tools.

Machine tools are a small industry: about \$3 billion in tools are produced annually in the US. The US machine tool industry has shrunk from being the world leader in the 1950s and 1960s to being a second tier player today. The US now provides about 5% of the world's machine tools. Leading countries are Japan, Germany, Italy, China, and Switzerland. US machine tool production capabilities today are on par with Taiwan and South Korea.

Although export controls impact industry growth and health generally, **the demise of the US machine tool industry was not caused by export controls**—they were not even an important contributor to the prolonged contraction. The IDA study team found that export controls reduce the revenue of the US machine tool industry by 1% - 2%. (In addition, for companies that export, the process of screening customers and applying for licenses costs about 2% of revenue, although that percentage is substantially higher for some small firms.) To the extent that there is revenue loss, it is not due to prohibited sales. Instead, the losses are in sales to potentially licensable Chinese customers. These sales are being lost to European competitors whose export control processes are swifter and more dependable. In many European countries (particularly Germany, Switzerland, Italy and Spain), the manufacturer can obtain preliminary judgments from export control authorities that permit them to confidently guarantee a Chinese customer at the time of sale that an export license will be granted. For US firms, approval of a license to export to China is never certain in advance. Furthermore, license approval in the European countries requires only a few weeks, while in the US, licenses to China usually take months. Partly as a result, European manufacturers command a 30% to 100% price premium in China, the largest machine tool market in the world.

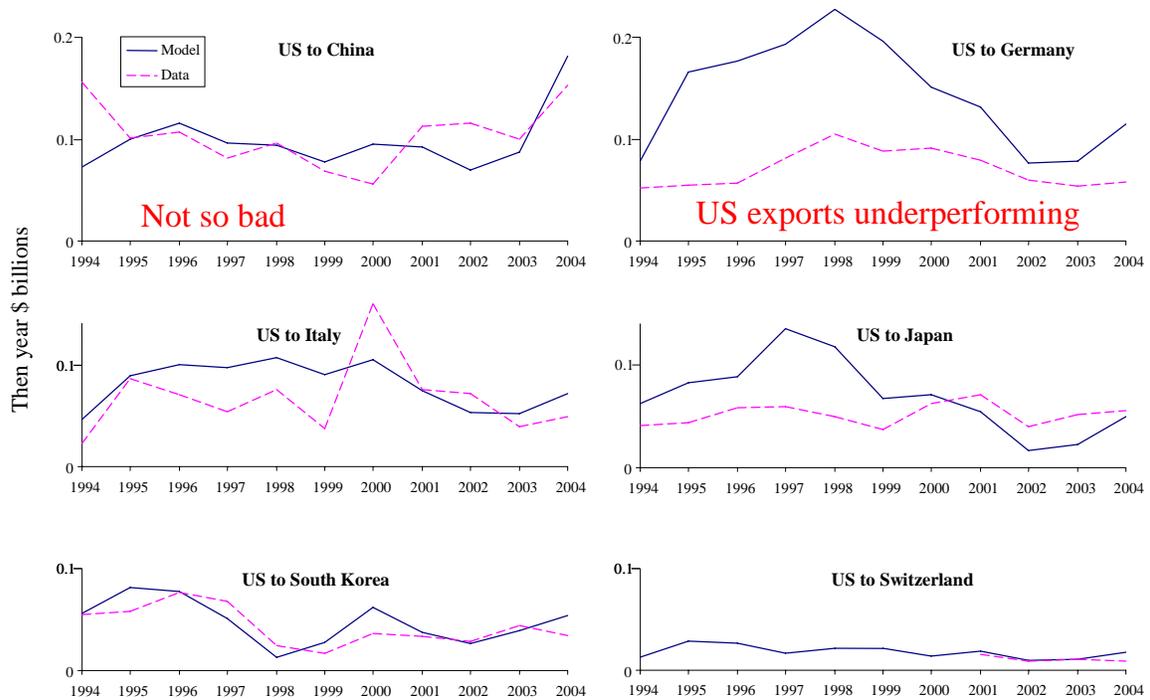
The quantitative impact of export controls on US exports of machine tools to China was analyzed with a gravity model of international trade in machine tools. The gravity model predicts exports from one country to another solely based on the size of machine tool production in the exporting country, the size of machine tool consumption in the importing country, and the distance between the two countries. If there is an additional factor that strongly affects exports, such as export controls, it ought to appear as a discrepancy between actual exports and the exports predicted by the gravity model.

Figure 1 compares the gravity model with actual exports from the US to China. The line labeled “model” are predictions from the gravity model, based on machine tool production and consumption of the eight major exporting countries. The line labeled “data” is actual new machine tool exports from US to China (not including parts and service). Actual exports are not significantly depressed compared to the model, which suggests that export controls do not strongly impact the dollar volume of US machine tool exports to China.



**Figure 1. Gravity Model Comparison with Actual US Exports to China**

To confirm this result, Figure 2 looks at all exports of new machine tools to major consumer countries during the period of interest. Actual exports to Japan and Germany are significantly lower than gravity model predictions. This indicates that the US machine tool industry is being hurt by factors that restrict exports to Germany and Japan, but not particularly by export controls on exports to China. Several experts interviewed attributed the depression in exports to Germany to German nationalism. However, Italy and Japan export into Germany at approximately the rate projected by the gravity model, and Swiss exports to Germany are almost double the model predictions. These data suggests that the perceived quality of US machine tools is the factor that depresses exports to Germany and perhaps also to Japan.



**Figure 2. Gravity Model Analysis of US Exports to All Countries**

Despite the relatively small percentage of lost sales overall, **the export advantage held by the Europeans in China is beginning to deeply hurt US machine tool producers in the most advanced segments of the industry.** Most of the larger US machine tool firms are owned by multinational companies. Increasingly onerous US export controls to China is driving these multinationals to pull their technology development and product development investments out of the US and focus them in Europe, accelerating the technological decline of US machine tool technology relative to the rest of the world.

Given that the ultimate goal of national security export controls is to preserve technology leadership in areas that materially contribute to military capabilities, they have completely failed in the machine tool sector. US leadership has been lost, perhaps irrevocably. Whether this is a crisis or not depends on whether, in today's world, an indigenous capability to manufacture cutting edge technology tools is still a critical defense need.

## D. ADVANCED MATERIALS INDUSTRY

Advanced materials encompass a variety of technologies and a diverse set of industries. This sector study focused on *advanced composites* which consist of high performance fiber reinforcements (carbon, glass or aramids) embedded within various material matrices (polymer, ceramic or metal). Advanced composites can be highly engineered for a host of divergent applications (often structural in nature) while providing remarkable properties superior to conventional materials (ultra lightweight, high strength and stiffness). Characteristics of these materials important to DoD include exceptional thermal protection, impact tolerance, electronic signature reduction and reduced fatigue while also enabling novel system-of-systems concepts such as the integration of electrical and mechanical technologies within conformable structures.

This sector study further focused on *carbon fiber reinforced, polymer matrix composites* (CF-PMC) and their use in *aerostructures applications* since collectively this is the most prolific and important application of advanced composites to DoD. CF-PMCs support critical and large-scale defense systems such as aircraft, space vehicles, missiles and munitions, as well as emergent applications in future military ground vehicles and naval vessels. While other US advanced composites industries share similar challenges with export controls, the CF-PMC aerostructures industrial base is the most widely impacted. The specific foci of this sector study included CF-PMC feedstock material suppliers (e.g., fiber and prepreg producers), Tier I & II composite fabricators of aerostructures and major OEM integrators of commercial and military products and systems. Additionally, the study included manufacturers of automated CF-PMC processing machines and providers of industry specific professional services (technical and marketing).

Worldwide revenues of the CF-PMC industry in 2005 was estimated at \$27B for fabricated composites across three major market segments—industrial, aerospace-defense and consumer product (sporting goods) applications. Of this amount approximately \$7B represents the value of aerospace and defense fabricated aerostructures. Approximately \$1.5B of this amount is the size of international demand for aerospace and defense feedstock materials (i.e., fiber and prepreg). Most of the CF-PMC industrial base (feedstock, composite fabricators and product integrators) is evenly distributed between, the US and Europe. The US has historically maintained leadership in space and defense aerostructures as well as related fiber and prepreg materials. Europe has traditionally maintained prominence in composites fabrication of commercial aerostructures and industrial products as well as niche areas of various high temperature resins and complex

woven fiber performs. However, Japan is by far the world's leader in carbon fiber production and an emerging supplier of leading-edge commercial aerostructures. Developing countries in Asia have long dominated composites fabrication of consumer sporting goods and play a growing role in manufacturing commercial aerostructures. Many of these industry leadership positions are regularly challenged and some are shifting due to a host of emerging globalization dynamics.

The early-stage development of today's CF-PMC aerostructures industrial base began in earnest during the late 1960s and early 70s and was led by DoD R&D investment in various aerospace and defense requirements. Subsequent technology maturation and transition throughout the 1980s and early 90s were fueled by DoD acquisition of military aircraft, ballistic missiles and satellites. At the height of the Cold War, DoD constituted nearly 50% of the US industrial base demand for CF-PMC's core feedstock material (carbon fiber). However, the large-scale popularity of CF-PMCs for diverse civilian applications quickly soared and commercial uses (industrial products, consumer goods and civilian aerospace) soon outpaced DoD demand. By 1999 DoD carbon fiber use declined to 9% of US demand and 4% of global consumption. Key factors contributing to the commercial success include increasing manufacturing affordability of CF-PMCs, a proliferation of commercial applications worldwide, and concomitant rapid industrial base globalization of CF-PMCs. DoD has benefited from increased capacity, innovation, affordability and productivity due to the expanding, commercial industrial base.

These dual-use industry dynamics are increasingly becoming conflicted with US export controls. The traditional notion of exports as foreign trade of physical products is being superseded by global supply chain enterprising, offshoring of manufacturing and R&D, export trade offsets (revenue-sharing), global teaming and joint ventures, foreign direct investment, licensing of intangible assets, etc. CF-PMC exports are regulated under both the Department of Commerce (DOC) via the CCL for dual-use goods and services and the Department of State under ITAR for highly sensitive materials for ablative, signature reduction, high temperature resistance and low coefficient of thermal expansion requirements. These controls regulate sales of CF-PMC feedstock materials, fabricated aerostructures, automated manufacturing equipment and technology "know-how," encompassing expertise in CF-PMC development, manufacturing processes, products and applications. ITAR maintains virtually complete control over exports of fabricated CF-PMC aerostructures for military and space-based end-uses and retains very tight and

comprehensive control over CF-PMC know-how. DOS and DOC share control over various Missile Technology Control Regime (MTCR) items and technology.

DOC control of feedstock material is largely based on the physical performance levels of materials (typically strength, modulus and temperature resistance). DOC controls also regulate trade in both advanced and less advanced, automated CF-PMC manufacturing equipment. Controls on the international exchange (export) of know-how can apply to almost any facet of CF-PMCs (i.e. from development to production to sustainment) while also applying to both controlled and uncontrolled materials.

While DOC regulates a rather limited number of CF-PMC feedstock materials destined for foreign markets in developing regions of the world, little to no control exists for NATO countries and within other nations with close US security ties such as Australia, Japan and South Korea. Most grades of feedstock material can be exported to almost anywhere in the world without a license, and most US exports are uncontrolled materials. More than 80% of US exports are destined to markets in Europe and most exports to Europe of controlled (licensable) materials are granted license exceptions for both commercial and most defense related uses. **As such, no widespread, demonstrable adverse impacts have been found due to Department of Commerce controls on exports of CF-PMC feedstock material. However, rising foreign demand for higher performing materials and the continued shift of industrial base supply chains to emerging markets (such as China, India, Brazil, and Russia) will likely result in greater control of feedstock materials.**

DOC controls on know-how, however, deeply penetrate CF-PMC firms' global supply chain through control of technical exchanges between individuals and "stacks" of enterprise-level collaborations between material suppliers, composite fabricators, subassembly contractors, OEM integrators as well as providers of engineering, design, testing and R&D support. For an example, the Boeing 787 *Dreamliner* commercial aircraft incorporates record use of CF-PMCs (over 50% of structural weight) and will apply some of the most sophisticated approaches to composites manufacturing. In addition the *Dreamliner* is employing a radically new, internationally distributed, technology development and manufacturing supply chain business model. This will result in most of the fabrication for this aircraft being outsourced with a large portion of this subcontract work taking place in developing countries to satisfy export offset obligations (revenue-sharing) while maximizing OEM cost-reduction, profits and business risk sharing. Reportedly the Department of Commerce controls on know-how have increased supply chain costs, caused scheduling delays and diminished foreign teaming

opportunities with attendant costs estimated to be millions of dollars. Beyond disrupting such exchanges between suppliers and customers, deemed export regulations interfere with interactions between US and foreign employees of the same firm that might collaborate on manufacturing process improvements, business development and new product innovation within the US and at offshore manufacturing and service facilities.

As described in the sector report on machine tools, DOC through the CCL tightly controls automated manufacturing equipment exports, inhibiting US firm presence in certain emerging high growth markets in less developed countries (China, India, Brazil, Malaysia). European competitors enjoy licensing advantages for machine sales to China, the fastest growing market. A recently approved license in Spain to export a tape laying machine to Harbin Aircraft in China (a manufacturer of aircraft for military and commercial uses) is cited as an example of Europe's less stringent controls providing a competitive advantage.

While automation equipment licenses are regularly granted for US exports to Europe, licensing conditions can be restrictive. For example, DOC will approve a machine export to a major European aerospace and defense firm, but prohibit the use of the US equipment for the development and manufacturing of certain aerospace and defense aerostructures (missiles, launch vehicles and unmanned aircraft). US OEMs believe their European counterparts are not similarly constrained. These equipment automation restrictions impact multiple tiers of US composite fabricators and domestic prime integrators who confront controls on machine process know-how when dealing with foreign firms in their supply chain thus disrupting globally distributed manufacturing enterprises. This further underscores an important emerging phenomenon in globalized competition: individual businesses are now competing at the global level of supply-chain-verses-supply-chain rather than competing simply at the local, firm-to-firm level. Unfortunately, in the CF-PMC arena the current controls on technological know-how impinge directly on the ability to form and maintain such globally dispersed supply chains.

DOC's proposed "China Catch-All," if implemented, would further tighten CF-PMC controlled exports to China as well as extend control to previously unregulated exports. This new rule would broadly constrict trade with a leading world market, significantly raise business uncertainty and increase regulatory risks associated with increased exposure to elevated control demands. Given that leading competitors of US firms in Europe would not face similar constraints, unilateral implementation of this proposed rule change would place US firms at an increased disadvantage.

ITAR controls, while specific to a limited number of very specialized military-related materials, also entail industrial base dynamics that are largely similar to those described for the dual-use industry. Most of these exports are to established European markets, and most licenses are ultimately approved. As such, **no demonstrable adverse impacts were identified due to ITAR's denial of licenses of US CF-PMC feedstock for military specific aerostructures.** However, the Department of State's implementation processes for the review and approval of licenses is besieged with serious problems including substantial delays, inconsistencies in decision-making, intrusions into supplier-customer relationships, and lack of process visibility, efficiency and accountability. These mounting problems in ITAR's implementation could reduce US leadership in European defense markets through European integrators designing out US ITAR products and providing incentives for the formation of non-US competitors. ITAR also imposes pervasive controls on technology know-how (i.e. TAAs and MLAs), impacting not only defense firms abroad and foreign defense ministries of close US allies but also directly affecting ongoing DoD military aircraft production (UH-60 Black Hawk), development of future combat systems (F-35 Lightning II) and associated export trade offset ventures. Various manufacturing, and development programs, have experienced scheduling delays, significant increases in costs and impediments to innovation of importance to DoD. Industry reports that millions of dollars of added supply chain costs result from these controls.

ITAR is increasingly impacting commercial aircraft production, due to "tainting" of CF-PMC aerostructures. Decades old legacy technology originally developed by industry with DoD funding and (or) qualification testing for a former defense program are typically considered ITAR classified (tainted). The added costs of industry "fire walls" and requalification of legacy ITAR technology for future commercial uses are measured in the tens of millions of dollars. Not only does this conflict with the fundamental business case for advancing a dual-use industrial base for the ultimate benefit of DoD and the civilian economy, but ITAR tainting can retard the continued technology maturation and future evolution of earlier R&D investments. For example, ITAR tainting impacted DoD's recently concluded \$150M Composites Affordability Initiative (CAI), in which private industry contributed 50% of the cost. The commercial aircraft industry is reluctant to commercialize CAI technologies because of ITAR tainting as major aircraft OEMs prohibit use of such tainted technologies in their products. Thus, DoD and US industry are not fully utilizing CAI's CF-PMC investments for either military or commercial applications. Similar ITAR tainting impedes DoD partnerships with US industry and

local universities through such investment vehicles as R&D broad agency announcements (BAAs), internal research and development (IR&D), Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTRs) and Cooperative Research and Development Agreements (CRADAs). **US firms and domestic universities are “opting-out” of DoD R&D cooperation opportunities and US industry is offshoring R&D abroad to escape ITAR tainting of future dual-use developments.** This is ironic since a cornerstone to the past success of the US dual-use industrial base for CF-PMC aerostructures is founded on the spin-on/spin-off opportunities, public-private collaboration and risk sharing entailed in this dual-use approach.

In conclusion, **the impacts and effects of export controls on this highly strategic and economically important US industrial base is not meaningfully measured by the modest loss of traditional export sales of physical products. More important are the broader effects on future competitiveness and implications of export controls at the global supply chain level for such a highly distributed manufacturing and R&D enterprise.** This wider perspective on larger-scale industrial base impacts of export controls requires developing a greater understanding of national and economic security implications and expanded insights on the highly dynamic and increasingly globalized, dual-use, US advanced materials industrial base.

## Department of Commerce Report on US Imaging and Sensors Industry— Export Control Findings

Infrared and thermal imaging and sensors is another technology sector identified for this study as potentially having been adversely affected by US export controls. Assessment was postponed pending completion of a separate study by the Department of Commerce: *Defense Industrial Base Assessment: U.S. Imaging and Sensors Industry*, released October 2006. The DOC study probed deeply into the economic health of this sector using its unique authority to directly survey individual companies. This made it unnecessary for IDA to assess the economic situation of this sector, but IDA did have to wait for the DOC study's findings before proceeding. Since the DOC study was completed only in the month prior to IDA's study deadline, only a preliminary review of its implications in terms of the impacts of export controls was possible.

The DOC study shows that the global market for imaging and sensors has been healthy and growing. Total US sales in 2005 were \$3.9 billion of which two thirds were for the military market. US exports of imaging and sensor products steadily increased from \$280 million in 2001 to \$462 million in 2005. In 2005 about 12 % of total revenue was derived from exports. US share of exports has been approximately 10% of worldwide exports. Night vision devices and components and *cooled* infrared imaging systems (predominantly for military systems mostly sold to NATO countries and Japan) were the two largest export categories each at about 25% of total US exports.

However, US exports of commercial uncooled infrared imaging devices—a growing product category in which the US was the only exporter in 1999—declined by almost two-thirds during the period between 2001-2005 from \$55 million to \$20 million. US manufacturers believe that export controls have played a large part in this decline, as European and Asian suppliers faced fewer export restrictions. For higher-end 640x480 focal plane arrays, for instance, the five major US manufacturers are not exporting due to foreign-based customers' displeasure with US export control restrictions, while EU firms are exporting these arrays. Given this loss of export revenue, it should be noted that robust domestic demand allowed total US revenue in uncooled IR imaging devices to still increase from \$202 million in 2001 to \$343 Million 2005.

Overall the health of the US infrared and thermal imaging and sensors industry rests on DoD acquisitions. However, about one-third of the total market is for commercial applications and it appears that export controls are a negative factor on the competitive position of US firms in this segment. Approximately one-third of manufacturers surveyed specifically recommended that current US export control policies be modified, with just under half of these reported losing sales due to export controls. Overall, export controls are estimated to reduce US manufacturers' *export* revenues by approximately 10%, or 1 % of total revenues, with potentially greater impacts in the future due to the lack of follow-on contracts. Certain US manufacturers are moving manufacturing offshore reportedly to take advantage of less restrictive controls. However, **in the final analysis, there has not been a demonstrable economic impact of export controls on this industry sector.** As with other industry sectors reviewed in this study, this is not to say that export controls are not an impediment causing competitive difficulties for US industry nor does this mean that such controls are implemented appropriately or effectively relative to US security interests. Nor does this imply there may not be significant negative impacts in the future on the competitiveness of the US IR and imaging industry due to export controls. For policymakers these conclusions imply that past and current economic impacts, and industry claims about such impacts, are not a definitive basis for determining the merits or problems associated with export controls. Thus, any policy decisions on revising export controls in this sector should be based on other criteria.

## E. CLOSING THOUGHTS

The Institute for Defense Analyses was tasked to assess the economic impacts of export controls on the defense industrial base. In conducting the study emphasis was placed on employing quantitative metrics of these impacts, getting “beyond anecdotes.” The study focused on four industry sectors: satellites, microelectronics, machine tools, and advanced materials. **For all of these sectors quantitative data, while generally available on business health and trends, did not reveal major impacts of export controls.** With controls limited to trade-related activities to certain proscribed destinations, such as China, North Korea, some Middle Eastern countries, and a few others, and the aspects of what is controlled being limited to certain higher-tech products and processes, by and large the overall economic impact of these controls is marginal compared to the overall scale and scope of these industries. **However, the impact on specific leading companies in the most advanced segments of these industries is, along with general globalization trends, encouraging leading edge product development to move overseas.** US implementation of export controls act like an import tariff on selected advanced technology products from the US. In a globalizing world, where firms are increasingly multinational and product development is multinational, a tariff on exports encourages firms to move advanced research overseas. In segments where the US maintains a significant historical lead and a diverse industry, such as in satellites and microelectronics, these impacts are not pronounced. In segments such as machine tools and advanced materials, where the markets are dominated by a small number of firms—often only one or two in a given country—export controls could contribute to the US-based firms abandoning the leading edge of the industry.

There is clearly an opportunity today for government and US industry to come together to modernize export controls to facilitate the *shared* goals of national security and economic competitiveness. Certain reforms can be made to simplify the application process, such as more effective information technology solutions and better integration of the various government offices involved in the licensing process. Reforms such as the Validated End User provisions of the recent “China Catch-All” proposal, if implemented appropriately and efficiently, could greatly facilitate maintaining international customer relationships. The control lists themselves need to be continuously updated so that different agencies are not applying different controls to identical technologies and, more importantly, so that time is not wasted attempting to control technologies that no longer

warrant such scrutiny, while facilitating faster and better review of genuinely critical technologies.

More deeply, the US government will benefit from research delving into the impacts of export controls on global supply chains and capital flows—particularly large scale multinational programs such as the 787, P8-A, Bell 407 and ACH 70—and, related to these, the changing locus of innovation in the international technology system. Such understanding would facilitate export control implementation becoming a constructive US policy tool that promotes both national security and economic competitiveness. For DoD in particular, better understanding the impact of export controls on major multinational defense programs could have broad implications on policies related to coalition warfare, as well as down-to-earth implications for military export trade offsets. Taken together, improved understanding of these phenomena would have implications for implementation of public-private S&T partnerships such as CRADAs, SBIRs/STTRs, BAAs, IR&D, and manufacturing technology (ManTech), e.g., the Composites Affordability Initiative.



INSTITUTE FOR DEFENSE ANALYSES

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**Export Controls and the  
U.S. Defense Industrial Base**

**Volume 2: Appendices**

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**APPENDIX A**

**IMPACTS OF EXPORT CONTROLS ON THE US SATELLITE INDUSTRY**



## SUMMARY

The Institute for Defense Analyses assessed the impacts of International Traffic in Arms Regulations (ITAR) on the US satellite industry. The study considered quantitative metrics such as lost revenues and unilateral costs, metrics on competitiveness, as well as qualitative impacts such as access to international talent. Data were collected via (1) interviews with industry, academia, and government officials; (2) government and industry reports; and (3) various open publications. From these sources, IDA constructed a database of global satellite sales, launches and subcontracts by region and by type for the period 1995-2006. This database was used to analyze the market position of US satellite prime contractors and subcontractors over time and to discern any changes in that position due to changes in export controls.

Today, all satellite and satellite component exports are licensed through the ITAR process, administered by the US Department of State (DoS). Related services and technical data transactions must also be licensed under a Technical Assistance Agreement (TAA). A representative from the Defense Technology Security Administration (DTSA) must be present at all meetings with foreign persons (with exemptions possible for NATO and other major allies), and Congress must be notified of all contracts valued at more than fifty million dollars. Between 1995 and 1999, export of commercial satellites, components and services were regulated under the Commerce Control List (CCL), administered by the Department of Commerce. The CCL regulates exports of “dual use” technologies and equipment: i.e., items that are primarily used for commercial purposes but also have significant military applications. CCL controls generally are significantly less stringent and more transparent than ITAR controls.

Throughout the period from 1997 to today foreign governments have regulated commercial satellite exports under their commercial export control regimes based on the Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies,” while in 1999 the US controls on satellites were moved by Congress to the ITAR from the CCL. Commercial satellites have become a global commodity with little difference between products offered by US and European primes in terms of performance, reliability, or ease of use. By applying ITAR controls to satellites, the US seeks to control technologies that are not tightly controlled by foreign governments and are widely

available from foreign sources. The changeover in US satellite export controls from CCL to ITAR in 1999 provides a basis for comparison of the impact of the US export control regime on the competitive position of US industry relative to their foreign competition—a concern that has been raised frequently by the US satellite industry.

The Department of State is currently overwhelmed by the quantity of ITAR applications—an increase of more than fifty percent since 2000—with processing delays often reaching several months. The backlog of cases is massive and growing as of this writing. In one instance, consideration of a company’s license application did not begin for six months after submission. License applications are processed case-by-case, with little transparency or predictability. The impact of processing delays and uncertainties is particularly acute for TAAs, directly affecting business development and execution of contracts.

Because foreign suppliers do not face similar controls, US export controls and their implementation impose unilateral hurdles on US satellite makers and suppliers and risk creating dissatisfaction among foreign customer with US suppliers. Industry representatives cited specific cases in which contract awards were lost due to ITAR processing delays or the inability to share technical data to back up the US company’s offering. Additional licenses are required for failure investigations, and a foreign subsystem that is sent to the exporting country for repair must be licensed for their return trip to the customer, meaning that US firm importing that subsystem cannot respond rapidly to urgent customer needs. One US subtier supplier indicated that it might exit the international marketplace if a “solution to export controls (is) not found.”

The precise economic impact of such delays and additional constraints on US satellite firms on the overall US satellite industry is difficult to discern against broader trends in the satellite industry, which is cyclical and “lumpy” due to the small number of launches in any given year. 1999, the year in which export controls on satellites moved from CCL to ITAR, corresponded with a major downturn for the worldwide industry. Satellite manufacturing faced significant overcapacity due to larger, longer-lasting satellites, and more efficient use of spectrum.<sup>1</sup> The combination of growth in power, size, and design life make the average satellite of today approximately nine times more capable than the average satellite launched in 1990. Additionally in the mid-1990s, European firms EADS and Alcatel aggressively entered

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<sup>1</sup> Futron Inc., “How Many Satellites are Enough? A Forecast of Demand for Satellites 2004-2012,” 2004.

the satellite market. Given these trends, US satellite revenue hit an all time low of \$3.2 billion in 2005, and overall US market share decreased as well.

The global export market is comprised primarily of commercial geosynchronous (GEO) satellites, and US commercial GEO satellites are the predominant US satellite export. From 1995-2006, export revenue from commercial GEO programs was about half of US firms' total GEO revenues. The US has historically dominated the global GEO export market. However, US market share for satellite prime contractors between 1995 and 1999 (under CCL control) was 68% compared to 58% between 2000 and 2006 (under ITAR), while EU firms' market share increased from 19% to 28% during the same periods. US industry cites this shift as evidence of the impact of tighter export controls. For example, Canadian TELESAT bought fifteen satellites from US vendors prior to 1999 but acquired the last three from Astrium, stating to the US vendor, "We will not buy from US due to export controls." However, analysis indicates that changes in US GEO market share have been consistent with trends in the global GEO and domestic US satellite markets. Due to the small number of launches, market share can vary widely by manufacturer and by region from year to year. For instance, US market share in 2005, measured in revenues, was 37%, but in 2006 it was 75%. Thus, while the entry of European firms into the satellite market clearly created additional options for the satellite telecommunications service providers, the data is not conclusive that export controls have had a major impact on the competitive position of US satellite makers and subtier suppliers.

Major telecommunications service providers represent a large share of the commercial GEO market. These customers tend to purchase from companies from a specific region. Eutelsat, a European intergovernmental organization, has always purchased from European companies. Similarly, many US companies only buy US made satellites. Moreover, customers switch manufacturers within a region: Data shows that customers will often change prime contractors, even within major constellations. The point is that customers increasingly look for the best offer, without loyalty to specific companies or regions.

Viewed from the perspective of customer buying trends, *Canadian TELESAT is the only example of a major customer permanently moving away from US manufacturers after the change in export jurisdiction from CCL to ITAR.* Arabsat, while blaming ITAR for not buying US satellites, has actually never purchased a US satellite. ITAR controls may have contributed

to a drop in US sales to European customers, but the US presence in Europe was small to begin with.

While China has never been a large GEO customer, those satellites it has imported have been mainly from the US. However, since 1999 a European firm has won a few contracts. As this market grows—Teal Group forecasts sixteen indigenous Chinese satellite programs scheduled for launch in the next ten years with very few prospective imports. Thus, with the Chinese seeking to produce their own satellites, it is not clear that ITAR will impact the ability of US firms to sell into the Chinese market. Moreover, China claims to be achieving “many important technology breakthroughs through independent research” and, as in other technology areas, is pursuing increasingly sophisticated indigenous capabilities.

Satellite component markets tend to be linked to the prime contractors and hence show the same regional biases: European primes tend to use European subcontractors, and US primes buy from US firms. Because US component manufacturers did not have a large share of the European market before 1999, US firms did not appear to lose market share abroad following the 1999 ITAR change (though the study’s data on this was limited). Outside Europe, the US component manufacturers have increased their foreign market share. Recent moves by European firms, which sometimes advertise their offerings as being “ITAR-free”, may erode the small foothold US component manufacturers have in emerging foreign markets.

Universities have claimed that export controls make US graduate school less attractive relative to their foreign competition, inhibit their foreign faculty in their research, interfere with cooperative research with foreign nationals, and force universities to decline certain research grants. Analysis of the data did not confirm any of these effects, though data specific to the satellite industry was not readily available.

In conclusion, export controls are only one factor in the buying decisions of satellite customers. European capabilities and presence were growing relative to the US before the shift from CCL to ITAR, and all existing manufacturers can expect to lose market share as emerging countries develop indigenous capabilities. *All in all, there is little quantitative evidence that export controls have diminished US prime contractors’ success in international markets. This being said, strong and increasing foreign availability raises strong doubts as to whether US export controls have any benefit for US national security that would justify stringent ITAR*

*controls*. If the intent of US export control policy on satellite technology is intended to keep China behind the state of the art, to keep US firms ahead of rest of world, or to sustain US industrial capabilities, these policies have failed. If anything, export controls have likely spurred foreign governments to develop their own industrial capabilities and avoid use of US technology.

The study team recommends that the US adopt specific technical criteria related to military criticality, via the Commodity Jurisdiction Review process, in order to determine whether ITAR controls should be applied to particular satellites and components. The value and need for onerous and costly DTSA monitoring of satellite-related meetings with foreign customers and suppliers should be reconsidered. Moreover, the serious breakdown in ITAR case processing should be rectified.

## Outline



- Tasking
- ITAR background
- Data Sources
- Findings
  - Process
  - Industry
  - Academia
- Conclusions

## Tasking



- Study assessed the impact of the International Traffic in Arms Regulations (ITAR) on the US aerospace industry
  - Identify appropriate metrics for evaluating the impact of ITAR
  - Assess the actual impact using these metrics
  - Assess other, non-quantifiable measures of ITAR impact on the US aerospace industry
  - Identify potential actions by the U.S. government to mitigate ITAR impact

- Focus specifically on satellite segment of aerospace

3

The Institute for Defense Analyses assessed the impacts of International Traffic in Arms Regulations (ITAR) on the US satellite industry. The study considered quantitative metrics such as lost revenues and unilateral costs, metrics on competitiveness, as well as qualitative impacts such as access to international talent. The satellite industry sector study was conducted conjointly with a study sponsored by the Office of Science and Technology Policy. While both sponsors were interested in the economic impacts of export controls and expressly on the development of metrics to assess these, the STPI study focused more broadly on issues concerning the science and technology base for satellites as well.

## Critical Issues



- How is ITAR implemented in the aerospace industry?
  - What is covered?
  - What is the process?
  - How is the process implemented?
- What is the commercial impact of ITAR?
  - Revenues/contracts
  - Costs
  - Human resources
- What is the academic impact of ITAR?
  - Foreign graduate students and faculty
  - International collaboration
  - Space related research at universities
- What is the national security impact of ITAR?
  - U.S. vs. Foreign access to critical national security technologies
  - U.S. vs. Foreign expertise in critical national security technologies

5

The joint IDA-STPI team used the questions above as a framework identify and evaluate appropriate metrics in order to assess the impact of ITAR on the aerospace industry.

## Study Metrics



- **Export Control Process**
  - Government
  - Industry
  - Academia
- **Economic Performance** — How have export controls affected:
  - Revenue
  - Sales [wins / losses]
  - Costs of Operations
- **Competitiveness** — How have export controls affected:
  - Technology dominance
  - Foreign cooperation—joint ventures
  - Buyer impacts
- **Academia** — Impacts on
  - Academic diversity—access to and involvement with international students
  - Collaborations—involvement with international institutions in research

6

The study team identified four primary areas for analyses and identified metrics to assess the impact on each area. This study addresses each area in the “Findings” section, with Economic Performance and Competitiveness covered in “Industry.”

## Agenda



- Tasking
- ITAR background
- Data Sources
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  - Industry
  - Academia
- Conclusions

7

This section provides the context and background for the study.

*ITAR Impacts Satellites Cradle to Grave* 

- Marketing
- Contract Negotiation
- Manufacturing
- Shipping
- Launch
- Insurance
- Failure Investigations

**Using any US components causes the entire satellite to be ITAR controlled; including foreign satellites**

Motivation for "ITAR-free"

8

ITAR impacts all interactions throughout the life-cycle of satellite development. Export licenses are required for all services prior to contract award, such as marketing and contract negotiation. Additional licenses are required for all post-launch services such as failure investigations and maintenance. Moreover, a foreign subsystem that is sent to the exporting country for repair must be licensed for its return trip to the customer, meaning that US firm importing that subsystem cannot respond rapidly to urgent customer needs. US industry contends that these measures have encouraged foreign manufacturers and customers to avoid US components and services. Because foreign suppliers do not face similar controls, US export controls and their implementation are seen as imposing unilateral hurdles on US satellite makers and suppliers and risk creating dissatisfaction among foreign customer with US suppliers.

## How ITAR applies to commercial sats



- USML Category XV
  - “Spacecraft, including communications satellites, remote sensing satellites, scientific satellites, research satellites, navigation satellites, experimental and multi-mission satellites.”
  - “All specifically designed or modified systems or subsystems, components, parts, accessories, attachments, and associated equipment for the articles in this category...”
  - **Communications satellites returned to USML in 1999**
- Types of Licenses
  - DSP: Export of a defense article or technical data
  - TAA (Technical Assistance Agreement): Providing a defense service or technical data
- License Processing
  - **Satellite licenses are always staffed**
  - **Congressional Notification**
    - Defense article or services under contract for \$50M or more (\$100M NATO and major-allied)
    - Requires at least 30 days before license may be granted (15 days NATO and major-allied)
- DTSA Monitoring
  - **All meetings with foreign persons must be attended by a DoD monitor**
    - Costs paid by US company
  - Exemption possible for NATO and major-allies

9

Between 1995 and 1999, export of commercial satellites, components and services were regulated under the Commerce Control List (CCL), administered by the Department of Commerce. The CCL regulates exports of “dual use” technologies and equipment: i.e., items that are primarily used for commercial purposes but also have significant military applications. CCL controls generally are significantly less stringent and more transparent than ITAR controls. Today, all satellite and satellite component exports are licensed through the ITAR process, administered by the US Department of State (DoS). The changeover in US satellite export controls from CCL to ITAR in 1999 provides a basis for comparison of the impact of the US export control regime on the competitive position of US industry relative to their foreign competition—a concern that has been raised frequently by the US satellite industry. Included in the ITAR regulations are requirements for multiple licenses, Congressional notification, and DoD monitoring.

## *ITAR Process: Industry Concerns*



- **ITAR processing within Dept of State is overwhelmed**
  - Delays in processing have reached crisis stage
  - Times for staffing cases & processing TAAs at all time high; seriously impairing business development and execution
- **Lack of transparency and predictability**
  - Lack of information on case status and situation
  - Inconsistent and excessive provisos
- **Control of widely available technologies**
  - No distinction between military and commercial satellites
  - Extra-territorial reach on components
  - Lack of a tiered system
- **US employs unilateral measures that place US firms at competitive disadvantage**
  - US treats commercial satellites as military while competitors consider them as commercial systems
  - Only US has deemed export controls
  - Only US requires government observers for satellite technical discussions

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Industry representatives cited specific cases in which contract awards were lost due to ITAR processing delays or the inability to share technical data to back up the US company's offering. Industry representatives maintain that the lack of transparency and predictability into the process only lead customers to purchase from foreign suppliers. Because foreign suppliers do not face similar controls, US export controls and their implementation impose unilateral hurdles on US satellite makers and suppliers and risk creating dissatisfaction among foreign customers with US suppliers.

## *ITAR Process: NASA Concerns*



- Foreign government space agencies disagree with separate TAA to implement export controls already negotiated in a government-to-government agreement
  - And increasingly are refusing to sign separate TAAs
- Provisos requiring dual-national employees of ESA to sign NDAs
  - Questions applicability when employees are concomitantly citizens of ESA member states
  - Reverse situation (NASA employees signing NDAs) would “conflict with longstanding legal and policy guidance”
- Requirement for additional State review of anomaly activity conflicts with safe real-time operation of ISS
  - Particular concern for ATV/HTV approaches

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While NASA itself, as a government agency, does not have to apply for export licenses, contractors working for NASA do. Not only do NASA programs encounter all of the same problems industry reports, but NASA also faces challenges in collaborating with foreign governments. Foreign government space agencies increasingly refuse to sign TAAs, arguing that export controls have already been implemented by the government-to-government establishing the collaboration. Some US restrictions on citizenship conflict with the laws of foreign partners. For example, the Canadian Space Agency considers inquiring into possible dual-nationalities of its employees a form of illegal discrimination. For several years NASA sought the authority to issue its own export exemptions, similar to DoD’s authority under foreign military sales. Draft exemptions were circulated in 2000 and 2005, but no final action has been taken.

## How ITAR Applies to Universities



- Research, experimental, and scientific satellites controlled by ITAR prior to 1999
- **Fundamental Research Exemption**
  - No license required if article\* or data is generated for "fundamental research"
  - No Publication Restrictions
  - Does not include information/services relating to the launch of a completed satellite
  - Only applies to EU, NATO, ESA, and strong non-NATO allies such as Japan and Israel
    - Foreign collaborators must certify that no articles or data are being provided to researchers from non-approved countries
- **Full-time Employee Exemption**
  - Eliminates deemed export license for full-time employees of accredited institutions of higher education
    - Employees must be informed in writing that they may not further export data
  - Students and postdocs may not be considered full-time employees
  - Note that green card holders are already considered US Persons

\*the only "articles" covered by the fundamental research exemption are category XV (space) articles.  
Any category of data is covered.

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Research, experiment, and scientific satellites have always been controlled under ITAR, not CCL. In theory, academic programs have several exemptions available that vacate the need for a license.

## *ITAR Process: University Concerns*



- ITAR regulations are unclear
- 2002 amendments intended to clarify fundamental research exemption actually included **more restrictive** language
  - Limiting exemption to certain countries (NATO, etc.)
  - Narrowed the definition of “public domain” and “fundamental research”
- “ITAR contains language that implies that the provision to a foreign national of even public domain information may be considered a defense service that requires a license under the ITAR (22 CFR 124.1(a)).”
  - COGR Export Control Brochure

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Academic experiences with export controls have changed recently due to reinterpretations of the regulations. Since 2002, universities have been subject to more cautious interpretations of export law and have experienced the general processing delays at the State Department.

## Agenda



- Tasking
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This section provides the sources used for this study.

## Data Sources



- Interviews
- Process Data
  - GAO reports
  - DDTC website
  - Companies
- Satellite Industry Data (see detail slides)
  - Built database of all satellites launched 1995-2006
    - Program name, Prime, Customer, sector, launch date
    - Value when available
  - Built database of subcontracts to commercial programs (when available)
  - Expected launches 2006-2014 from Teal
  - Industry websites, media (Space News), analysts (Futron)
- Academic Data
  - Science and Engineering Indicators
  - OpenDoors Project

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This study used the above sources for this study. Extensive interviews were conducted with all of the US (and some foreign) satellite systems integrators and many subsystem suppliers. As will be described below IDA built its own database of satellite production and launch based on several open data sources. This data was compared to other compendiums when available, but the IDA-STPI database was used for the economic assessment to avoid having to depend on any single data purveyor for analytical results without having visibility into the underlying data.

## Interviews



Industry	Academia	Government
Associations – Aerospace Industries Association – Satellite Industry Association – Space Transportation Association	• Stanford University • University of Colorado • Caltech • USC	• Department of Commerce • Department of State
Companies – AeroAstro Corp – Aerojet (with STA) – ATK – Boeing Company / Boeing Satellite Systems (BSS) / Boeing – China – EADS – Lockheed-Martin – L3 – Northrop Grumman – Orbital Sciences Space – Systems/Loral (SS/L) – Raytheon		

- Additional interviews, discussions with and briefings from numerous industry, academic and government "observers"

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The study team members interviewed the above organizations for this study. To collect information on actual export control processing experience and to get data on detailed economic impacts often several interviews, iteratively with a single firm were required.

## Satellite Industry Data: Primes



- Prime contractor and customer, historical launch data 1995-2006
  - Primary interest is in large commercial satellites—GEO Comsats
  - Satellite name, function, customer, constructor, and cost (where available) obtained from
    - On-line records of rocket launches, including NASA and space.com
    - DACIS Infobase
  - Will allow us to test for export control effects on prime contracts
  - Does not provide information on lower tier suppliers
- Prime contractor and customer, expected 2006-2014
  - Permits visibility into role of US primes in projected programs
  - Satellite name, function, customer, and constructor (where available) obtained from
    - Teal Space Mission Briefing
- Corporate data on satellites programs
  - Some companies made available their own listings of satellite wins, bids and programs including some categorizing of “export control impacts”

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In order to provide program level industry analyses, STPI team compiled a database of all satellite launches from 1995-2006. This database was used to analyze the market position of US satellite prime contractors and subcontractors over time and to discern any changes in that position due to changes in export controls. The STPI team also compiled a database of projected launches forecasted through 2014. In addition some companies made available their own listings of satellite wins, bids and programs including some categorizing of “export control impacts”. These contained both proprietary information as well as corporate judgments which made this data difficult to use as a primary source, but it was very useful as a check on the completeness of the data we obtained from other sources.

## Satellite Industry Data: Subcontractors



- Current and Future programs listed in Teal's *World Space Systems Briefing*
  - ~94 Programs
- Commercial, mostly GEO, satellites launched between 1995-2005
  - Program/satellite identified on STPI's launch database
  - Search DACIS' Infobase for supplier data
  - ~142 Satellites/Programs
- 1271 subcontracts found
  - Majority launched 1995-2009
  - Occasional launches 1970-1993, and 2011-2015 also included
- Analysis focuses on commercial satellites launched 1998-2001 and 2002-2005.
  - Estimate that payloads launched in 2002 were the first to be affected by the ITAR change during construction

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To the extent possible, the STPI team compiled a database of satellite sub-contracts using Teal Group and DACIS sources. This database was used to analyze the market position of US satellite sub-contractors over time and to discern any changes in that position due to changes in export controls.

## Outline

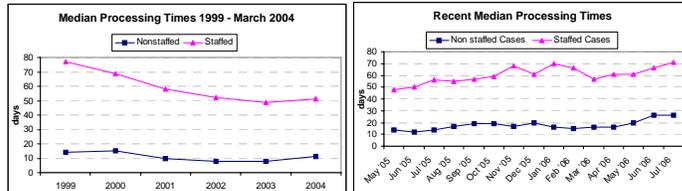


- Tasking
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The section presents the team's findings on the ITAR licensing process.

## State Department Delays



- Median processing times for all arms export cases declined between fiscal years 1999 and 2002, but began increasing in fiscal year 2003 with this upward trend continuing into 2006
  - All satellite applications are staffed (sent to other departments for review)
- Industry reports increased delays in last 2 years
- High case load and low staff numbers continue at DDTC has led to massive and growing backlog

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One major concern of the satellite industry is that the ITAR export case processing system is becoming increasingly inefficient in terms of the time it takes to process cases. State Department statistics verify that case processing has become substantially slower over the past four years. After initially declining through 2002, the median processing time for ITAR licenses has increased to 70 days for staffed cases. Separate statistics are not available by USML category, although all satellite cases are staffed. Several sources have reported that there is a six month backlog at State before cases are first looked at by a licensing officer.

While increasing numbers of cases over this time period (an increase of about 50%) is one factor in increased case processing times, another major factor is the decreased staffing within the Department of State.

## ITAR Processing: Company Concerns



- **Process itself is *the* major issue** — ITAR processing times have increased substantially for 2005 and 2006
  - Major problem is inconsistency and unpredictability in processing times: "Average is 80 days with 70 days standard deviation"
  - Major factor is 50% increase in cases from 2000-2005 (~35,000 to over 60,000). State staff has not kept up—in fact has shrunk
  - Processing time increase centered at DDTC—takes 60-90 days to staff, and over a month to process at end—DoD still turns around in 30 days.
  - 2 years ago cases cleared entire process in 50-60 days; today cases are taking 120-160 days and more
  - Major time and effort required for process and approval of Tech Transfer and Control Plan (takes 2-3 weeks for approval)— 40 days required to schedule DTSA monitors and we bear their cost
  - Staffing issue at DDTC is major problem—do not have the military officers needed to process TAAs
  - Backlog has grown geometrically—companies report the number of cases in DDTC system on a given day has doubled in 2 years

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Thus ITAR case processing is singled out as *the* major issue industry has in dealing with export controls. Both industry and government officials cite the ITAR licensing process as a problem. While issues such as Congressional notification and DoD monitoring contribute to case processing, the issue of delays appears to be localized in DDTC. An increasing in the number of cases compounded with DDTC staffing issues have resulted longer processing times and a growing backlog of cases. Inconsistency and lack of transparency continue to frustrate industry.

Since the entire marketing and delivery process is affected by export controls, this means that companies are hampered in dealing with prospective customers by these delays and further frustrated by delays in receiving licenses and agreements after contracts are signed and during the delivery and launch process. One significant issue, which increases the load on ITAR case processing, is that for any single satellite deal multiple licenses and agreements are required. Moreover, should there be changes or even emergent requirements—such as the need to send a foreign component back for repair—new licenses or TAAs are often needed, and the processing times can make these extremely difficult for the producer in meeting his contract obligations with the customer.

## ITAR Processing: Company Concerns



- Recent foreign wins faced major delays in being able to implement, creating both risk and customer dissatisfaction
  - For Asian customer there were several months delay to receive TAA to proceed after contract since the marketing TAA was no longer valid
    - "Puts us at risk because we cannot hold System Requirement Review with customer, but still need to proceed if we are to make launch commitment"
  - For an off-shore launch on US-owned Sea Launch (with Russian rocket) license application "sat on desk at State for months", and company had to use "extraordinary means" to get license at 11<sup>th</sup> hour to permit launch
  - ITAR seriously impairs marketing—TAAs take 3-4 months putting us at disadvantage in discussing tradeoffs versus what we can provide, while foreign competitors are not similarly constrained
    - "Even with NATO countries we need 45 days advance to get DTSA monitors"

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These types of processing problems are reflected in individual company examples, which show that processing delays and unpredictability are seen as major impediments to US satellite firms. Industry executives cited a number of specific cases where licensing delays have impaired business activities after a contract has been awarded. The ITAR process adds risk in proceeding with the program and it damages the relationship with the customer.

## **ITAR Processing: Company Concerns**



- Have lost awards specifically due to ITAR processing
  - Concerns of customer on “adequate access to data” cited as key reason for loss
  - Info restrictions led to “shallow technical response” to European bid; where a European vendor was able to satisfy customer with “a lot more data”
- “ITAR puts us at competitive disadvantage”...
  - Provisos for DTSA monitoring have caused customers to consider alternative non-US vendors for follow-ons
  - Issue of returning hardware for repair: Licenses take 3-4 months when we need to have response to an urgent need
  - Problem of added license burden when many component manufacturers are merging—and the licenses / TAAs must be reworked

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Industry has argued that the ITAR process has put them at a competitive disadvantage, citing cases where customers have awarded contracts to foreign competitors to avoid US restrictions and requirements, or simply because ITAR restrictions prevent the US company from offering an effective proposal. While the scale and scope of “lost business” is difficult to quantify, and certainly export control problems are only one factor that affect the outcome of these complex business transactions, companies have specifically identified cases where the customer either balked at the terms and conditions of the controls, or was dissatisfied with the level of technical detail that US firms could provide due to export control restrictions. Thus, export controls are seen as an additional competitive disadvantage that US firms must overcome in contending with technically equivalent and highly aggressive foreign competitors. As one firm put it, “export controls are a major factor in every foreign transaction, whether we won or lost.” In addition, losing a single initial bid for a series of satellites has long-term ripple effects, as customers usually do not change satellites in the midst of a specific series.

## ITAR Processing: Company Concerns



Company S (Subsystem vendor):

- Have lost awards specifically due to ITAR processing
  - ITAR processing delays led to loss of subcontracts from European satellite vendors who required quick response
  - European firms do not have processing time constraints
- ITAR puts us at competitive disadvantage
  - TAAs taking 6 months—DSPs 4 months
  - **“Last month (July) State Department started to process applications received in January—a 6 month delay.”**
  - Our system is major disadvantage for interacting with Europeans because of deemed export constraints on who can attend meetings—even a European team that had an Australian required having to remove him from discussions
  - Customer “blackout period” after award (waiting 6 months for a new TAA) causes major concerns for customers—concerned about risks due to lack of communications

**“If solution to export controls not found, Company S may exit the international marketplace.”**

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Subsystem vendors also see major impacts in engaging foreign customers. Export controls affect interaction with foreign firms both in terms of who can be involved and also the flow of the product development. The impact is such that some sub-tier suppliers are seeing that staying in the international business may be just too unpredictable and costly, and consider exiting the international marketplace altogether. The STPI team interviewed one subsystem vendor that claimed it might exit the international marketplace entirely due to export controls. The company cited processing delays as the primary reason for its issues, in addition to complaints about deemed export regulations.

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•	Subcontractors	
•	General Competitiveness	
–	Academia	
•	Conclusions	

The STPI industry analyses examined the satellite prime contractor and sub-contractor markets in order to characterize trends in satellite manufacturing before and after the shift in jurisdiction of commercial satellites from CCL to ITAR. The precise economic impact of delays and additional constraints on US satellite firms on the overall US satellite industry is difficult to discern against broader trends in the satellite industry, which is cyclical and “lumpy” due to the small number of launches in any given year. The following analyses use historical customer tendencies as a baseline for determining whether or not a contract award may have been influenced by more stringent export controls. Also as a part of the industry analyses was an evaluation of the general competitiveness of US satellites vs. foreign competitors.

## Industry Analysis: Study Approach



- Examined
  - Industry-wide trends
    - Revenue (Total, Export, Commercial GEO)
    - Market share
    - Major commercial constellations
  - Regional trends
    - Prime contractors (historical and forecast)
    - Subcontractors (historical)
- In order to determine
  - relative importance of domestic and foreign sales to US companies
  - regional market position
  - US versus Foreign market share
  - impact of shift from CCL to ITAR

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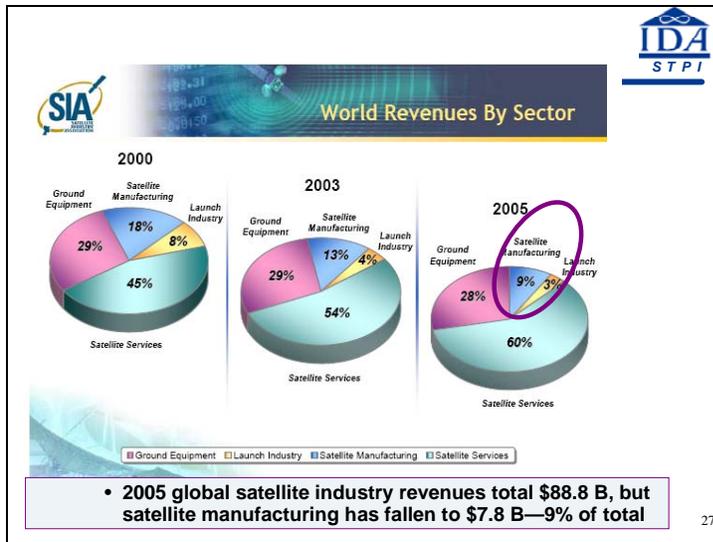
This section of the study examines trends in:

- Global market
- Export market
- Commercial GEO market
- Regional markets

Analyses of program level trends in these areas focuses on whether or not the US position in the satellite industry appears to have diminished (or if an already diminishing position has been accelerated) as a result of the shift in export controls.

Note:

- All program revenue data plotted in launch year (allow at least 18 months for satellite development)
- 2006 data includes launches scheduled through the end of the year



SIA/Futron data has shown that global satellite manufacturing revenue has decreased with respect to revenue for satellite services.

## Factors depressing GEO demand



- Significant overcapacity in the market
  - Transponder utilization ~60%
- Trend towards larger individual satellites
  - Between 1990 and 2002 the average number of transponders per satellite grew by 86% from 26 to 48 (36 MHz equivalents)
- Longer lasting satellites
  - Since 1990, the average design life of GEO communications satellites has increased 38% from 10 years to nearly 14 years
- More efficient use of spectrum
  - “increases in compression rates and frequency reuse, have also contributed to the enhanced performance of each satellite”

“The combined growth in power, size, and design life make the average satellite of today approximately 900% more capable than the average satellite launched in 1990.”

Source: Futron, “How Many Satellites Are Enough? A Forecast of Demand for Satellites, 2004-2012,” 2004.

28

A study conducted by Futron in 2004 attributed shrinking global demand for satellite manufacturing to overcapacity and superior technology.



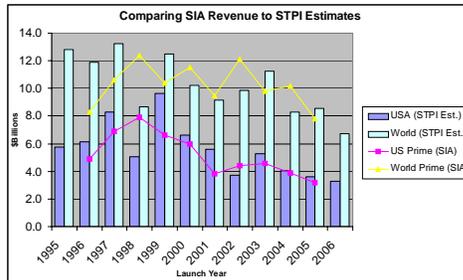
1999, the year in which export controls on satellites moved from CCL to ITAR, corresponded with a major downturn for the worldwide industry. Additionally in the mid-1990s, European firms EADS and Alcatel aggressively entered the satellite market. Given these trends, US satellite revenue hit an all time low of \$3.2 billion in 2005, and overall US market share decreased as well. This fall in market share is widely cited by industry as evidence that export controls have damaged the US satellite industry.

## Satellite Manufacturing Revenue



- STPI developed data on satellite revenue to provide independent basis for detailed analysis
- Estimated revenues applied when contract values were not available
  - GEO: \$200M
  - NGO: \$50M
- STPI vs. SIA / Futron: STPI totals show a higher market share for US companies

- Percent of payloads with estimated value, by prime region
  - USA: 12%
  - Europe: 36%
  - ROW: 73%



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In order to provide program level analyses, STPI team compiled its own data all global satellite launches since 1995. Fields collected include:

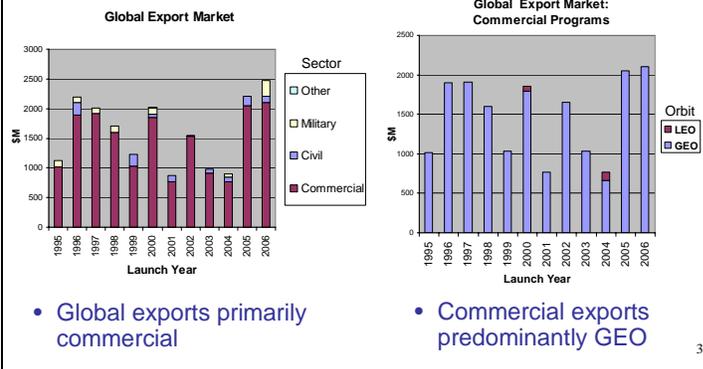
- Launch Year
- Payload Name
- Sector
- Customer Country
- Prime Contractor
- Prime Nationality
- Orbit
- Prime contract value

When prime contract value was not available, STPI estimated the value to be \$200M for GEO programs and \$50M for NGO. SIA/Futron data was not available for comparison.

## Major Focus for Exports is GEO SATCOM Market



- The predominant satellites available for export are Commercial GEOs primarily for SATCOM



31

Because the global export market is comprised primarily of commercial GEO satellites, the following industry analyses will focus on commercial GEO programs.

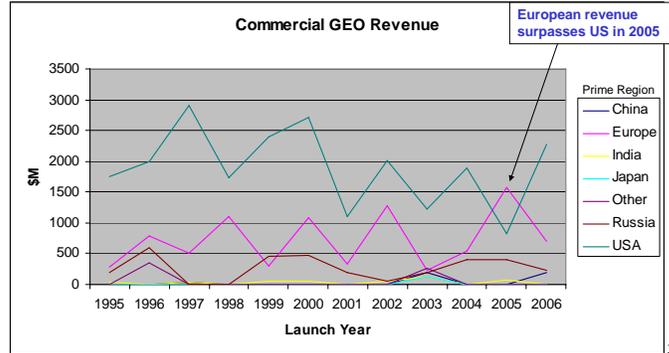
Note:

- For the purposes of this study, Intra-European activity is not included as an export.

## Commercial GEO Revenue: 1995-2006



- US revenue shows step level shift from 2000-2005 while European revenue demonstrates growth trend
  - Both demonstrate saw-tooth variation

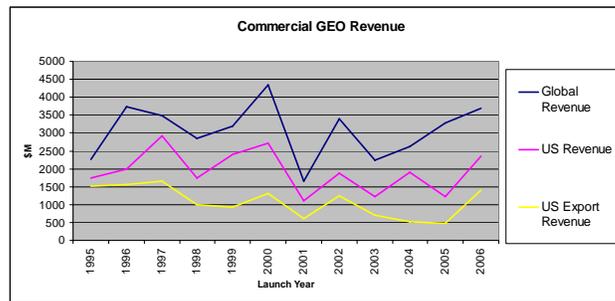


Global prime contractor revenue for commercial GEO satellites is dominated by manufacturers from the United States and Europe, and both demonstrate a saw-tooth trend every 1-2 years. While European revenue demonstrates an upward trend (with respect to peaks) US revenue fell to a 10-year low in 2005. However, in 2006, US revenue rebounded to a 5-year high while European revenue fell. The 2006 rebound in US revenue contradicts claims that the switch from CCL to ITAR has permanently damaged US industry.

## Commercial GEO Market Trends



- Historically, US Commercial GEO total market and export market follow Global Market
  - 2004-5 US export revenues decline while world revenue increases
  - 2006 US export revenues rebound sharply (near all-time high)



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Historically, the US export market tends to follow a trend similar to that of the global market. In 2003-2004, US export revenue continued to fall as the global market rebounded. The depressed US export market corresponds to the time period when the effects of delays and customer dissatisfaction would surface as reduced demand for US satellites. In 2006, however, the US export market appears to recover. Again, the growth in 2006 negates the argument that export controls continue to depress the market.

## Commercial GEO Manufacturers: 2005-2006



- Due to small number of launches, market share can vary widely by manufacturer and by region from year to year

	Manufacturer	2005 Market Share* (#Satellites)	2006 Market Share* (#Satellites)
US	<b>Boeing Co.</b>	<b>15% (3)</b>	<b>14% (2)</b>
	<b>Lockheed Martin</b>	<b>0% (0)</b>	<b>35% (5)</b>
	<b>Space Systems/Loral</b>	<b>17% (3)</b>	<b>19% (3)</b>
	Orbital Sciences Corp.	5% (3)	7% (1)
Europe	<b>Alcatel Alenia Space</b>	<b>21% (4)</b>	<b>14% (2)</b>
	<b>EADS</b>	<b>27% (3)</b>	<b>3% (1)</b>
Russia	NPO Pribladnoi Mekhaniki	12% (2)	0% (0)
India	ISRO	2% (1)	0% (0)
<i>Total Market Share:</i>		100% (19)	92% (16)
<b>Total US Market Share:</b>		<b>37% (9)</b>	<b>75% (11)</b>

\*Market share listed in terms of revenue, not number of satellites launched

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The satellite market is comprised of a small number of high value programs. Because these programs are competed among only a few manufacturers, market share for one region or one company can vary greatly across years. 2005 data shows what appeared to indicate a major loss of market for US manufacturers. US market share fell to 37%, while Alcatel and EADS each experienced record revenue. However, one year later the US combined for 75% of global revenue. In such a high value yet discrete market, year-to-year trends may not indicate larger trends within the market.

## Commercial GEO Manufacturers: 1995-2006



- Commercial GEO market is dominated by 5 manufacturers
  - After switch to ITAR, US Market share falls from 68% to 58% as European firms grow from 19% to 28%
  - ISRO and NPO PM dominate respective domestic markets, but do not export

	Manufacturer	Market Share 1995-1999	Market Share 2000-2006
US	<b>Boeing Co.</b>	<b>31%</b>	<b>20%</b>
	<b>Lockheed Martin</b>	<b>22%</b>	<b>17%</b>
	<b>Space Systems/Loral</b>	<b>14%</b>	<b>17%</b>
	Orbital Sciences Corp.	1%	4%
Europe	<b>Alcatel Alenia Space</b>	<b>11%</b>	<b>16%</b>
	<b>EADS</b>	<b>8%</b>	<b>12%</b>
Russia	NPO Prikladnoi Mekhaniki	5%	8%
India	ISRO	1%	1%
<i>Total:</i>		94%	96%
<b>Total US:</b>		<b>68%</b>	<b>58%</b>

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Analyzing market share in 5-year intervals (as opposed to year-to-year) shows trends consistent with those of the early 90s. The US maintained the majority of the market while European firms grew slowly. While the entry of European firms into the satellite market clearly created additional options for the satellite telecommunications service providers, the data is not conclusive that export controls have had a major impact on the competitive position of US commercial GEO satellite makers.

## Satellite Customer Perspective



- Customers often change prime contractors within major constellations
  - International customers will often choose one prime/bus for a specific satellite series
    - E.g. Inmarsat 2F series uses Eurostar 1000 (EADS) while Inmarsat 3F series uses AS 4000 (Lockheed)
  - Some constellations are captive within one country or region, but switching still occurs within that region
    - E.g. DirecTV is captive to US, but goes back and forth from Boeing to SS/L
- Several examples of switching between US and European suppliers occur both before move from CCL to ITAR
- No apparent evidence of a permanent move away from US
  - Except possibly Telesat Canada

**ITAR is only one factor in buyer decisions**

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STPI examined the historical tendencies of major satellite customers in order to provide a baseline for recognizing shifts due to the shift from CCL to ITAR. It is clear from the data that certain customers tend to purchase exclusively from a specific region. Eutelsat, a European intergovernmental organization, has always purchased from European companies. Similarly, BSAT, a major Japanese service provider, buys only US made satellites. The data also shows that customers will often change prime contractors, even within constellations. Overall, the data shows only one potential shift away from the US.



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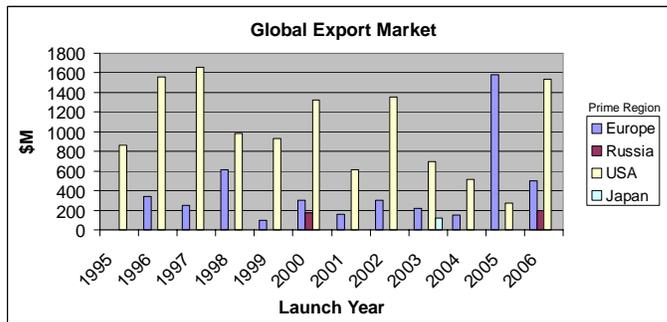
*Export Market Findings*

This section analyzes the global and US export market.

## Global Export Market: Prime Contractor Revenue



- Export market historically dominated by US
  - 2005 appears to be a major boost for Europe, but US rebounds in 2006



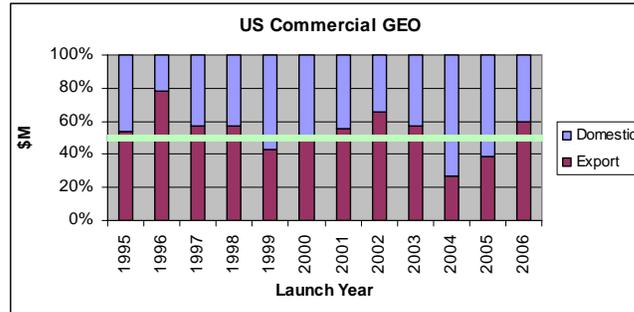
39

US export revenue experienced a sharp and steady decline from 2002-2005, while Europe experienced a major surge in 2005. The 2006 US rebound is a key factor, showing that the US has returned to pre-2000 level revenues for exports.

## US Export Market: Prime Contractor Revenue



- On average from 1995-2006, **export revenue** from Commercial GEO programs has been ~50% of Total Commercial GEO revenue
  - Percent was lower than average in 2004-5, but back to 60% in 2006



• For US commercial GEO firms; exports are clearly important 40

Over the past decade the US-based Commercial GEO business has derived more than 50% of its business from exports. 2004-05 were aberrant years with exports well below 50% of total revenue, but in 2006 exports reached 60%. Clearly loss of export business would significantly reduce total revenue for US manufacturers.

## Details of 2005 European Exports



Payload	Customer Nationality	Prime	Value (\$M)	Shift?	Comments
Anik F1R	Canada	EADS	200	Y	First European built commercial GEO for Canada
Apstar 6	China	Alcatel Alenia Space	200	N	Third European built commercial GEO for China
Inmarsat 4-F1	International	EADS	350	N	Contract awarded in 1999 with Matra Marconi
Inmarsat 4-F2	International	EADS	350	N	Contract awarded in 1999 with Matra Marconi
Thaicom 4 (PSTAR 1)	Thailand	Alcatel Alenia Space	200	N	Thailand has historically only bought from Europe – never from US
AMC 12	USA	Alcatel Alenia Space	140	N	Customer is SES Americom, purchased by SES Global of Luxembourg in 2001. SES Americom as bought from Alcatel in the past.
AMC 23	USA	Alcatel Alenia Space	140	N	

- 2005 export surge from Europe does not appear to be major shift away from US
  - Canada is only example of possible post-ITAR shift

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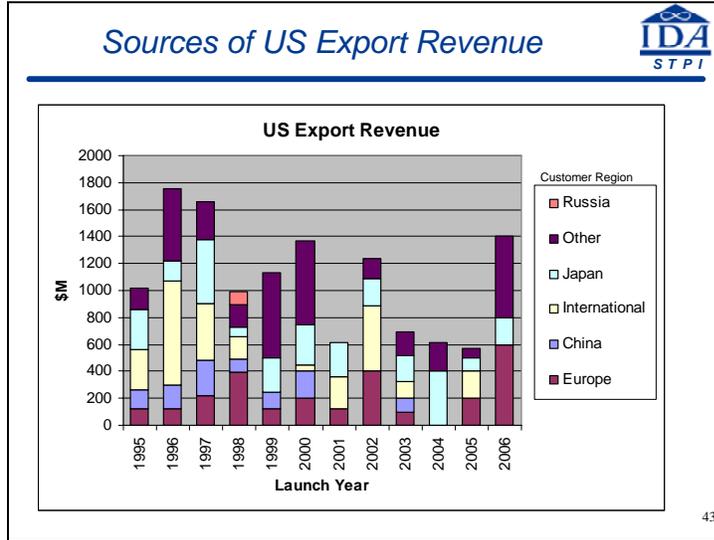
Program level analysis of 2005 European exports shows only one example of a possible Post-ITAR shift. Telesat Canada, historically a US customer, orders the replacement of a US satellite from EADS. All other export payloads in 2005 are consistent with historical trends.

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*Regional Analyses*

This section analyzes the US position in regional markets.

## Sources of US Export Revenue



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US primes export to a large number of global manufacturers. The following analyses will examine trends for specific regions before and after the shift of export licensing to State.

## Regional Analyses Summary



### Available Markets

- Europe
  - Never has been a large customer
  - There are some programs available to US where ITAR may dissuade customers
- Japan
  - US dominates export market
  - ITAR seemingly not a factor
- Other
  - Significant source of US export revenue
  - No trends in shifting prime region
  - Small market in recent years
- Canada
  - Traditionally a US customer, but has switched to European manufacturers
- International
  - Has been significant source of US export revenue
  - Recently US has lost some position— but also gained some back

### Closed Markets

- India
  - Provides own capability
- Russia
  - Provides own capability
- China
  - There are few potential programs available for exporters
  - Many factors in US foreign policy prevent US export to China

- In sum the scale and scope of satellite export market is small and crowded with each competition hotly contested amongst up to 6 potential bidders
- This is a buyers' market for a commodity product

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The section titled “Available Markets” includes those regions with customers who have imported US satellites in the past. Analysis of these regional markets shows little evidence that ITAR has had a major effect on US ability to export. Only Canada demonstrates a move away from US customers. STPI could not identify losses attributable to ITAR in Europe, Japan, International consortia, and other countries. See Backup Slides for data. US companies do not export to regions included in the section “Closed Markets.”

## International Consortia



- Intelsat
  - Historically buys US
  - Intelsat 10 awarded to EADS in January 2000
    - ITAR may have been a factor
- Inmarsat
  - Historically uses both US and European vendors
  - Last award made to EADS in 1999
- Eutelsat
  - Historically buys European
- Arabsat
  - Historically buys European
  - **Has stated that ITAR is a reason it will not buy US**

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Of the major international customers, Intelsat (which now includes Panamsat) and Inmarsat are the only consortia to purchase from the US. STPI could not identify any major ITAR effects in the international consortia. While Arabsat has claimed that it avoids US manufacturers due to ITAR, it had never purchased a US satellite in the past (purchased 4 satellites from Alcatel pre-1999).

Intelsat, the largest commercial GEO customer since 1990, has awarded 28 of 29 programs to US manufacturers.

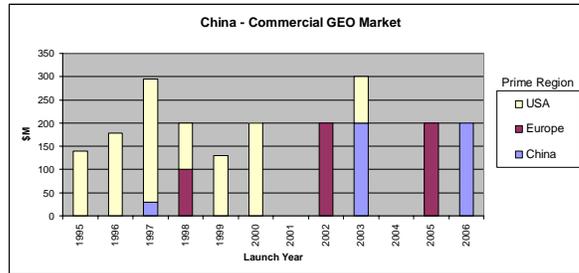
“Intelsat awarded the contract of Intelsat-10 (originally a two-satellite contract, although one of the two was later cancelled) in 2000 to Astrium fearing the effects ITAR, though they later awarded Intelsat Americas 9 to the US manufacturer Space Systems/Loral in 2004 as part of a deal in purchasing Loral’s North American satellite fleet.” – Space Review, <http://www.thespacereview.com/article/533/1>

Panamsat has been the second largest customer since 1990. The US-based company, now a part of Intelsat, has ordered 24/26 satellites from US customers.

## China



- China has never been a large customer for Commercial GEO
- Historically, China has done business with the US
- 2005—Europe gains major win— What will this mean for future?



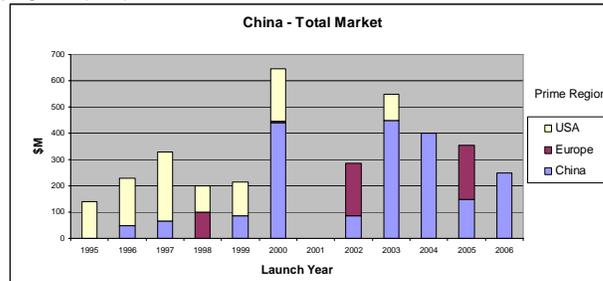
46

In the late 90s, the US dominated the small but steady Chinese commercial market. Since then, the US has been mostly absent from that market while Europe has had 2 wins in the last five years. US industry has voiced the complaint that European manufacturers will have a captive market in China noting that European manufacturers even take advantage of US export control policy with marketing campaigns (i.e. ITAR-free). However, there has been very little commercial business available for exporters in China and recent data suggests that there will be very few opportunities in China, as China appears to be focusing on using indigenous capabilities.

## China: Historical Tendency to “Crawl, Walk, Run”



- In the late 90s, China primarily purchased commercial satellites from the US (*crawl*)
- More recently, the resources have been shifted to indigenous civil and commercial programs (*walk*)



- Teal Group Forecast shows 16 Chinese satellite programs (*run*)
  - 2 Commercial (1 domestic, 1 export to Alcatel)
  - 12 Civil (domestic)
  - 2 Military (domestic)

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China’s focus on indigenous satellite capabilities follows an approach it has followed in many technology sectors: a “crawl, walk, run” policy. In the early stage, China primarily buys technology from foreign countries. China then moves to more advanced expertise through partnerships and collaborations. China uses this expertise to then develop domestic capabilities. China initially purchased most of its satellites from US customers, but has more recently been developing domestic civil and commercial programs. The forecast data shows more evidence of this trend. There is little commercial business available in China for US or other foreign (European) manufacturers.

*“China to launch new communications satellite”*



- “China will launch a new satellite for television broadcasting, mobile communications, and other services in late October this year”
- “‘Xinnou 2’ is China’s first large capacity communications satellite”
- “‘Xinnou 2’, which has taken six years to develop, marks a breakthrough in China’s development of a **new generation of large-capacity static orbit satellites**”
- “China achieved many important technology breakthroughs through independent research”

Source: Xinhua, “China to launch new communications satellite,” Sept. 5, 2006,  
[http://news.xinhuanet.com/english/2006-09/05/content\\_5049526.htm](http://news.xinhuanet.com/english/2006-09/05/content_5049526.htm)

48

This article provides evidence of China’s policy of increasing domestic capability.

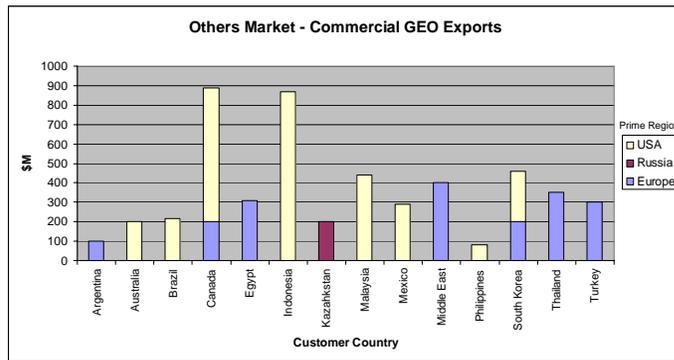
Note:

The source of the article is a state-sponsored media outlet

## Others Market: Commercial GEO Exports



- Exports to “Other” countries have been few



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The “Other” market includes all countries besides the major satellite customers: Europe, Japan, Russia, India, and China. There has been little export activity for commercial GEO programs to “Other” market countries since 1995. Those countries that have purchased satellites have tended to stay within one region. Canada demonstrates a change, as illustrated in the slide 2005 European Exports. South Korea also awards a major program to Alcatel in 2006 after previously launching satellites built by Lockheed.

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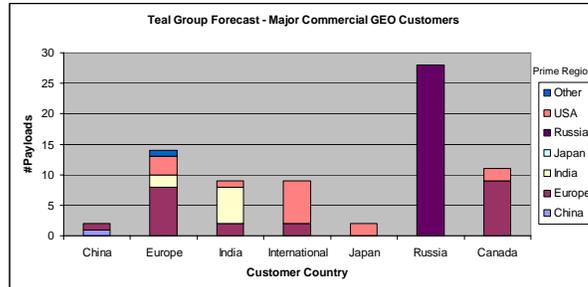
*Regional Analyses - Forecast*

This section analyzes the forecast in regional markets.

## Forecast – Major Commercial GEO Customers



- Similar to historical data
- However, Canada is a major exception, shifting largely to European manufacturers (9 of 11 payloads)
- International shows major gains by US vendors
- India moving into import and export market
  - Will ITAR be a factor?
- Little commercial activity from China



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The forecast for major customer shows trends very similar to those seen in the historical data.

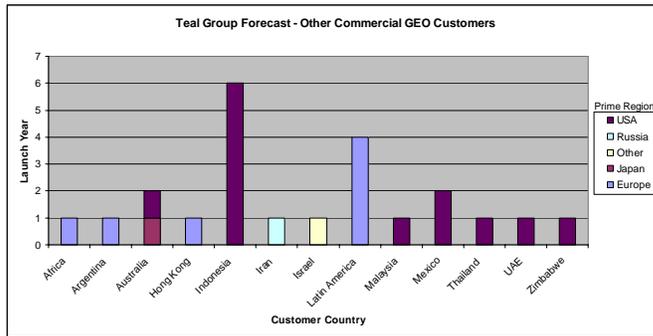
Items of note:

- India imports 2 satellites and exports 1. This could prove to be a large opportunity.
- Canada continues to avoid US manufacturers

## Forecast - Other Commercial GEO



- Other market remains small in the forecast
- Similar to historical data



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In the “other” market forecast, there remains little commercial GEO activity. There is no evidence that ITAR has diminished the US position with smaller customers.

## Satellite Market: Conclusions



- Overall satellite market is cyclical
  - has oscillated from \$8B to \$12B over last decade
  - currently at low
- US Commercial GEO market
  - 2001-2005 US revenue slumped
  - 2006 US revenue rebounds
- European capabilities and presence have grown since the mid-90s (before shift to ITAR)
- Traditional US manufacturers losing market share as competitors (US/others) develop capabilities
- Little quantitative evidence that export controls have diminished US prime contractors' success in international markets
  - Recent and forecast data indicate lost opportunities in Canada, possibly attributable to ITAR

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Using historical tendencies as a baseline, STPI could not identify a major loss in US ability to compete in international markets. While 2003-2005 data appeared to demonstrate a steady decline for US manufacturers, the 2006 data reverses the trend. The STPI team found little quantitative evidence that export controls have diminished US prime contractors' success in international markets.

*Agenda*



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- Tasking
- ITAR background
- Data Sources
- Findings
  - Process
  - Industry
    - Primes
    - **Subcontractors**
    - Competitiveness
  - Academia
- Conclusions

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Anecdotal evidence suggests that small subcontractors have been more severely impacted than the prime contractors by the change in ITAR regulations. It was suggested that small contractors did not have the personnel resources to manage the complex State regulations or the connections to expedite a seriously delayed case as a deadline approached. To investigate the experiences of subcontractors, the research team collected publicly available contracting information from the late 1990s through the present. The analysis considers primes from six different countries and subcontractors headquartered anywhere in the world. The data were analyzed in 1998-2001 and 2002-2005 blocks to determine the success of subcontractors obtaining contracts with primes in and outside their home countries before and after the ITAR switch. The years refer to launch dates, as contracting dates were not always available. Most satellites ordered before the ITAR switch took effect were launched by the end of 2001.

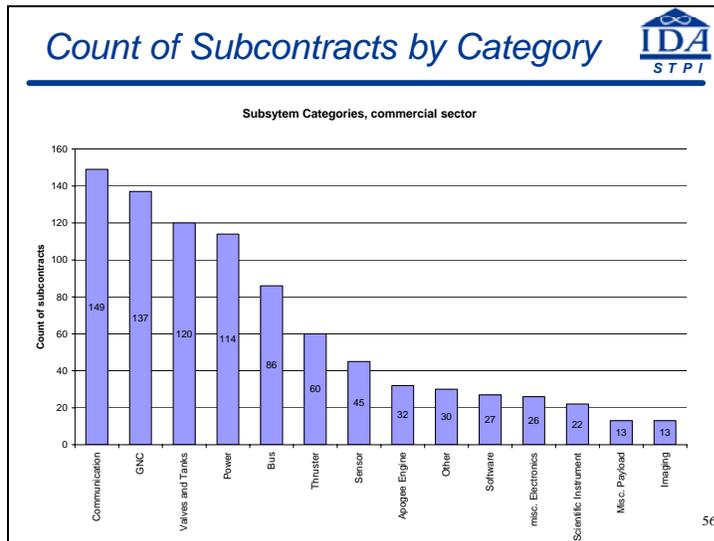
## Subcontractor Caveats



- Subcontract data presented here may not be representative of the market as a whole
  - Includes only subcontracts listed on the program page in Infobase or in Teal's *World Space Systems Briefing*
  - Does not represent a comprehensive list of subcontracts
    - Example: Bus data included for only 86 of 188 commercial payloads
    - Since starting this analysis have found references to additional subcontracts on the internet which are not included here
- Commercial sector only

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Results of this analysis may not be characteristic of the satellite component market as a whole. Publicly available data on satellite contracts are unfortunately sparse. While additional information could be found by searching industry news sites, for consistency, this analysis is limited to data contained in Teal's *World Space Systems Briefing* and Infobase. These program records are incomplete, and the results may be skewed in favor of sectors or companies that are more transparent. For example not all programs have a recorded bus manufacturer, while contracts for valves, which are a comparatively small component, are often given. In addition, results are reported based on number and percent share of reported subcontracts and are not weighted for dollar value, which is usually not available.



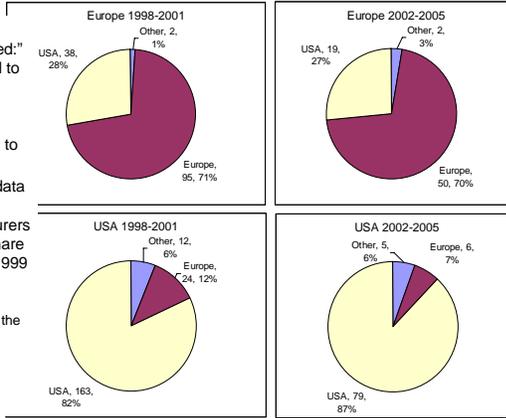
1271 subcontracts were reported on 188 different commercial satellite programs. These subcontracts were grouped into 14 categories. Descriptions of components in each category are

- communication: antennas, TWTAs
- guidance navigation and control (GNC): gyros and reaction wheels
- valves and tanks: thruster propellant valves and tanks
- power systems: solar panels and batteries
- the bus
- thrusters: compressed gas station keeping, electric propulsion
- Sensors: star/earth trackers for navigation
- apogee engines: special purpose chemical engine, distinct from thruster, e.g. R-4D (electrics which are also used for orbit raising are classified as thrusters)
- software: on board signal processing or command software, includes ground system
- miscellaneous electronics: wiring harnesses
- scientific instruments: sensors specially built for scientific mission e.g. Insat's meteorological instruments
- imaging: camera systems, e.g. Orbview
- miscellaneous payload components: data recorders and contracts listed as "payload"
- other

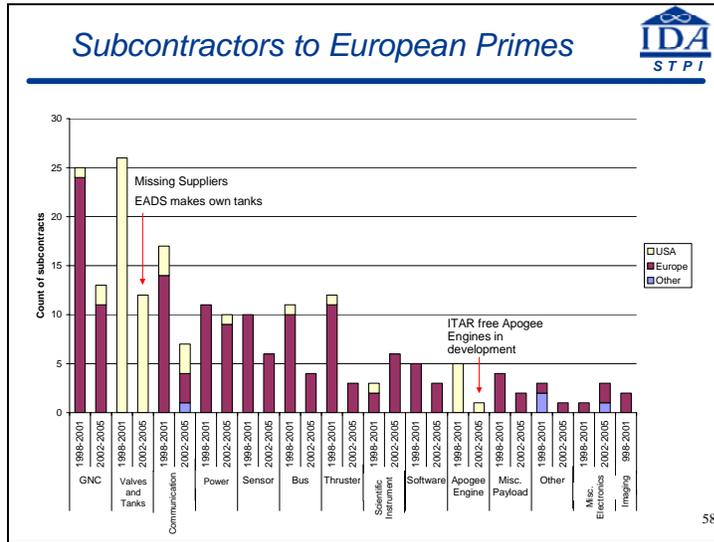
## Share of subcontracts by nationality of Prime and Sub



- Satellite component markets tend to be "tied:" European primes tend to buy from European component manufacturers, and American primes tend to buy American.
- Based on the limited data STPI collected, US component manufacturers did not lose market share abroad following the 1999 ITAR change.
  - Small share of the European market in the 1990s.



Available subcontracting information is summarized here for the two major prime regions: Europe and the US. Based on the available data, both the European and the American markets tend to be “tied”, and were so before commercial satellites returned to ITAR. No evidence of ITAR encouraging American primes to buy American and for foreign primes to buy non-American is seen in the data. However, American manufacturers did not have a large fraction of the European market (as based on number of known contracts) when commercial satellites were controlled by Commerce. Of the subcontracts issued by European primes, 71% went to European subcontractors for satellites launched between 1998-2001 and 70% went to European subcontractors for satellites launched between 2002-2005. American subcontractors had 28% and 27% respectively of the known contracts in those same time periods. American markets are even more skewed towards domestic producers. American primes issued 82% and 87% of the known subcontracts to American companies for payloads launched between 1998-2001 and 2002-2005 respectively.



While American manufacturers have only had about one quarter of the European-primed subcontracts, the data show American manufacturers having market dominance in two component categories. All of the known subcontracts for valves and tanks on European-primed payloads were given to Arde Inc or Moog Space Products. All of the known subcontracts for apogee engines on European-primed payloads were given to Kaiser Marquardt. American dominance in Apogee Engines coupled with ITAR difficulties has caused European manufacturers to develop an “ITAR-free” apogee engine. The strong US presence in valves and tanks is probably misleading: EADS is a known supplier to itself and to Alcatel of propellant tanks.

## Examples of ITAR-Free Components



- Apstar 6
  - Built by Alcatel for a Hong Kong communications company.
  - Launched in 2005.
- European Apogee Motor
  - EADS, ESA, DLR (German National Space Agency)
  - Expected to be available commercially in 2008
- SED-26 Star tracker-based attitude control
  - EADS Sodern
  - Being proven aboard Apstar 6
- Compressed Gas Thrusters
  - Surrey Satellite Technology LTD
  - Currently available.
  - 1<sup>st</sup> feature listed on data sheet is “Completely ITAR free.”
- DC/DC converter
  - Need for a European DC/DC converter expressed by EADS in 2005

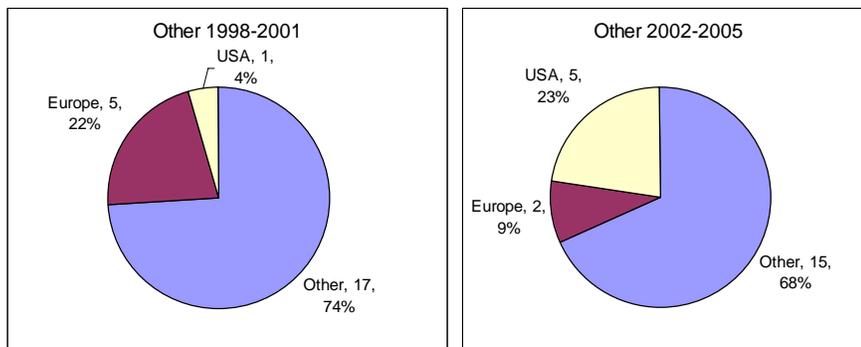
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European manufacturers began advertising “ITAR-free” systems shortly after the ITAR switch. Apstar 6, contracted in Dec 2001, was the first of several “ITAR-free” satellites built by Alcatel for China and Hong Kong based communications companies. The European Apogee Motor, currently in development, is at least partially driven by “ITAR-free” goals. A search for the term “ITAR-free” in Google brings up several more products using the term in their marketing material including Surrey Satellite Technology’s compressed gas thrusters and an EADS star tracker. The Google search also uncovered conference material discussing the need to develop European DC/DC converters to replace low-cost, industry standard US DC/DC converters because of US export restrictions.

## Supplying Other Primes



- India (ISRO), Israel (EI-Opt, Israel Aircraft Industries), Japan (Mitsubishi), Russia (Korolev, NPO PM, RSC Energia)
- 8 commercial payloads with 45 subcontracts listed.
- Primes in countries with a developing space program tend to purchase components indigenously.
- US Subcontract share small, but increasing.



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Subcontracting trends for the other commercial satellite manufacturers are similar to trends seen in Europe and the US. Primes in India, Israel, Japan, and Russia have tended to buy components domestically. While the data show large gains for US subcontractors on 2002-2005 payloads, the small number of subcontracts and known spottiness of the data reduce confidence in the results.

## *Conclusions: Subcontracting*



- Government and Industry state that component suppliers most affected by ITAR
- 1999 CCL-ITAR switch did not significantly change subcontracting behavior
  - US manufacturers did not have a large part of the European market pre-1999
  - Other prime market is small, but US has increased share post-1999
- Europe’s efforts to develop “ITAR-free” technologies may erode small foothold US component manufacturers have in foreign markets

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Government and industry personnel have expressed the opinion that subcontractors may be disproportionately affected by ITAR. Analysis of publicly available contracting information does not show a change in contracting behavior following the change from CCL to ITAR. US sub-tier manufacturers did not have a large portion of the foreign market in the late 1990s, but they have maintained their market position since 1999. The stated intention of European manufacturers to develop “ITAR-free” products may erode the small foothold US manufacturers have in foreign markets.

*Agenda*



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- Conclusions

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Debates about the usefulness versus the burden of ITAR often eventually turn to the competitiveness of US manufacturers versus their major rivals in Europe. Some claim that US technological superiority overcomes the disadvantage of more restrictive export controls, and that more advanced US technology is further justification for restricting satellite exports. Others say that there is now little technical difference between American and European satellites, and that ITAR creates a significant marketing disadvantage that US manufacturers must then overcome with other concessions. Previous sections have explored the actual impact of ITAR on contracting trends in the last decade. This section explores the relative capabilities of American and European commercial GEO communications satellites in the same time period.

## *Competitiveness*



- How does US technology compare to European technology?
- Does ITAR impose a scheduling disadvantage?
- Does ITAR impair US ability to market?

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This section explores three aspects of competitiveness: technical characteristics, delivery time, and reputation.

## US & European Buses are Comparable



- The major US and European Primes have offered similar GEO bus models since at least 1998.

Bus Series	Bus Company	Cost Low (\$M)	Cost High (\$M)	Max Launch Mass (kg)	Max Transponders	Max Power (kW)	Year Introduced
1300	Space Systems/Loral	100	300	6200	90	19	1998
A2100	Lockheed Martin	100	150	2000	50	11	1993
Boeing-702	Boeing	100	300	5200	118	25	1995
Eurostar 3000	EADS			6000	96	20	<1998
Spacebus 4000	Alcatel	120	200	6000	110	18	<1998

- Satellites have become global commodity with little difference between products offered by US and European primes
  - Performance
  - Reliability
  - Ease of Use

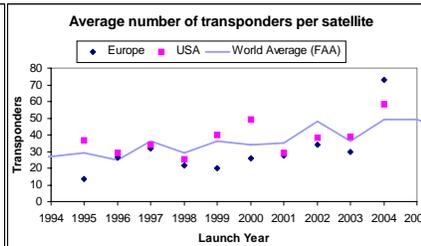
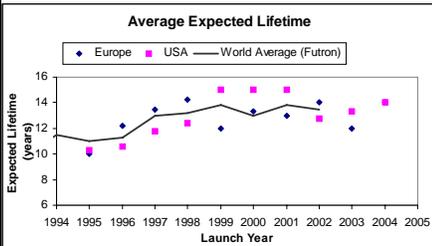
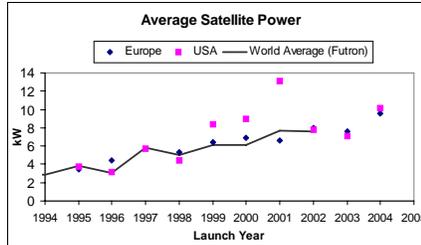
64

Based on their advertised capabilities, Alcatel and EADS have offered buses comparable to US manufactured buses since at least 1998. (The first contracts for the Eurostar 3000 and for the Spacebus 4000 were in 1998. It is unclear when they were first advertised.) Three common indicators of GEO communication satellite performance are satellite size, number of transponders, and power output. Loral, Boeing, EADS, and Alcatel all have buses in the 5-6 thousand kg range capable of carrying around 100 transponders requiring a total power supply of around 20 kW. (In practice, most customers request far less than the maximum capability.) Lockheed Martin's flagship commercial bus, the A2100, is listed as about half the size as the other top-of-the-line models, but this is indicative more of Lockheed's market focus than their technological ability.

## Comparing Satellite Performance



- Capabilities of Commercial GEO satellites
  - Data for Europe and USA reflect what is readily available online, not comprehensive
    - Boeing
    - Enthusiast site describing satellites servicing Europe
  - World averages collected by Futron or FAA
- 1995-1998, Europe had a lifetime advantage
- 1999-2001 (launch year), US built larger, higher power, longer lived satellites.
  - Could be an artifact of customer requirements in those years
- **2002-2004, US and European built systems are similar across all three metrics**



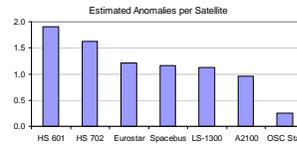
To explore the trends in launched capabilities over time, STPI collected information on the total power output (beginning of life), expected lifetime, and number of transponders of European and US built GEO communication satellites. Of the 210 commercial GEO satellites built by European and American primes between 1995 and 2005, data was only available for 90 – 125 satellites, depending on the variable. Average power and expected lifetime of commercial GEO satellites launched world-wide between 1994 and 2002 are reported by Futron in “How Many Satellites Are Enough? A Forecast of Demand for Satellites, 2004-2012.” The average number of transponders launched per satellite between 1994 and 2005 is reported by the FAA in the 2006 commercial space transportation forecast. The trends in technical capabilities collected by STPI agree well with the world trends reported elsewhere. The average number of transponders and power output has been similar for European and US built satellites since the mid-1990s, although between 1999 and 2001 US-built satellites had higher performance on all three metrics than European built satellites. It is unclear from this data if this is an artifact of customer requirements or an actual difference in the capabilities of the respective companies. Since 2001, satellite performance has been similar across all three metrics.

(Outlier note: the high average power of US satellites in 2001 is due to the 2 XM radio satellites built by Boeing, each of which had a total power consumption of 18 kW.)

## Reliability and Ease of Use

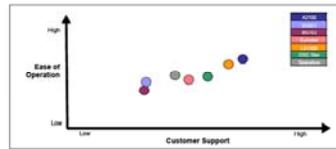


- Based on studies sponsored by Lockheed Martin
- Reliability
  - Normalize total number of anomalies (1996-2002) by number of bus-type in operation.
    - Estimated from charts published by Futron (see side box)
  - Lockheed A2100 "most reliable" of GEO buses with long history.
    - Orbital's Starbus is a relatively recent model.
  - Boeing models "least reliable"
  - European models "average"
    - Similar to LS-1300
- Ease of Use
  - Lockheed A2100 rated the best in customer support and ease of use
  - Boeing 601 and 702 rated worst
  - European models rated as average
  - Based on Futron interviews with satellite operators



Total anomalies 1996 - April 2002 estimated from Figure 7 in Futron's "Satellite Insurance Rates: On the Rise - Market Correction or Overreaction?" (2002). Number of each bus type in operation estimated from Table 2 in Futron's "GEO Commercial Satellite Bus Operations: A Comparative Analysis" (2003).

Chart: Operator Evaluation of Ease of Use and Customer Service of Currently Available 3-Axis Stabilized Satellite Bus Types



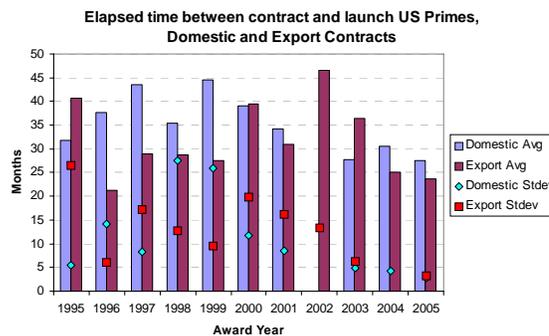
Source: Futron, "GEO Commercial Satellite Bus Operations: A Comparative Analysis," 2003. 66

Other aspects of technical performance are reliability and ease of use. Using the total number of anomalies and total number of each bus type in operation reported by Futron, STPI estimated the anomalies per satellite seen between 1996 and 2002. Futron surveyed major satellite operators about the ease of use and quality of customer service for each major bus. On both of these performance measures, European buses are in the middle of the pack. Boeing had the highest number of anomalies per satellite as well as the lowest rating on customer service and ease of use. Loral and Lockheed Martin had the best performance on both measures.

## Delivery Times: US Domestic vs. Export



- Hypothesis: License processing delays result in delivery delays (elapsed time between contracting and launching)
- Exported satellites had shorter average delivery times in all years except 2003.
- Initially high standard deviation for exported satellites has decreased every year since 2000.
  - Reached levels similar to non-ITAR satellites by 2003.
  - May illustrate companies becoming more efficient at managing licenses.



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Industry and State Department officials both state that there are significant delays in the export licensing process. However, these delays do not appear to be impacting the delivery times of satellites. Using data obtained from industry, STPI compared the elapsed time from contract signing to satellite launch of US-ordered (domestic) and foreign-ordered (export) commercial satellites awarded between 1995 and 2005 to US primes. On average, exported satellites did not take longer to manufacture and deliver than domestic satellites, although exported satellites had more variability in delivery times in the early 2000s. The average (mean) delivery time for exported satellites exceeded the average for domestic satellites only in 1995 and 2003. The standard deviation of export delivery times jumped in 2000, the first full year of ITAR controls, but fell steadily over the next five years. The declining standard deviation could reflect manufacturers becoming more efficient at managing licenses.

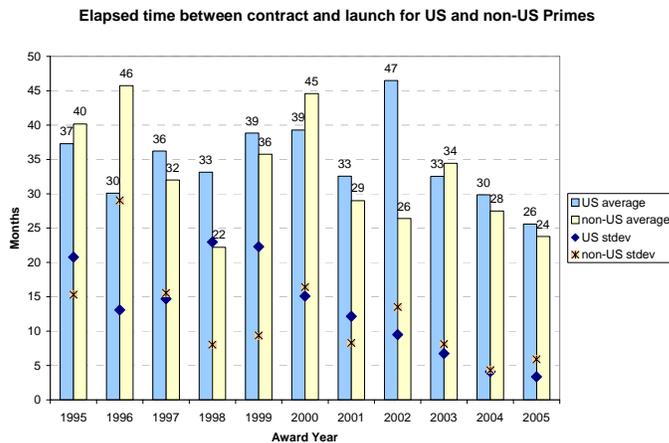
### Notes:

- Commercial Programs Only
- Launch date not given for the 1 non-ITAR, commercial, US satellite awarded in 2002
- Only 1 ITAR-affected, commercial, US satellite awarded in 2004, therefore the standard deviation is 0
- Launch dates for awards made in 2004 and 2005 are predicted, not actual.

## Delivery Times – US versus Europe



- Hypothesis: US manufacturers have longer delivery times than non-US primes and/or greater variance
- Non-US primes had shorter delivery times, but were no more consistent than US primes
- Since 2003, production times have been similar
  - Average delivery times differ by 1-2 months
  - Standard deviations differ by 1-2 months



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If ITAR licensing delays are a competitive disadvantage for US manufacturers, one piece of evidence would be increased delivery times for US primes relative to European primes. In 7 of the last 11 years, non-US primes have had shorter average delivery times than US primes. There is not, however, any distinct trend that coincides with the changes in US export regulations.

## Competitiveness: Industry Comments



- Export controls are encouraging satellite makers to avoid using foreign subsystems and components
  - Discourages Europeans from using US suppliers and vice versa
  - For [European firm] ITAR restrictions extremely burdensome since “we have to get multiple licenses for each destination to which the satellite moves throughout Europe”
  - Difficulties of ITAR limit technical visibility and makes risks higher—“with European products ‘emerging’ this becomes factor in risk decisions on using US components”
  - Failure in command receiver required replacing a switch—took 3 months to get license putting satellite at risk
  - ITAR impairs our ability to support our own product—unable to return foreign subsystem to manufacturer due to time required for license—easier to bring foreign technicians to US—but then have to do in manner to avoid deemed export controls
    - What does this type of control protect?

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Industry representatives interviewed for this study maintain that even if the business impacts of ITAR are not seen in quantitative metrics like sales and schedules, the uncertainties and complexities of the ITAR process create customer relations problems, add risks to programs, and create additional headaches for the manufacturers. Some of their illustrative comments are included on this and the following page.

## ***Competitiveness: Industry Comments***



- Processing Time is Competitive Disadvantage
  - Congressional notification is major additional delay and uncertainty factor; nothing like this exists for European competitors
- Canadian TELESAT: Has bought 15 satellites from US vendors, but acquired last 3 from Astrium, stating to US vendor, “We will not buy from US due to export controls.”
- DTSA monitoring is additional financial burden as well as added time and risk factor
  - For smaller vendor “has substantial impact on profits”
    - Vendor pays \$250/hr for each DTSA monitor plus expenses
    - Every monitor requires 2 additional company staff
  - Has direct risk impact on meeting schedule commitments

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Industry representatives argue that excessive processing time and risk places US companies at a competitive disadvantage with respect to foreign companies who do not face similar controls. Canadian TELESAT has cited to industry representatives that it will not buy US satellites due to export controls.

## *Conclusions: Competitiveness*



- US and European built satellites have similar features and reliability
- Despite licensing delays, exported US satellites do not have significantly longer deliver times
- ITAR creates delays, uncertainties, and restrictions for US products that competitors don't face

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The analyses presented here found no overall technical competitive advantage for US satellite primes or a particular schedule disadvantage due to ITAR. Since the late-1990s, European and US satellite manufacturers have offered GEO buses with similar features and reliability. American manufacturers have had slightly longer delivery times on average than their European counterparts, however this difference does not appear to be related to ITAR as US-made satellites built for US customers have longer average delivery times than US-made satellites built for export. Negative competitive impacts of ITAR may be qualitative involving added risk during development and customer dissatisfaction.

*Agenda*



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- Tasking
- ITAR background
- Data Sources
- Findings
  - Process
  - Industry
  - Academia
- Conclusions

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Universities have claimed that export controls make US graduate school less attractive relative to their foreign competition, inhibit their foreign faculty in their research, interfere with cooperative research with foreign nationals, and force universities to decline certain research grants. STPI's analysis of the data did not confirm any of these effects, though data specific to the satellite industry was not readily available.

## Example Comments

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*“ITAR restrictions on foreign students is at least partially responsible a 30% decrease in foreign applications each year.”*

*“We have had to decline acceptance of many research grants due to ITAR restrictions.”*

*“Much of the equipment that is banned from foreign student use is available at foreign universities.”*

*“Some U.S. citizens have gone to foreign universities for better collaborative research opportunities.”*

*“ITAR has effectively barred much innovation in space engineering and science avenues.”*

*“Foreign universities are taking advantage of our stupidity.”*

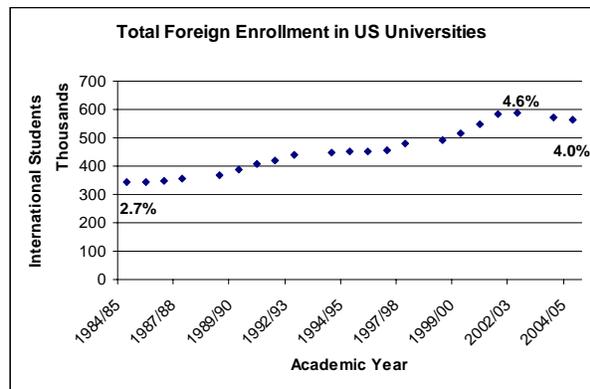
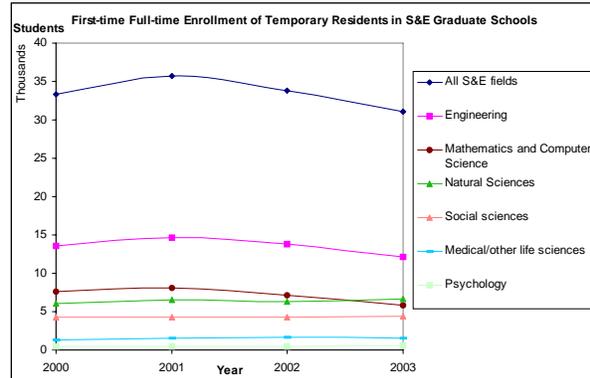
73

Representatives from academia made the above comments regarding export controls.

# Metrics - Enrollments



- Hypothesis: Deemed export controls make US graduate schools less attractive
- First-time, full-time enrollments of foreign graduate students decreased by 13% between 2001 and 2003
  - Down 17% in engineering (sub-fields not available)
  - Down 34% in computer science
- Total foreign enrollments declined only 1.6% in 04/05.
- **Disconfirmed: Signs of increasing enrollments in 05/06**
  - 1% increase in first-time, international graduate student enrollment (Council of Graduate Schools Survey )
  - 74% of US colleges and universities report level or increased foreign enrollment in fall 2005. (Institute of International Education Survey)

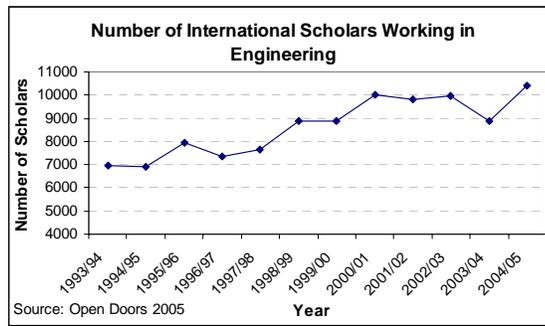


Representatives of US aerospace departments have said that ITAR is partially responsible for a decline in foreign applications. There is a documented decline in first-time, full-time enrollment of foreign graduate students, but that decline is generally attributed to the changes in *immigration* regulations following 9/11 not export law. The actual causes and the severity of the decline are controversial, but 2005/06 enrollments show signs of a rebound.

## Metrics – International Faculty



- Hypothesis: ITAR has created an environment in which foreign-born faculty cannot effectively carry out research and attract new foreign students to U.S. universities. This results in de facto pressure to push such faculty toward other countries.
- The number of engineering scholars teaching and researching in US universities stagnated and declined between 2001 and 2004.
- **Disconfirmed:** In 2004/2005, the number of engineering scholars increased to above 2001 levels



STPI was unable to find trends in foreign faculty at US universities by specific field or department. The nation-wide trend for Engineering shows an overall increase between 1999 and 2005. If export controls have helped create a negative environment for foreign scholars in the US, the impact is too small to see in the academic Engineering workforce as a whole.

## Metrics – Source of Funding



- Hypothesis: having to decline research grants with nationality/publishing restrictions means a decrease in funding available.
  - Decline in foreign graduate students funded by the university/Increase in foreign graduate students requiring outside funding
- **Disconfirmed:** Between 2003 and 2005 there is an increase in international graduate students funded by their universities.

Academic Year	2002/03	2003/04	2004/05
Personal & Family	50.7	51.6	44
U.S. College or University	38.3	40.4	43.6
Home Government/University	2.8	2.2	2.9
U.S. Government	0.8	0.7	0.7
U.S. Private Sponsor	1.5	1.5	5.5
Foreign Private Sponsor	1.9	1.7	1.1
International Organization	0.4	0.4	0.3
Current Employment	1.2	1.4	1.3
Other Sources	2.2	0	0.6

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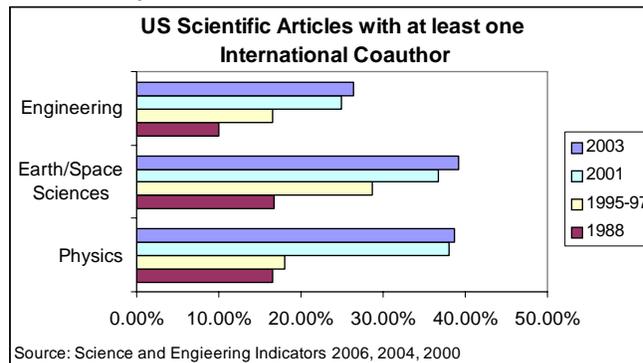
The potential link between source of support and ITAR is indirect. ITAR could lead to a decrease in available funding for foreign graduate students because of the increasing number of grants with restrictions on participants' citizenship. Universities are either rejecting these grants outright, or if they are accepting them, the related funds are not available to foreign students. Source of support was not available by field, but across all fields, the percentage of graduate students supported by the university increased by 5% between 2002 and 2004. (Seventy percent of foreign graduate students were in science and engineering disciplines in 2003.) In addition, at the large research universities, the documented amount of funding being turned away due to ITAR is very small relative to total research budgets. MIT rejected over three million dollars worth of contracts between 2003 and 2005, and UC-Berkeley reject a half million dollar contract from the Army due to restrictions on foreign nationals. (Broniatowski, et al.) This is, however, only a very small part of the hundreds of millions of dollars each of these universities spend on research annually. It therefore appears unlikely that export controls are leading to an inability to fund foreign graduate students.

Broniatowski, D., Jordan, N., Long, A., Richards, M., Weibel, R., "Balancing the Needs for Space Research and National Security in the ITAR", AIAA 2005-6800.

## Metric: Coauthorship of S&E Articles



- Hypothesis: Harsher export enforcement led to a decrease in international collaboration
  - Which would be reflected in declining international co-authorship
- **Disconfirmed: US-International coauthorship has increased in aerospace-related fields**
  - 2001-2003: 1-2% increase in international coauthorship in Physics, Engineering, and Earth/Space sciences
  - Mid-1990s – 2001: 8% increase in Engineering and Earth/Space Sciences, 20% increase in Physics



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While the fundamental research exemption theoretically allows for international collaboration in academic science and engineering, academic personnel interviewed for this study have suggested that ITAR is hindering collaboration. STPI uses coauthorship of Science and Engineering papers and articles as a measure of collaboration. All three space-related disciplines described in Science and Engineering Indicators had a modest increase in the number of US-Internationally coauthored papers between 2001 and 2003. There is however, anecdotal evidence of restricted participation of foreign scientists at conferences and workshops due to both visa difficulties and export controls. As seen with the anecdotes from industry, these instances do not appear to be widespread enough to show up in an field/industry-wide metric.

## *Conclusions: Academic*



- No definite ITAR impact is seen in these metrics
- Foreign enrollments are recovering
- Results might differ with higher resolution data
  - ITAR effects cannot be isolated from visas and other policy and perception issues
  - Satellite-related fields are not isolated, and are dwarfed by the larger higher education system

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STPI found no definite impact of ITAR on foreign enrollments, numbers of foreign faculty, support of foreign students, or international collaboration in academia. Data, however, were not available by department or field of engineering. Also, recent changes to US immigration policy, which negatively impacted US universities, make it difficult to isolate any potential ITAR effects.

## Agenda

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- Tasking
- ITAR background
- Data Sources
- Findings
  - Process
  - Industry
  - Academia
- **Conclusions**

## Critical Issues - Conclusions



- How is ITAR implemented in the aerospace industry?
  - What's covered?
  - What is the process?
  - How is the process implemented?

**Processing implementation has become a serious issue**
- What is the commercial impact of ITAR?
  - Revenues/contracts
  - Costs
  - Human resources

**Data show limited market impact of export controls**
- What is the academic impact of ITAR?
  - Foreign graduate students and faculty
  - International collaboration
  - Space related research at universities

**No evidence of substantial impact;; data show rebound in previously negative trends**
- What is the national security impact of ITAR?
  - Do ITAR controls on satellites effectively limit foreign access to critical national security technologies?
  - Do ITAR controls on satellites reduce US access to / expertise in critical national security technologies

**Pervasive, increasing foreign availability raises strong doubts**

**No Evidence**

80

Export controls are only one factor in the buying decisions of satellite customers. European capabilities and presence were growing relative to the US before the shift from CCL to ITAR, and all existing manufacturers can expect to lose market share as emerging countries develop indigenous capabilities. While license processing times are a real concern, the quantitative metrics examined in this study show no conclusive negative impacts of the ITAR export control regime on the market position of US satellite manufacturers. This being said, strong and increasing foreign availability raises strong doubts as to whether US export controls have any benefit for US national security that would justify stringent ITAR controls.

The following pages summarize the quantitative and qualitative metrics examined for each critical issue.

## Metrics



License Processing	Metric	Negative ITAR-related trend?
	Number of license requests - By year, since 1999	Possible—ITAR cases increased from ~40K to ~62K in 5 years which contributed to process delays
	Average license processing time - By year, since 1999	<b>Yes. Significant processing delays evident in DOS data over past 2 years and explicitly identified by industry</b>
	Fraction of costs directly attributable to ITAR process - Includes DTSA monitors, license staff, fees	Possible—but costs are less an issue than impact on customers

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The metrics on case processing show strong evidence that the performance of the ITAR process in terms of the throughput of cases is seriously impaired. These delays and the attendant backlog that has built up at the Department of State was cited frequently by satellite producers and suppliers as a major and growing concern. The dollar costs of the export control system are an added burden, especially with the additional costs of paying for DTRA observers at meetings with non-US nationals. For those satellite producers / suppliers that do large amounts of business with the DoD, these costs are spread throughout their larger business base; for those firms that are more narrow producers of commercial satellites these costs are a proportionally larger piece of the total costs of business—and a greater cost than their foreign competitors bear. While we were not able to probe in-depth, the study team did hear concerns of smaller vendors that the costs of the ITAR process are a major disadvantage that can keep them from considering the export market.

# Metrics



Economics	Metric	Negative ITAR-related trend?
	Market share of US prime contractors - by launch date and customer nationality - value/number of awards	<b>Possibly—Data shows reduced market share 2005 but increase in 2006</b>
	% of US Commercial GEO revenue coming from exports - By launch date	<b>Possibly—Data shows reduced % export revenue 2005 but increase 2006</b>
	Incumbency rate of US Primes with major GEO communication fleets.	<b>Possibly—Telesat Canada</b>
	US share of orders from new customers	No
	Market share of US subcontractors - By prime nationality - By component type (bus, communications, power, etc.) - Commercial satellites launched 1998-2001 and 2002-2005.	No
	Number of US companies exporting satellite components - For satellites launched 1998-2001 and 2002-2005.	No data showing firms exiting market.
	Fraction of US content in European built commercial satellites - By launch year 1995 - 2006	No

Economic data—in terms of market share, exports, orders, etc. show that while there have been some notable declines in US market position in commercial satellites, that [1] these trend have oscillated rather markedly and that in the most recent year (2006) the US market position recovered sharply after two years of decrease; [2] that there are a number of other factors that have much stronger impact on the overall market including a general decline in the satellite market overall due to increased productivity of satellites and the emergence of new competitors—first European and now Asian. Attention needs to be paid to future sales and launches to see if 2006 is an aberration for US sales, or whether the overall trend continues as one of a highly competitive, and highly perturbed market, in which discrete decisions by satellite service providers can have major impacts on market shares.

## Metrics



Metric	Negative ITAR-related trend?
Relative capability of GEO communications satellites - Average total power, lifetime, and number of transponders - By launch year and prime nationality	No
Relative reliability of GEO communications satellites - Average number of anomalies per satellite by Prime	No
Elapsed time between award and launch - By award year and prime nationality	No
Variability of time between award and launch - By award year and prime nationality	<b>Possibly, increased US variability 2000-2002.</b>
Number and type of technology development programs with stated goal of replacing US components	<b>Yes—several specific “ITAR free” efforts</b>

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Competitiveness metrics show that generally the US lead in satellite technology—especially that for commercial communications has dissipated as producers in Europe and now Asia have become adept at producing the entire range of technologies needed for a competitive satellite system. This creates an ideal market situation for the ever more demanding service suppliers who can choose amongst a mix of providers. In this highly competitive situation satellite and subsystem vendors are using whatever competitive leverage they can—and for non-US producers that includes sharply differentiating their products as “ITAR-free”, in the hopes that this can give them a leg up on US producers. To date this “marketing campaign” has not had major effect—but it does emphasize an advantage that non-US vendors are willing to exploit.

# Metrics



Academic	Metric	Negative ITAR-related trend?
	Total enrollment of temporary residents in US graduate schools, 1983 - 2003	<b>Possible, but aerospace-related not isolated</b>
	First-time, full-time enrollment of temporary residents in US graduate schools, 2000 – 2003 - By major field	<b>Possible – 2002-2004 decline attributed to visa policy. Increase in 2005/06.</b>
	Number of international faculty in engineering 1994-2005	No
	University funding of international graduate students, 2002-2005	No, aerospace not isolated
	Coauthorship of S&E articles by field, 1988 and 2003 - Engineering, Earth/Space Sciences, Physics	No

Our analysis of academic metrics showed little discernible effects of export controls. These results were for data that was across all engineering areas and not specific to aerospace. There are other more broad trends in technical education and academic research that generally overwhelm the specific effects of export controls.

## Conclusions: National Security



- What are metrics for national security?
  - If objective of national security controls is to keep technology from proscribed destinations, have controls on satellites achieved this?
    - Who are we seeking to restrict satellite tech from?
    - If the intended target is China, our policies and implementation have totally failed
    - If aim is to keep US ahead of rest of world our polices and implementation have totally failed
    - If aim is to sustain US industrial capabilities relative to others, our policies and implementation have totally failed
  - Evidence that export controls have actually spurred others to develop their own capabilities and avoid use of US satellites and components

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If the intent of US export control policy on satellite technology is intended to keep China behind the state of the art, to keep US firms ahead of rest of world, or to sustain US industrial capabilities, these policies have failed. If anything, export controls have likely spurred foreign governments to develop their own industrial capabilities and avoid use of US technology.

## Conclusions: National Security



- What are metrics for national security?
  - If the objectives of satellite controls are aimed at launch vehicles and missile proliferation...
    - What is the relevance of controlling the satellites themselves?
      - Who is the adversary?
        - » China
        - » Russia
        - » India
        - » France
      - What do we think they will learn from us that matters?
    - Why not limit controls to launch activities?

**If policy makers demand quantitative metrics for assessing whether export controls have negative impact on firms, is it not appropriate to demand and assess metrics on national security impact as well?**

If the intent is to restrict access to missile technology, what is the relevance of controlling the satellites themselves? While this study found little direct market impact to firms, there are elements of the ITAR process that are certainly onerous. Yet, the national security value of controlling satellites as weapons has not been examined in a similar quantitative way. If policy makers demand quantitative metrics for assessing whether export controls have negative impact on firms, is it not appropriate to assess metrics on national security impact as well?

## Recommendations



- Address the breakdown in ITAR case processing in the State Department
- Reconsider value and need for controlling *commercial* satellites on ITAR
  - At minimum consider technical differentiation based on performance with very high threshold based on military criticality
  - Provide some level of discrimination on controlling components that counteracts “ITAR-free”
  - Recognize that commercial satellites essentially are commodity product available from multiple global sources
  - Reconsider value and need for onerous and costly DTSA monitoring for satellites
- Separately assess health of satellite subtiers
  - Export controls not likely the main problem

The STPI study team recommends that the US adopt specific technical criteria related to military criticality, via the Commodity Jurisdiction Review process, in order to determine whether ITAR controls should be applied to particular satellites and components. The value and need for onerous and costly DTSA monitoring of satellite-related meetings with foreign customers and suppliers should be reconsidered. Moreover, the serious breakdown in ITAR case processing should be rectified.

*Backups*

## *Examples of Processing Times*



- Optus
  - 1yr delay waiting for Congressional Notification
  - Not yet launched
- Civil Caltech-Korea collaboration
  - 1 month for initial export of hardware to S. Korea
  - 4.5 months for export of satellite from S. Korea to Russia for launch
- Galaxy 16
  - State failed to send license to Congress
  - 5 month delay
  - last minute phone calls to get action by launch date
- GRACE
  - NASA-DLR (Germany) science mission
  - US Contractor's inability to obtain a TAA resulted in NASA replacing them with a German company (after 15 month delay)

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Above are specific examples cited by industry where licensing delays have negatively impacted a satellite program.

Sources:

Optus – company interviews

Caltech-Korea – Council on Government Relations

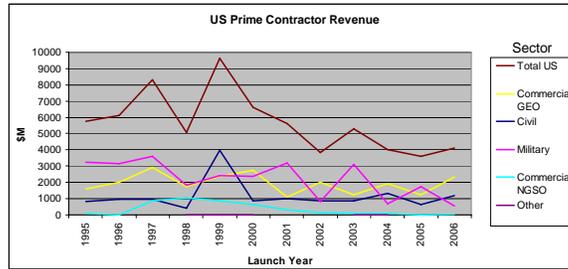
Galaxy 16 – company interviews

GRACE – “Export Control Challenges and Solutions”

## US Prime Contractor Satellite Market



- **Overall**
  - US overall revenues spiked in 1999 driven by 2 large civil scientific satellites and the LEO bulge, but has fallen sharply in 2000s
- **Commercial**
  - GEO trend shows general decline (shrinking global demand vs. competitors)
  - Non-GSO, mostly LEOs, have largely disappeared
- **Civil**
  - Mostly stable market
  - 1999 boost due to two major launches: Terra and Chandra X-Ray Observatory (combined 2850M)
- **Military**
  - Has provided significant revenue to US Primes



90

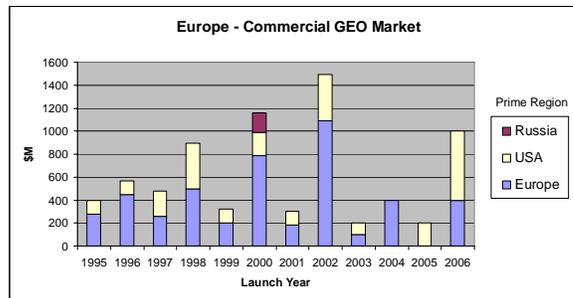
The US satellite market is lumpy and has declined since the late 1990s. Commercial, military, and civil programs all provide significant sources of revenue to US manufacturers.

Note: "Other" group includes small university or amateur satellites – very low value

## European Market



- While European customers have historically tended largely toward European primes, US prime contractors own a small but steady share of European business
  - Typically 1-2 satellite launches per year
  - 10 of 21 exports to SES Astra (now SES Global)

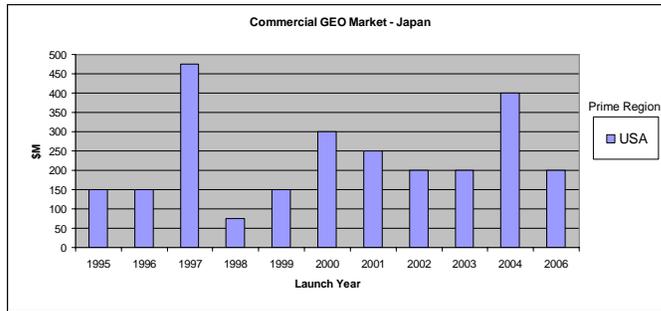


91

US revenue in Europe has been small and does not show signs that export controls have limited the ability of US firms to compete in those markets.

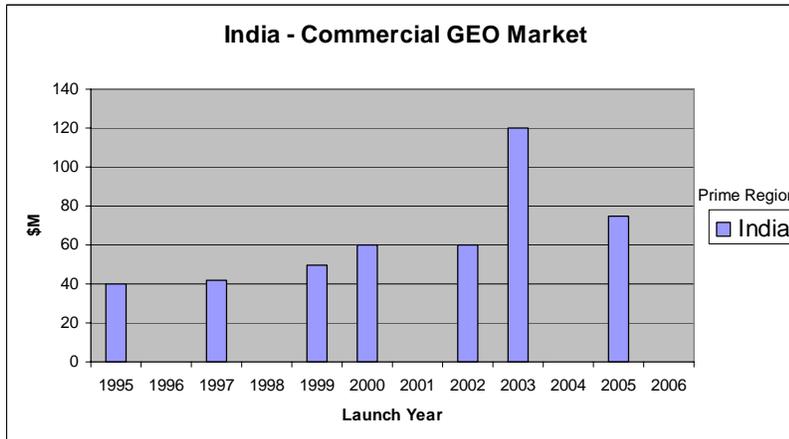
1995	Astra 1E	Luxembourg	Boeing Co.
1996	Astra 1F	Luxembourg	Boeing Co.
1997	Astra 1G	Luxembourg	Boeing Co.
1997	Thor 2	Norway	Boeing Co.
1998	Astra 2A	Luxembourg	Boeing Co.
1998	NSS-806	Netherlands	Lockheed Martin
1998	Sirius 3	Sweden	Boeing Co.
1998	Thor 3	Norway	Boeing Co.
1999	Astra 1H	Luxembourg	Boeing Co.
2000	Astra 2D	Luxembourg	Boeing Co.
2001	Astra 2C	Luxembourg	Boeing Co.
2002	Astra 3A	Luxembourg	Boeing Co.
2002	Hot Bird VI	Europe	Space Systems/Loral
2002	NSS-6 (IS 603)	Netherlands	Lockheed Martin
2002	NSS-7	Netherlands	Lockheed Martin
2003	e-BIRD	Europe	Boeing Co.
2005	XTAR-EUR	Spain Space	Systems/Loral
2006	Astra 1KR	Luxembourg	Lockheed Martin
2006	Astra 1L	Luxembourg	Lockheed Martin
2006	Hot Bird VIII	Europe	Space Systems/Loral
2006	NSS-8	Netherlands	Boeing Co.

- US dominates small commercial GEO market in Japan



All Japanese commercial GEO launches have been through US manufacturers.

- India has a very small indigenous commercial GEO program with no export market available to the US (or anyone else)

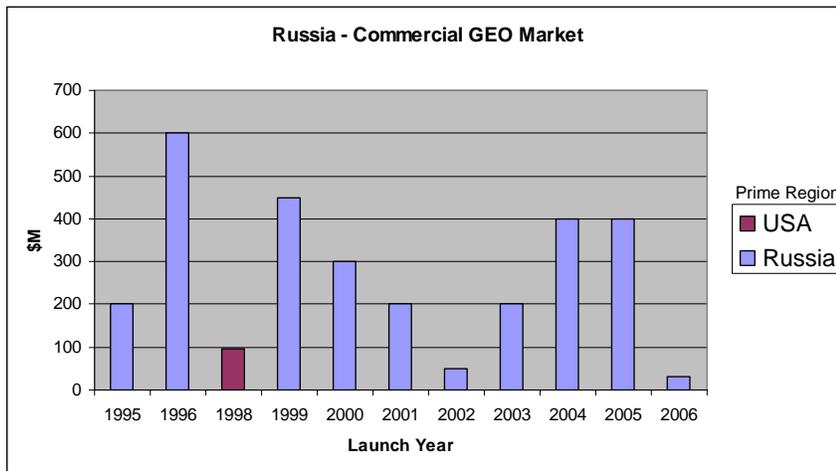


India has never imported a satellite in any other sector.

# Russia



- Russia has a small indigenous commercial GEO program, with little-to-no export market available to the US



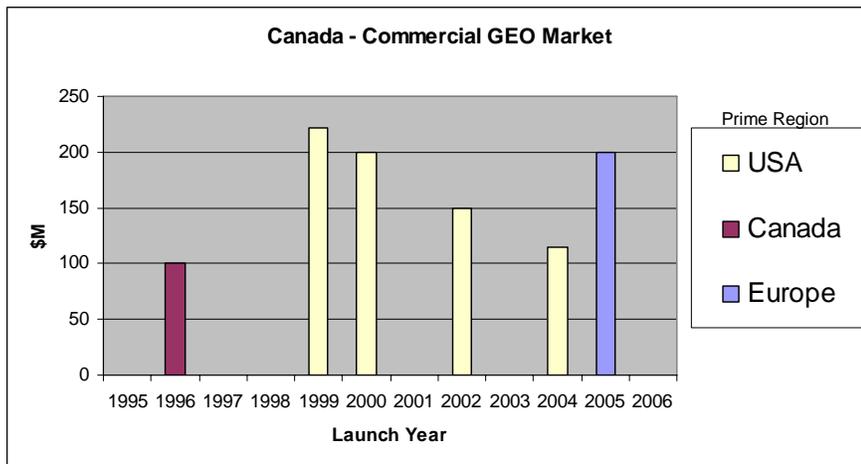
94

Russia is unlikely to purchase satellites from the US in the future regardless of export controls.

# Canada



- Canada has a small commercial GEO market, historically built by US manufacturers
  - 2005 shows a post ITAR shift to European manufacturer



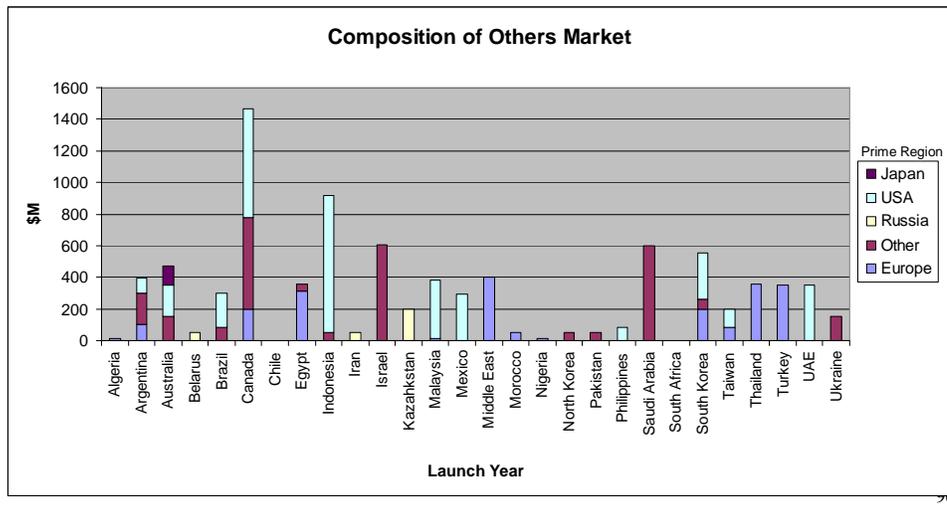
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Canada, historically a US customer, demonstrates a shift to Europe. The 2005 launch was the Anik F1R satellite built by EADS (contract awarded Feb. 2003). All previous Anik satellites were built by the US. Anik F3, under development by EADS, is scheduled to launch in 2007.

## Who is left? – “Others Market”



- Some programs dominated by US manufacturers, some by European manufacturers, some indigenous, few competitive

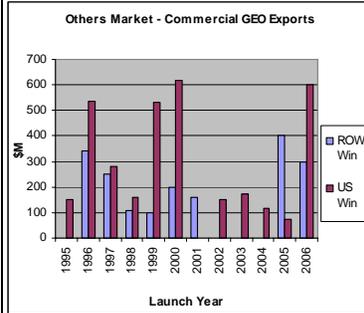


Overall, the “Other” market is small and scattered. If these markets increase demand for satellite services, they may become significant sources of revenue. The data does not indicate that the US is losing market share in these countries.

## Others Market Trends



- 2005 appears to indicate a shift away from US primes
- However, only one actual change occurs, based on historical tendencies



Year	Country	Prime	Shift ?
2005	Canada	EADS	Y
2005	Indonesia	Orbital Sciences Corp.	N
2005	Thailand	Alcatel Alenia Space	N

97

Recent exports to “Other” countries are consistent with historical customer behavior.

## International Consortia



- **Intelsat**

- Founded in 1964 with 11 countries; had over 100 members in 2001
- Became a private company in 2001; merged with Panamsat (US) in 2005
- 28 Commercial GEO since 1990, 1 forecast
  - **Historically all series built by US manufacturers** (27 of 28)
  - Intelsat Americas 9 (SS/L) forecasted for 2007
  - **Contract for Intelsat 10 series awarded to EADS in Jan. 2000\***
    - Option for up to 12 satellites

- **Eutelsat**

- Established in 1977 as European IGO; Became private in 2001
- 21 Commercial GEO since 1990
  - **Always awarded to European manufacturer**

- **Inmarsat**

- Founded in 1979 by the International Mobile Satellite Organization (IMSO); as of 2005 publicly traded on London Stock Exchange
- 11 Commercial GEO since 1990, 1 forecasted for 2007
  - Four Inmarsat 2F satellites built by EADS (1990-1992)
  - Five Inmarsat 3F satellites built by Lockheed (1996-1998)
  - Three Inmarsat 4F satellites built by EADS (2005-2007); contract awarded in 1999
  - **Historically uses both US and European vendors**

- **Arabsat**

- Founded in 1976; Currently has 20 member states
- 6 Commercial GEO Since 1990
  - **Always awarded to European manufacturer**



**APPENDIX B**

**IMPACTS OF EXPORT CONTROLS  
ON THE US SEMICONDUCTOR INDUSTRY**

**Michael J. Lippitz  
Michael Marks  
Richard Van Atta**

**January 2007**



## SUMMARY

For the purposes of this sector study, the “semiconductor industry” comprises firms producing semiconductor materials, semiconductor manufacturing equipment (SME), and semiconductor integrated circuits (ICs).<sup>1</sup> Worldwide revenues in 2005 were \$31 billion, \$34 billion, and \$227 billion, respectively. The semiconductor industry is widely viewed as “strategic,” supporting economic growth through innovative clusters of electronics and broader information technology (IT) firms (such as in “Silicon Valley”), as well providing high value-added exports and high-wage employment. Beyond the economic importance of the semiconductor industry, today’s dominant US conventional military capabilities derive from the US Department of Defense’s relative success in fostering and exploiting semiconductor-based computer, communication and sensor networks for military purposes. Advantage in “network centric warfare,” based on advanced electronics, is assumed in much current US defense strategy and planning.

**While electronics and IT are critical to US military capabilities, the most advanced ICs today play a relatively small role, and the US Department of Defense (DoD) is a niche player in the market.** With a few exceptions in areas such as sensors and intelligence systems, the ICs embedded within today’s most advanced military systems tend to be far from commercial state-of-the-art. Nevertheless, the US government has sought to prevent adversaries from accessing the most advanced ICs, SME and materials through the CCL, administered by the US Department of Commerce. Radiation hardened ICs used in nuclear and space systems are controlled by the Department of State through the ITAR. US export controls are coordinated internationally through the “Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies,” which came into force in 1996 as successor to the Soviet-era “Coordinating Committee for Multilateral Export Controls” (CoCom).

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<sup>1</sup> The industry includes numerous major suppliers and subcontractors to these firms, such as computer aided design and other software companies. These firms were not contacted for this study.

**US-based IC, SME and materials firms depend on exports.** For US-based IC firms, much of their market is serving electronics products manufacturers (both US and foreign-owned) located outside of the US. For SME and materials firms, this is due to rapid growth of advanced IC manufacturing in Taiwan, China and Korea (a significant portion of which is due to foreign direct investment by US-based firms). Some observers of the US semiconductor industry are concerned about this migration as well as the loss of US commercial participation in certain SME segments. Disparities in application of export controls by the US relative to its Wassenaar partners is said to exacerbate the problem by restricting US industry in accessing rapidly growing Asian markets. without conferring any national security benefit, due to the ability of the Chinese to access comparable technologies from Europe and Japan. Semiconductor industry leaders have called on the US government to address these disparities as part of a broader effort to respond to purported unfair trade practices by foreign governments, organizations, or firms.

**This study found that, since the inception of Wassenaar, US-based IC, SME and materials companies have not been severely impacted by export controls, but this may not be the case going forward.** US implementation of semiconductor export controls burdens US semiconductor companies with more conditions on foreign sales and longer and less predictable waiting periods for license approval than that faced by competitors in Europe or Japan selling comparable products, but licenses are rarely denied. Companies contacted by this study and published reports cite only a handful of instances where sales were lost to a foreign competitor due to delays or conditions in US export licensing. However, staffing requirements and administrative burden of export controls represent a unilateral cost to US industry relative to its foreign competitors. The costs of compliance are rising and threaten to become a competitive disadvantage to US-based firms in the increasingly competitive international semiconductor industry. More importantly, licensing delays and uncertainties threaten to give US suppliers a reputation of being unreliable partners in the lean, “just in time” worldwide supply chains that increasingly characterize high technology industries. Implementation of “deemed exports”—a license that must be obtained before providing to foreign nationals information related to controlled technologies—has led some companies no longer hire Chinese researchers and other controlled foreign nationals due to the risk and difficulty of complying with these regulations. Many of these talented individuals are doubtless hired by foreign competitors.

As of this writing, unilateral costs to US-based semiconductor firms are relatively small in direct, quantitative terms. Qualitative factors—reputation for unreliability in supply, diversion of R&D funds to export control compliance, restricted access to foreign talent, barriers to developing a foothold in emerging markets such as China, etc.—are hard to assess but could soon be reflected in lost sales and competitiveness. Furthermore, certain prospective issues, if unaddressed, could lead to severe if not debilitating problems for the US semiconductor industry:

- Proposed changes to Department of Commerce rules for dual use exports to China, if adopted, would cause currently decontrolled SME and materials to come under tighter scrutiny. The new rules would require US firms to confirm the commercial nature of customers and end users in China, with potentially severe penalties for exporting equipment or technology that was found to be supporting the production of Chinese military systems. For SME and materials companies, such verification could be impossible, as these are general purpose equipment that could be used to build any type of ICs, which themselves are general purpose devices. (This problem could be mitigated by the “Validated End-User” provisions of the proposed rules—which would provide a blanket license for exports to certain foreign entities—though it is unclear how readily that designation will be given and how much of the export control burden it will relieve.) The ambiguity of the proposed rules confers potentially open-ended liability on US firms, based on subjective application by the Department of Commerce. This expansion of export documentation, investigation requirements for China, and potential liability would likely be unilateral, as other Wassenaar signatories have shown no interest in similarly tightening their implementation.
- Continued unilateral application of deemed exports regulations could inhibit US companies in hiring top foreign talent from controlled countries, beyond the limitations imposed by immigration policy. In the case of China, this burden adds to the incentives for top Chinese technologists to stay in country or leave the US. This disadvantages US companies relative to foreign competitors, which do not face such hiring restrictions. Deemed export regulations could also inhibit US companies from performing joint research with leading Chinese institutes, some of which are approaching world-class standing in semiconductor technology.

- The criteria for control of radiation hardened ICs in Category XV (d) of the ITAR could, within a few years, encompass most ICs and any electronics products incorporating them. This would make standard commercial ICs of all types subject to intensive control as “military items” regulated by the Department of State. The reason is that continuing miniaturization of IC circuits, introduction of low-power materials, new design techniques and improving error correction software are conferring inherent radiation hardness to all ICs—enough to possibly meet the ITAR criteria for being controlled, even if these ICs were not designed for use in nuclear or space systems and would be unreliable in such applications. Under ITAR’s “see through” rules any system containing a controlled part is considered a controlled item, which could lead to the perverse outcome of subjecting Japanese video games and European cell phones to US ITAR controls, which would effectively destroy the US IC export market. ITAR controls on ICs would doubtless be unilateral, as it is quite unlikely that the US would persuade foreign sources to treat all ICs as though they were weapons.

In the final analysis, for such a dynamic and globally dispersed technology as microelectronics it is very difficult for any control regime to be effective. As the locus of advanced IC consumption and production moves to Asia, including China as well as Taiwan and Korea, the underlying rationale for controlling microelectronics technologies appears to be negated. Today US IC manufacturers are little affected by export controls, although they have to maintain the processes required by the government. What is worrisome is that in the near future there will be unintended consequences seriously impacting US IC manufacturers if either the China Catch-All comes into effect as proposed or if changes are not made to the ITAR RADHARD provisions.

## **DESCRIPTION OF THE SEMICONDUCTOR INDUSTRY**

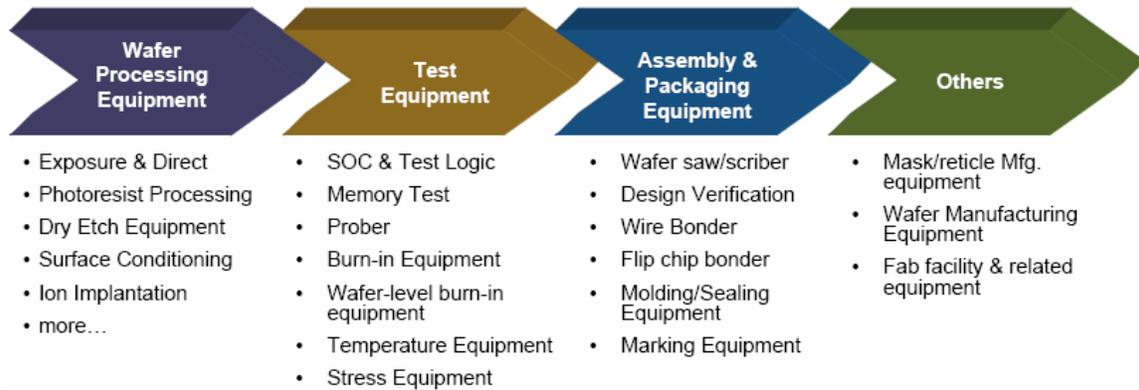
### **Definition and market information**

For the purposes of this study, the “semiconductor industry” comprises firms producing semiconductor materials, semiconductor manufacturing equipment (SME), and semiconductor integrated circuits (ICs).<sup>2</sup> Semiconductor fabrication consists of a series of processes in which the device structure is built up. This involves the deposition, doping,

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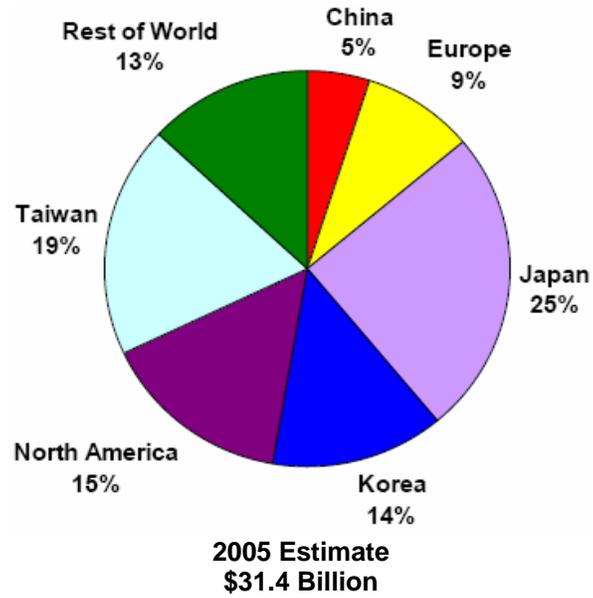
<sup>2</sup> The industry includes numerous major suppliers and subcontractors to these firms, such as computer aided design and other software companies. These firms were not contacted for this study.

and selective removal of various thin film layers on a silicon or other material substrate. Each deposition and removal process is generally followed by cleaning as well as inspection steps. The raw semiconductor “chips” that result from this process are then packaged, tested, and sold as finished ICs. Materials used in the process include silicon wafers, substrates, photomasks, wiring assemblies (known as leadframes), packaging, and various fabrication chemicals. Highly efficient SME (or “tools”) have been developed for each manufacturing step to ensure repeatability and high throughput. The major categories of SME include wafer processing, test, and assembly and packaging, as summarized in Figure 1.

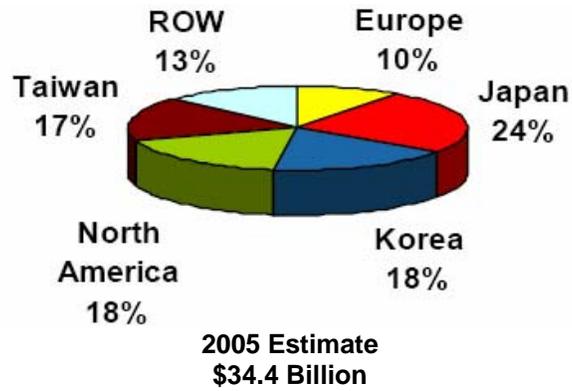


**Figure 1. SME Equipment types** (Source: SEMI)

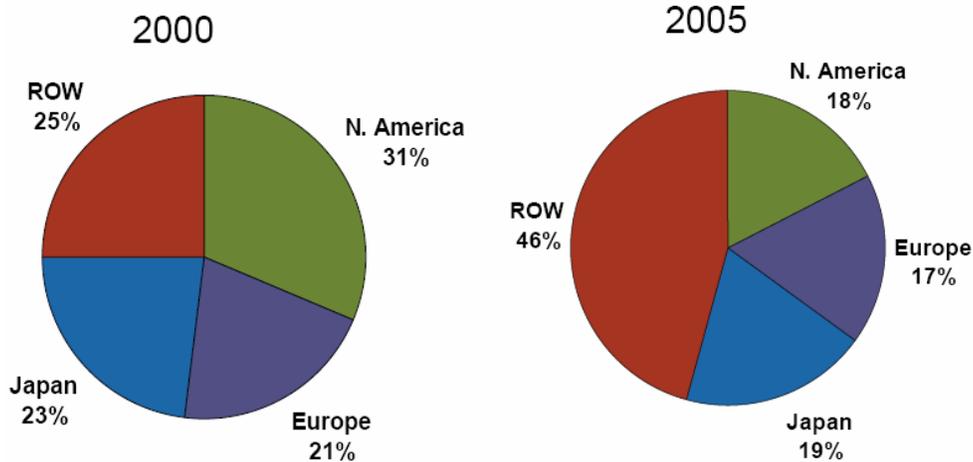
Worldwide, the semiconductor materials, SME and IC industries had 2005 revenues of approximately \$31 billion, \$34 billion, and \$227 billion, respectively. The 2005 semiconductor materials market by region is shown in Figure 2. The 2005 SME market by region is shown in Figure 3. The total IC market region is shown in Figure 4, both for 2005 and 2000. Market percentages by region of materials and SME have been fairly stable in recent years, save for an increase in the percentage of SME going to Korea from 8% in 2000 to 18% in 2005. The percentage of ICs going into the “rest of the world” (outside North America, Europe or Japan) has expanded dramatically since 2000, comprising almost half the market today.



**Figure 2. Total Semiconductor Materials Market by Region**  
 (Source: SEMI CGMG Q4 Market Materials Data Subscription)



**Figure 3. Total SME Market by Region**  
 (Source: SEMI/SEAG February 2006 and Gartner Group)



**Figure 4. Total IC Market by Region in 2000 and in 2005**  
 (Source: IC Insights, as published by SEMI)

The growth of Asian demand for ICs is a major driver of semiconductor industry growth today. Increasing outsourcing of electronic equipment manufacturing to China has led to an almost five-fold increase in Chinese IC consumption, from approximately eleven billion dollars in 2000 to over fifty billion dollars in 2005. At the same time, there has been continuing growth in outsourced semiconductor fabrication to Taiwan and significant investment in Korea. The movement of IC manufacturing to Taiwan and Korea is driven by the increasing capital costs of competitive commercial semiconductor fabrication. The movement of IC manufacturing to China is driven by numerous complementary factors:

China's stated goal is to become self-sufficient in the production of semiconductors for its domestic market and to develop technology that is competitive on the world market. This goal is being pursued for economic and national security reasons and is directed by a series of 5-year economic plans, and projects focused on high-technology industries. China has pursued a number of strategies to acquire the technology to meet its current and future semiconductor needs, including procuring semiconductors on the open market for both commercial and military uses and developing a domestic manufacturing capability. China also recognizes the importance of foreign investment and has instituted numerous incentive programs, which include free use of land and low taxes, to attract some of the world's leading semiconductor manufacturers and equipment suppliers. To encourage domestic innovation, China has constructed 53 "Silicon Valley"-style, high-technology development zones. In addition, China is cultivating the human capital to operate and manage semiconductor design and manufacturing facilities, in part from students returning to China after earning degrees at U.S. universities in semiconductor-related subjects. It also is acquiring expertise from foreign semiconductor manufacturers who provide their Chinese employees with

advanced training and establish research and development facilities in China.<sup>3</sup>

The economics of semiconductor manufacturing, with its high capital costs and performance improvement with miniaturization, have always put a premium on optimizing yield while increasing the processing capacity of individual chips. Hence, much of the industry's investment since the 1980s has focused on productivity enhancements such as quality control and improved IC design, shrinking transistor sizes through improved SME and processes, and increasing wafer sizes. As Japanese firms achieved a substantial lead in quality control and SME during the 1980s, manufacturing of commodity semiconductor products such as memory chips moved there from the US. As quality control came to be mastered worldwide, semiconductor manufacturing began moving to places such as Korea and Taiwan, where lower capital costs, tax incentives, government financing, and cheaper engineering labor make overall production costs more competitive.

The capital costs of competitive commercial semiconductor manufacturing have risen to the point where firms have begun to specialize in providing fabrication services, in order to spread these costs among many users. Increasing standardization of certain IC design components and tools is allowing entire systems to be realized efficiently on a single chip. A vertical disaggregation of the IC industry has resulted, with many firms outsourcing everything but design and development. Worldwide "fabless" revenues reached forty billion dollars in 2005 (more than half in the US)<sup>4</sup> and the fabless business model has grown to represent 20% of the US IC industry,<sup>5</sup> as depicted in Figure 5.

The larger US semiconductor industry firms such as IBM, Intel and Texas Instruments have maintained state-of-the-art, US-based fabrication facilities, but they have also built semiconductor "fabs" worldwide through foreign direct investment. China is increasingly a recipient of foreign direct investment in semiconductor manufacturing, as firms take advantage of the same economic forces that drove manufacturing to Taiwan and Korea. Chinese tariffs on imported ICs and explicit government policies aimed at fostering a domestic IC industry have also encouraged this trend. Only a small percentage

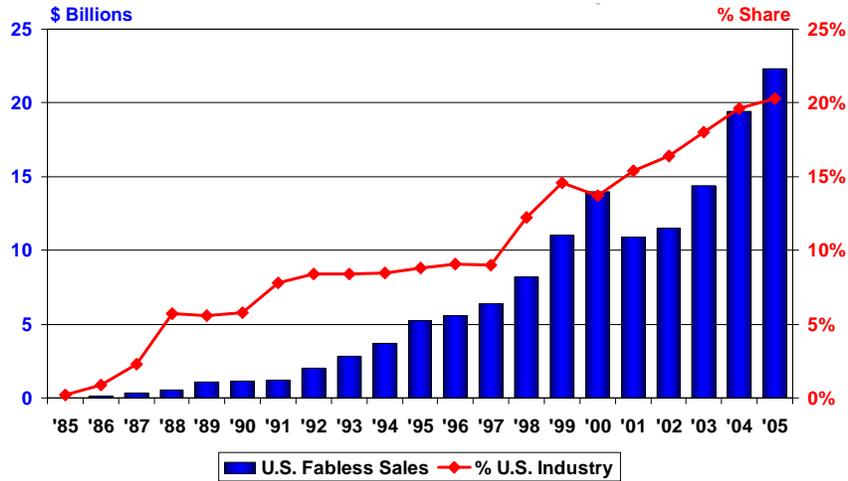
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<sup>3</sup> US Government Accountability Office, "Export Controls - Rapid Advances in China's Semiconductor Industry Underscore Need for Fundamental U.S. Policy Review," GAO-02-620, April 2002, pp 11.

<sup>4</sup> "Fabless Revenues Continue Growth," *Electronic News* 52, no. 12, p.7, March 20, 2006.

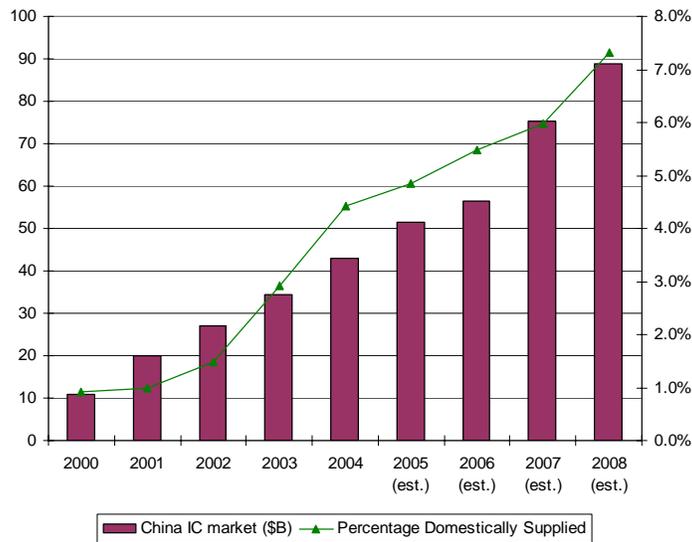
<sup>5</sup> D. Hatano, "Update for DSB ask Force on High Performance Microchip Supply, Semiconductor Industry Association, April 2006.

of the ICs used in Chinese electronics manufacturing are made in China today, though that percentage is projected to grow rapidly (Figure 6).



**Figure 5. Growth of the “fabless” business model among US IC firms**

(Source: SIA update for Defense Science Board task force on High Performance Microchip Supply, April 2006.)



**Figure 6. Growing Chinese IC consumption and manufacturing**

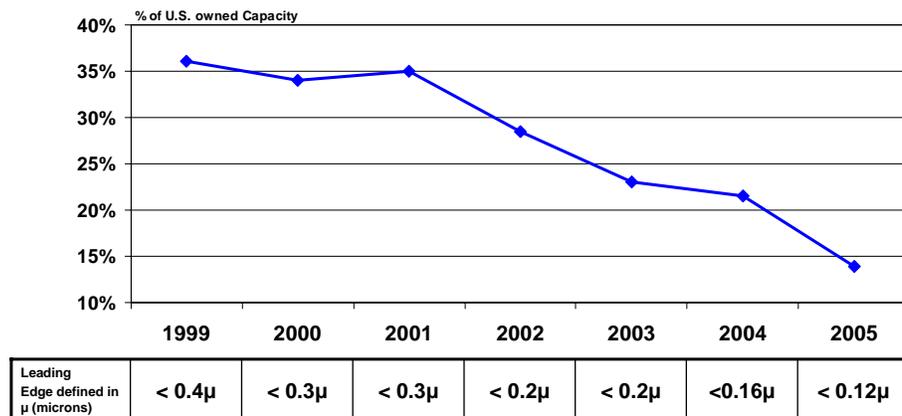
(Sources: SIA, iSuppli)

Some US industry observers have raised concerns about the increasing percentage of leading edge semiconductor fabrication facilities based overseas.<sup>6</sup> US-based ownership

<sup>6</sup> Defense Science Board, *Report of Defense Science Board Task Force on High Performance Microchip Supply*, February 2005.

of leading edge capacity has been steadily declining for years, as shown in Figure 7. In 2001, the leading edge for IC technology was defined by line widths of 0.3 microns or less on 200 millimeter wafers, and 35% of that capacity was US-owned. In 2005, the leading edge was defined by line widths of 0.12 microns or less on 300 millimeter wafers, and only 14% of that capacity was US-owned. Most of the new 300 millimeter fabrication capacity is being sited in Asia (ex-Japan), as depicted dramatically in Figure 8.

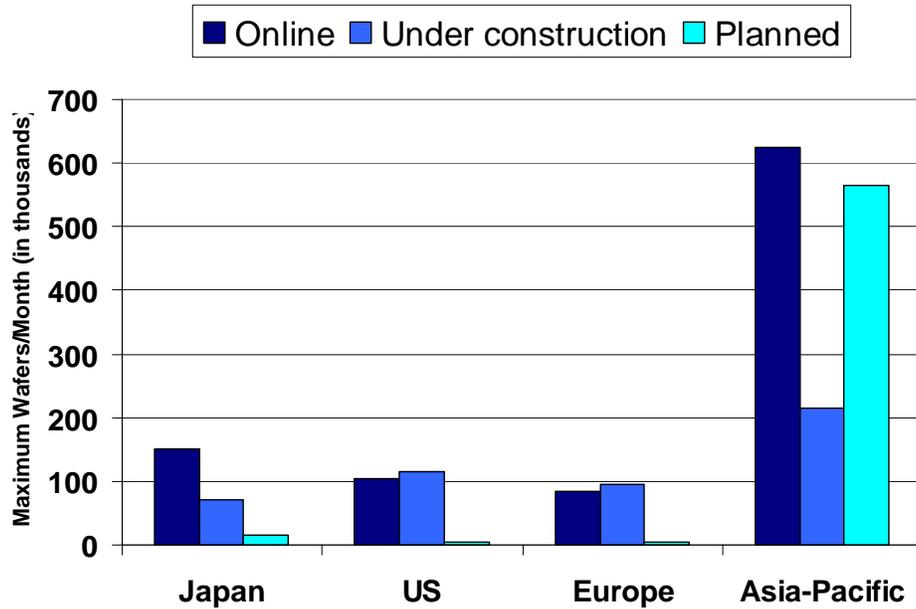
Despite the growth of IC manufacturing in Asia, the US continues to be a major player. While the US consumes less than twenty percent of worldwide IC production, US-based firms garner almost half total worldwide sales, as depicted in Figure 9. For the US domestic industry, the key to competitiveness since the 1980s—after catching up on manufacturing quality and productivity thanks in large part to the SEMATECH consortium<sup>7</sup>—has been through emphasizing higher-end products such as microprocessors, signal processors, and analog/mixed signal electronics. While manufacturing yield remains important to these segments of the semiconductor industry, design capabilities are more critical. The US continues to dominate these segments.



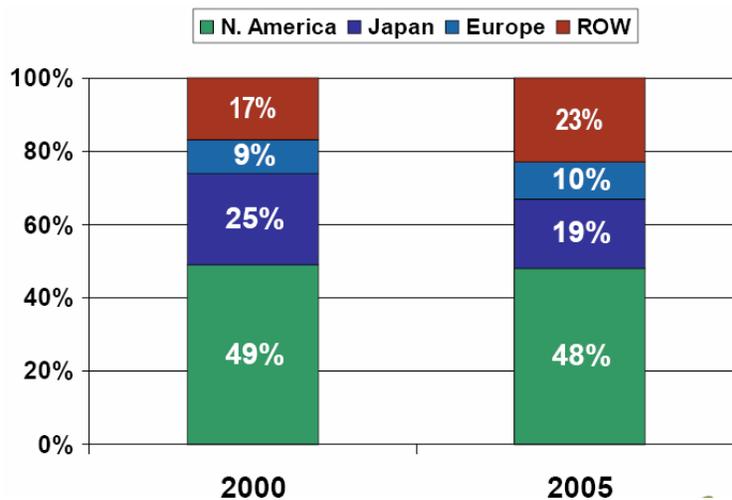
**Figure 7. US-owned leading edge IC manufacturing capacity**

(Source: adapted from SIA data)

<sup>7</sup> SEMATECH (SEmiconductor MAnufacturing TEChnology) was formed in 1987, when 14 US.-based semiconductor manufacturers and the US government (through the Defense Advanced Research Projects Agency, or DARPA) came together to solve common manufacturing problems. DARPA provided matching funds for SEMATECH through 1994. In 2000, SEMATECH began to operate as an international forum for cooperation on standards and specifications.

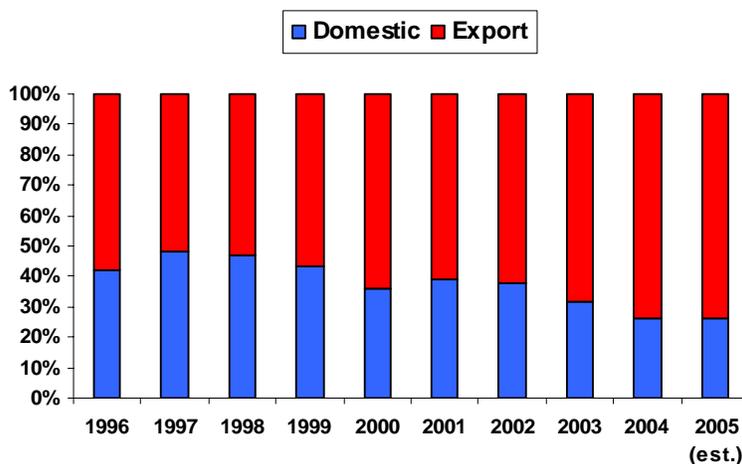


**Figure 8. Existing and planned leading edge IC fabrication capacity by region**  
 (Source: World Fab Watch Database, January 2006, as presented by SEMI)



**Figure 9. IC manufacturers Sales by Headquarters Location**  
 (Sources: IC Insights, The McClean Report, 2006 Edition, as published by SEMI)

The disparity between IC sales by North American-based firms and IC consumption in North America means that an increasing portion of these firms' revenues come from overseas sales, as depicted in Figure 10. Clearly, North American IC firms—and, by extension SME and materials firms—must export to survive. Sales of US-origin ICs by foreign-based subsidiaries of US firms to foreign customers are still legally considered exports and require licenses.



**Figure 10. Domestic vs. Export Sales for North American Headquartered Companies**

(Source: SMEI/SEAJ February 2006)

For the SME industry, the costs of development have also been increasing with the advance of IC technology, leading to a consolidation of that industry. The top three SME firms—Applied Materials (US), Tokyo Electron (Japan), and ASML (Netherlands)—accounted for about one third of the SME market in 2005. (Table 1) The top ten firms control sixty percent of the market. Most firms specialize in particular SME functions.

The role of technology leadership in SME presents a complex and less understood aspect of semiconductor industry competitiveness than IC design and fabrication. The macroeconomic contributions of the semiconductor industry—growth, high value-added exports and high-wage employment—has historically been viewed be dependent on cross-fertilization among different levels in the value chain. Co-location of manufacturing and advanced technology development has characterized the semiconductor industry for many years, and industrial “clusters” like the Silicon Valley demonstrate the innovative power of close coupling between development, design, manufacturing and application. By coordinating design and manufacturing process development, for instance, IC manufacturers are able to be first to market with leading-edge products.<sup>8</sup> By the same token, co-location helps SME companies better comprehend the problems and challenges of IC manufacturers. Electronics manufacturing, a \$1.3 trillion worldwide market in 2005, benefits from early knowledge of and access to the most advanced ICs. And internet, software and other information technology (IT) companies benefit from timely knowledge of emerging advances in the electronics systems that form the infrastructure of their industries.

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<sup>8</sup> Defense Science Board, p. 27.

Top 10 SME Companies by Revenue	2005 Revenue (\$millions)	2005 Market Share (%)	Etch	Chemical Vapor Deposition	Physical Vapor Deposition	Implant	Lithography	Resist Track/Processing	Mask Making	Chemical Mechanical Polishing	Thermal	Cleaning/Surface Conditioning	Inspection/Measurement	Test
Applied Materials US	4,738.5	13.7	Blue	Blue	Blue	Blue			Blue	Blue	Blue	Blue	Blue	
Tokyo Electron Japan	3,851.7	11.2	Red	Red							Red		Red	
ASML Netherlands	2,732.6	7.9					Green							
Advantest Japan	2,089.3	6.1												Red
KLA-Tencor US	1,654.9	4.8							Blue				Blue	
Nikon Japan	1,507.8	4.4					Red		Red				Red	
Lam Research US	1,147.0	3.3	Blue											
Novellus Systems US	1,130.1	3.3		Blue	Blue			Blue		Blue				
Dainippon Screen Japan	991.5	2.9						Red				Red		
Hitachi High-Tech. Japan	837.5	2.4	Red					Red					Red	
Others	13,793.7	40												
<b>Total</b>	<b>34,474.6</b>	<b>100</b>												

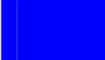
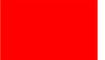
US  Japan  Europe 

Table 1. Summary of top SME companies by 2005 revenues, country, and SME category

To the extent that firms support each other in posing and solving problems, the network effect of clustered industries can be dramatic. The national economy benefits not only from the strength of its individual firms but also the interconnections among them that create enhanced growth possibilities for all. Nations have strategically targeted such industries frequently, supporting them with financing and subsidies or protecting them from foreign competition until they can realize the economies of scale and experience to compete internationally.<sup>9</sup> Hence, as electronics and IC manufacturing in China continues to grow, an increase in indigenous SME production, IC design and semiconductor research is occurring, due in part to government support for R&D infrastructure. The Ministry of Information Industry of China (MII) announced in August of 2005 that it was going to select software and ICs as the key fields for support in the eleventh Five-Year Plan (2006-2010) in order to realize new breakthroughs in the electronics industry.<sup>10</sup>

The US Department of Defense and NASA served in this role for the early US semiconductor industry, through providing research funding and, perhaps most importantly, by acting as a lead customer for fledgling domestic firms. For the next two decades, when reduction of semiconductor feature size was a critical element of improving semiconductor component performance, access to state-of-the-art SME conferred significant advantages to IC manufacturers. Delayed delivery of advanced Japanese SME to US manufacturers was part of the impetus for SEMATECH. However, the vertically integrated companies of years past, which performed the full range of IC manufacturing activities in house, from product definition to design to manufacturing to customer support, has largely given way to a global dispersion of manufacturing operations performed by a few multinational players in each horizontal sector, due to the increasing capital and research intensity of increasingly sophisticated SME.<sup>11</sup>

Unlike the early days of SEMATECH, however, little action has been taken by US-based IC firms or the US government to maintain domestic commercial suppliers of critical components of the semiconductor manufacturing chain, such as lithography and mask making. For some, this is an alarming development borne of industrial targeting by foreign governments. For others, this is a natural progression of an increasingly

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<sup>9</sup> Martin C. Libicki, "What Makes Industries Strategic," McNair Papers #5, The Institute for National Strategic Studies, 1989, p. 10.

<sup>10</sup> SinoCast/COMTEX, "MII to Lend Key Support to Software, IC Industries," SinoCast/COMTEX, Hoovers, August 19, 2005.

<sup>11</sup> Defense Science Board, pp. 17-22.

productive and standardizing industry, coupled with the necessity of firms to have a physical presence in the markets that are growing most rapidly.

A competitive forecast for the IC, SME and semiconductor materials industries is beyond the scope of this report. However, it is clear that the historical importance of development linkages—between systems developers and semiconductor developers, and between semiconductor developers and SME developers—are weakening as the semiconductor manufacturing industry matures, becomes multinational, and hence relies increasingly on international coordination, research consortia, and standardization. The semiconductor market today has achieved the diversity and global footprint that permits the US, Europe, and Asia to be players.

A recent report by the President’s Council of Advisors on Science and Technology (PCAST), Subcommittee on Information Technology Manufacturing and Competitiveness, was chaired by George Scalise, president of the Semiconductor Industry Association.<sup>12</sup> The PCAST report affirmed that US competitiveness in IT “depends upon dynamic ‘innovation ecosystems’ in which basic R&D and manufacturing constitute the ecosystems’ primary pillars...It would be a mistake to view individual pieces separately.” Rather, US policy should emphasize:

- A strong basic R&D investment;
- A large body of skilled scientists and engineers;
- A flexible and skilled work force;
- Reliable utilities and other infrastructure;
- Federal and state laws and regulations that do not inhibit high tech manufacturers from locating facilities at home;
- A competitive investor and tax environment; and
- A level playing field, with enforcement of trade agreements and intellectual property (IP) rights.

Accordingly, the report recommends more federal support for S&T and scientific education, permanent continuation of R&D tax credits, and more vigorous, continuous and timely US assessment and response to foreign industrial targeting, IP, and market

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<sup>12</sup> President’s Council of Advisors on Science and Technology, *Sustaining the Nation’s Innovation Ecosystems: Report on Information Technology Manufacturing and Competitiveness*, January 2004.

access issues.<sup>13</sup> A report by the Defense Science Board came to similar conclusions, as well as making several recommendations specific to current US military interests in the semiconductor industry. Hence, the consensus of top leadership and close observers of the semiconductor industry is that direct action is not called for today to protect particular segments of the semiconductor industry. Rather, US industry and government should attend to the innovative foundations of the industry and respond directly only to evidence of unfair trade practices by foreign governments, organizations, or firms.

### **Importance to Defense Industrial Base**

Beyond the economic importance of the semiconductor industry, ICs are widely employed in military electronics equipment. US defense strategy and planning is founded on qualitative systems superiority over all adversaries, and today's dominant US military capabilities are due in large part to success in exploiting electronics-based IT for military purposes. The current US advantage in electronics-based military capabilities was built over decades from a variety of substantial efforts: science and technology (S&T) investment, industry support and shepherding, acquisition policy, training, complex experimentation, and doctrine development. Discovering and realizing these capabilities have depended on interlinked the efforts of private companies, government contractors, academia and the US Department of Defense (DoD).

The nature and extent of DoD involvement with commercial industry has varied with changing circumstances. DoD and NASA played pivotal roles in the emergence of the US semiconductor industry in the 1960s, most importantly by acting as a lead customer for fledgling domestic firms. DoD was a driver of semiconductor advancement and consumed the majority of the output of the industry. Those early semiconductors enabled US superiority in a wide range of tactical and strategic weapons systems including intercontinental ballistic missiles and aircraft. In the 1980s, DoD was still a significant player and maintained a direct interest in access to the most advanced products, but at that time a partnership through SEMATECH, along with increased research funding, was seen as the most sensible way to support the health of the domestic industry in response to the challenge of Japanese industrial competition. The resulting resurgence helped keep US-based industry at the forefront of exploiting semiconductor-

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<sup>13</sup> *Ibid.*

enabled IT and, in doing so, facilitated DoD in realizing a “revolution in military affairs” (RMA) in the 1990s.<sup>14</sup>

Today, DoD again faces diminishing market share and concomitant fears of its impact on defense capabilities, this time from “globalization.” Semiconductor, electronics and IT capabilities have grown worldwide and diversified. Firms increasingly look externally for new ideas and partners to help bring technologies to fruition and to maintain competitiveness. With the end of the Cold War, US firms even contract for R&D in Russia (at a fraction of the cost of R&D in the US). As a result, as described in the previous section, US firms are no longer broadly dominant across all elements of the microelectronics supply chain, and the US share of leading edge IC manufacturing and investment is diminishing.

However, advanced ICs today play a relatively small role today in enabling dominant military capabilities, and DoD is no more than a niche player in the market. Commercial demand for processing speed, small size, and low power overlap with defense needs. However, defense consumers of ICs tend to be less price-sensitive than commercial customers and demand greater reliability, given that a soldier’s life may depend on the operation of an electronic system at a crucial moment. ICs destined for military applications often have to operate in severe environments in terms temperature range, shock, vibration and radiation. Radiation hardened semiconductor electronics, for example, is a unique requirement for defense systems that may have to operate after exposure to the radiation from a nuclear weapon.

In general, DoD’s exploitation of IT is increasingly realized at the subsystem and system level rather than the IC level. The DoD does not and, in general, cannot trace the origin of the ICs in its military systems. As the semiconductor industry has matured, DoD has depended more and more on defense contractors to manage the development and production of most of its electronic systems. Much of the current US military advantage in the exploitation of electronics derives from complex integration of these electronics into “systems of systems.” Top-of-the-line US weapons systems typically take more than a decade to develop and produce versus new IC generations being introduced every two years or so. Hence, with a few exceptions in areas such as sensors and intelligence

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<sup>14</sup> Richard Van Atta and Michael Lippitz, *Transformation as Transition: DARPA’s Role in Fostering an Emerging Revolution in Military Affairs*, IDA Paper P-3698 (Alexandria, Va.: Institute for Defense Analyses, March 2003).

systems, the ICs inside today's most advanced military systems tend to be far from state-of-the-art.

Even though Japan and much of Western Europe have since the 1980s maintained domestic semiconductor manufacturing capabilities equivalent to the US, their ability to develop and field RMA-style military capabilities still lags. The same limitations may affect China's ability to convert advanced semiconductor technology into military advantage:

...the semiconductor manufacturing technology China has acquired will enable it to produce components to enhance current and future weapon systems. However, having the components does not guarantee that China will be able to produce complete weapons systems...(as) China has experienced problems translating theory and design into reliable weapons systems. ...China's defense industry faces technical, structural, and other barriers that impede its ability to absorb and utilize advanced technologies for weapons production. For example, China's defense industry lacks many of the basic skills, such as making complex systems work together, necessary to fully utilize acquired technologies...(and) the highly compartmentalized and risk-adverse hierarchical structure of China's defense industry make it difficult for various branches of the industry to collaborate on weapons design or extract greater benefits from technology.<sup>15</sup>

This disparity in timescales between military systems development and commercial IC development has been true since the mid-1990s, and hence much of DoD efforts with respect to the semiconductor industry has been to undertake acquisition reforms to take greater advantage of commercially-available ICs that in many cases are both higher in performance and lower in cost than the DoD norm. Furthermore, many of the advanced ICs used by DoD today are in areas such as signal processors and mixed signal electronics. While manufacturing yield remains important in these segments of the microelectronics industry, design capabilities are more critical, and US continues to dominate these segments.

Even in the high-volume commercial arena, US capital expenditures lead the world. While the US share of state-of-the-art 300mm wafer fabs has dropped from over 30% to less than 14% in the past few years (as depicted in Figure 7 on page 10 of this section), the actual number of those fabs in the US has doubled, and US firms continue to make larger overall capital investments than those of any other country. The market is

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<sup>15</sup> GAO-02-620, *op. cit.*, p. 17.

expanding, making it possible to sustain IC manufacturing centers in areas with significant electronic systems manufacturing. The loss of market share is due, in large part, to a rapid expansion of semiconductor manufacturing in China, Taiwan and Korea not a significant weakening of absolute US capabilities.

A certain due diligence is required when using commercial ICs of all types. DoD shares this problem with the electronics industry, as counterfeit parts have emerged as a significant problem for commercial IC users.<sup>16</sup> However, for the most part, commodity components bought on the open market—particularly the somewhat older and time-tested components in deployed defense systems—can be “trusted.” Indeed, the defense acquisition reforms of the 1990s recognized that, in terms of total reliability, DoD could do better using standard commercial ICs from production lines producing millions of ICs (which are amenable to more rigorous quality control) than was possible for DoD-unique production lines producing only thousands of ICs to military specifications. DoD contractors have made significant efforts in recent years to alter electronics design and testing practices to provide best value to DoD through systems level tradeoffs.

While much of the U.S. military’s need for microelectronics can be met by using commercial devices, there are important cases in which it is prudent for DoD to maintain a more strongly and directly “trusted” production source. For instance, many application-specific integrated circuits (ASICs<sup>17</sup>) include proprietary or even classified information in their designs. DoD must protect these ICs from malicious compromise. Fortunately, the fact that multi-billion dollar fabs are required to be commercially competitive in certain segments of the semiconductor manufacturing industry does not mean that state-of-the-art manufacturing is inaccessible to DoD. Recently, DoD obtained a contract with IBM for ten years of semiconductor manufacturing services using state-of-the-art fabrication processes, for use on sensitive ICs in the intelligence community and for major DoD programs.

Specific areas where DoD requires ICs with performance characteristics that are distinct from standard commercial offerings include those in the following list. This list corresponds to ICs and technology on which export controls are still applied.

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<sup>16</sup> Dean Takahash, “The billion dollar problem Counterfeiting is big business and is only going to get worse. If you're not actively managing the risk, you're not managing your business,” *Electronics Supply and Manufacturing*, 5/1/04.

<sup>17</sup> Application Specific Integrated Circuits (ASICs) are designed for a specific customer application (frequently by the customer or a design house on their behalf) rather than a broad merchant commercial market. These ASICs are then fabricated in a semiconductor manufacturing plant.

- Radar processors

Radars are used for many civilian purposes, such as air traffic control systems and remote sensing systems for natural resources. However, many forms of radar technology are unique to the defense world. The most common defense radars, such as the Aegis SPY-1, are phase array radars which are used to survey, detect and track multiple air targets. Because the large number of antenna elements, phased array radars require high performance radar processors. These processors employ custom designed circuitry and architectures, as well as specialized packaging and interconnect technologies.

- Advanced analog-to-digital converters (ADC) and digital-to-analog (DAC) converters

Commercial applications of ADCs and DACs have much lower speed and resolution than is needed for military systems, such as the high-accuracy radar applications discussed in the previous example. Military sensing and communication systems require very high linear dynamic range to detect small target signals obscured by a strong background of interference, jammers, and clutter. The difficulty is compounded by the increasing tendency to require that these same systems also receive over a very broad bandwidth. Given system bandwidth requirements, the dynamic range offered by current commercial electronic systems is far short of what DoD requires. As future battlefields continue to digitize, advanced ADC technology will be needed to realize the next generation of small, low-weight, programmable digital receivers.<sup>18</sup>

- Digital signal processing (DSP)

High speed, high resolution DSP chips are used in defense system for signal processing such as filtering in radar systems. DSP technology differs from microprocessors in that the DSP processor usually features repetitive addition and multiplication operations designed to support high-performance numerically intensive signal processing. Since its development in the 1960s by Texas Instruments with its TMS320Cxxxx series of chips, DSP has become an important segment of the semiconductor industry. DSP technology is widely used in commercial devices such as cell phones, video recorders, CD players, hard disk drive controllers, and modems. Today the highest performing DSP, Texas Instrument's TMS320C67xx, runs at 600 MHz at 16-

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<sup>18</sup> ADCs at 16 effective bits at 100 MHz instantaneous bandwidth and >100 dB spurious free dynamic range (SFDR) are needed for these digital receivers. This represents a significant breakthrough in digitizer performance. These high performance ADCs are generally not required nor available in the commercial marketplace.

bit fixed point arithmetic. Defense systems, in high performance signal processing systems such as Fast Fourier Transform (FFT) processors, require DSP performance on the order of 1GHz at 16-bits or more as military radar systems are moving the digital signal processing closer to the front end.

- Infrared focal plane arrays (IRFPA)

IRFPA sensors are the “eyes in the digital battlefield,” as they are used for the imaging and detection of objects that cannot be detected in the visible spectrum. While commercial use of IRFPAs is expanding in areas such as security surveillance and automobile safety, military applications still dominate the requirements today. IRFPAs are widely used in military systems such as Forward Looking Infrared (FLIR) sensors on aircraft, night vision goggles, and missile seeker applications. IRFPAs at 256 x 256 pixels at the mid-wave (MWIR) or long-wave (LWIR) spectral band are generally used for missile seeker applications. These IRFPAs based on HgCdTe generally require cooling with a dewar and are bulky. Room temperature, uncooled IRFPAs, using III-V strained layered materials or multiple quantum well structures are being researched for defense applications using state-of-the-art semiconductor processing technology.

Thermal contrast reversals, camouflage matched to a particular background, and the variety of environmental conditions worldwide present significant issues to single band sensors. Hence, for defense applications, high-performance IRFPAs need to be tuned across the infrared (IR) spectrum. Multispectral imaging can address the most challenging target detection problem: the detection of a stationary target in a cluttered environment where the target-to-mean background signal differential is small compared to the fluctuation in the background. (The ultimately desired capability is to be able to electrically tune the sensor on a pixel-by-pixel basis, thus enabling the real-time reconfiguration of the array to maximize either spectral coverage or spatial resolution.) Multispectral imaging systems under development are large, complex, power hungry, and computational intensive systems. Typical imaging systems employed in avionics applications employ stabilized optical systems and cryogenically cooled detectors in order to provide target recognition ranges of about 5km. New mission requirements, which include a variety of distributed remote sensor platforms such as UAVs, drive the need for smaller, lighter weight imaging sensors with more capability than the current generation.

- High-power high-frequency devices and technologies

The ubiquitous radar systems installed in warships and fighter aircraft today employ many state-of-the-art high power microwave solid state devices and amplifiers. Power distribution, hybrid vehicles, and electromagnetic weapons also require ICs with high power handling capabilities. To accomplish this, wide-bandgap semiconductor materials are used, rather than standard commercial silicon. Extremely high RF power ( $> 1\text{KW}/\text{cm}^2$ ) electronic integration assemblies are also employed. The realization of high power devices requires the availability of large ( $> 100\text{ mm}$ ) semi-insulating, high quality substrates and epitaxial material technologies with better than  $\pm 1\%$  composition, thickness, and doping control. The development and exploitation of the material, device, and circuit properties of wide band-gap semiconductors is an area unique to defense electronics.<sup>19</sup> These high frequency, high power devices have few commercial applications.

- Navigation chips and technology

In the 1980s, the DARPA advanced Micro-Electro-Mechanical Systems (MEMS) technology for use in missile guidance, aircraft inertial navigation, and weapons fusing. The technology is now used in many civilian applications, such as airbag devices in automobiles. However, defense applications require MEMS devices capable of operating reliably under large temperature excursions, large power throughputs, high g-forces, presence of corrosive substances, and the like. Small, low-power, rotation rate sensors can be used in inertial navigation systems for small platforms, including individual soldiers, unmanned (micro) air vehicles, unmanned underwater vehicles, and even tiny (e.g., insect-sized) robots. The robust requirements for these MEMS gyroscopes (e.g. drift better than  $0.01^\circ/\text{hr}$ ) make these MEMS devices unique to defense systems.

- Radiation hardened (Radhard) electronics

Radhard electronics assure that space and nuclear systems can continue to operate in the most extreme, inhospitable radiation environments. In nuclear applications, radhard parts were a central element of mutual deterrence as the US was assured that its nuclear forces and their control systems would continue to operate through a potential

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<sup>19</sup> The leading candidate semiconductor material for 10 kV class high power devices and circuits is SiC in the 4H polytype. SiC has a unique combination of a high critical electrical breakdown field, good majority carrier transport, long minority carrier lifetimes due to its indirect band gap, and high thermal conductivity. These attributes combine to give SiC the potential to significantly exceed the current-carrying density, temperature and voltage-blocking capabilities of existing silicon power semiconductor devices. The next step is to fabricate 10-20kV,  $100\text{A}/\text{cm}^2$  power devices using high quality SiC materials.

nuclear attack, and hence the Soviet Union knew that a preemptive nuclear strike that would not disable our ability to respond. In space applications, the requirements for radiation tolerance were generally lower but still vital for the reliable functioning of satellites in orbit, including critical military communications and reconnaissance systems. Commercial space systems also require some degree of radiation hardening, but less than for defense systems. For defense systems, unique design and layout techniques are often needed to fabricate radiation hardened ICs.

In these and other areas, DoD continues to perform research in semiconductor technology relevant to its electronics systems requirements, including emerging technologies whose exact application to future defense systems is not clear. (In some cases, such as with MEMS, DoD S&T investments are leveraged to develop lower-performance, lower-cost ICs for commercial applications.) Military application areas include aiming and position accuracy of weapons, all-weather surveillance and mobility, unmanned robotic vehicles and aircraft, real-time global surveillance, and reliable (minimum downtime) global and mobile wireless communications as needed for information dominance and network-centric warfare. Representative S&T investment examples include infrared detectors and lasers for both tactical and strategic applications; wide-bandgap semiconductor research that is critical for high-temperature engine controls, high-power RF active aperture arrays, and shipboard switching devices; 100-GHz logic for digital RF and beamsteering; RF and optical computing devices needed to achieve major weight/size reductions in air and spacecraft signal processors; and mobile wireless communications and networking for the highly dynamic network topologies of the battlespace.<sup>20</sup>

Total DoD basic research funding in electronics has been in the \$130 million to \$145 million range since 2004. Approximately \$30 million to \$45 million has been for the Multidisciplinary University Research Initiative (MURI). The remaining \$100 million is divided into three areas: solid-state and optical electronics, information electronics, and electromagnetics.

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<sup>20</sup> DoD basic research in electronics is distributed over the military services in a manner that avoids duplication and maximizes benefits to specific service mission requirements. Army research areas are closely coupled to Army mission requirements for ground vehicles and soldier support; Navy programs are driven by considerations derived from multifunctional RF, ocean, and submarine operational needs; Air Force research efforts are dictated by requirements for high-performance aircraft and space platforms. In addition to service-specific programs, there are multiservice and multidisciplinary efforts to effectively focus resources on recognized high-priority DoD topics.

- Solid-State and Optical Electronics

Research in solid-state and optical electronics will provide the warfighter with novel or improved electronic and optical hardware (including nanoelectronic hardware) for surveillance, target acquisition, tracking, electronic controls, radar and communication, displays, data processors, and advanced computers. Research in solid-state electronics emphasizes topics of limited commercial interest such as radiation-hardened, low-power, low-voltage applications for soldier or space support; ultra-high-frequency devices to be applied in secure communication; remote detection devices for personnel and chemical or biological agents; versatile, wideband, multifunctional RF technology; or robust building blocks for future generations of efficient, ultrafast, dedicated supercomputers. Optical electronics, including photonics, takes advantage of the very high transmission bandwidth and aims at massive optical storage and parallel channels as critical building blocks of photonic computation. Other optical research is directed to multifunction infrared (IR) and ultraviolet (UV) devices for target and threat detection and avoidance.

As silicon device geometry continues to shrink to below 100nm, there is a need to explore both evolutionary silicon nanoelectronic technology and revolutionary new nanoelectronic device technology for application in next generation defense systems. DoD sponsors research to provide radical innovation in semiconductor technology that provide solutions to barrier problems in the path of sustaining the historical productivity growth and performance enhancement of semiconductor integrated circuits. DoD research in nanoelectronics concentrates on topics that will provide superior capabilities to the DoD while at the same time sustain the growth of the semiconductor industry as part of the defense infrastructure.

- Information Electronics

Basic research in information electronics pushes the performance envelope for wireless communications and mobile wireless networking, simulation and modeling, coding, digital signal processing, and image/target analysis and recognition. Research in information electronics is dedicated to signal processing for wireless applications and image recognition and analysis. Coding schemes for secure communication and robust communication networks are being investigated. Unique cellular arrays are being investigated for image processing to bypass software and algorithm bottlenecks. Optimum control of distributed information processing and transmission is also receiving

substantial attention. Innovative approaches to modeling and simulation of devices and circuits are being pursued.

- Electromagnetics

Electromagnetics research aims to advance DoD capabilities in signal transmission and reception such as found in radar, high-power microwaves, or secure communications in built-up areas. The electromagnetics research program is focused on fundamentals of antenna design, dispersion-free beamsteering, scattering and transmission of electromagnetic (EM) signals, vacuum electronics modeling and simulation, and efficient and low-energy RF components for use predominantly in multifunctional and wireless applications. Computational electromagnetics is receiving strong emphasis, along with novel approaches to time-domain modeling of electromagnetic wave generation, transmission, and propagation. A substantial part of the program is focused on modeling of millimeter-wave (MMW) phenomena by optical means. New adaptive, reconfigurable RF radio/sensor concepts are also being explored.

Service-specific interests and commonality in Electronics are presented in

## **EXPORT CONTROLS ON THE SEMICONDUCTOR INDUSTRY**

### **CCL and ITAR**

Most semiconductor materials, SME and ICs are currently decontrolled for export to all countries except those under US sanctions. For many semiconductor companies, none of their products is controlled. The US Department of Commerce controls certain advanced semiconductor ICs, SME and materials under the Commerce Control List (CCL). Radiation hardened ICs used in nuclear and space systems come under the control of the International Traffic in Arms Regulations (ITAR), administered by the State Department. Licenses for controlled semiconductor materials, SME and ICs require the vendor to affirm the commercial nature of the customer as well as to determine the intended application. There may be more than a dozen detailed conditions placed on a license. Transfers of technical data require licenses also. Every foreign worker hired requires an extensive review of their job and work environment to determine whether an individual deemed export license is warranted, while overseas facilities such as those in China only require site licenses to cover controlled technology transfers. For some semiconductor companies, these “deemed export” controls constitute more than half their export control activity.

CCL-controlled materials include advanced, high-quality items such as:

- III/V compounds and IV/IV alloys such as gallium arsenide, gallium-aluminum arsenide, indium phosphide, silicon-germanium and silicon-carbide
- Advanced photoresists and resists designed for use with electron beams, ion beams or X-rays, or optimized for surface imaging technologies.
- High-purity organo-metallic compounds of aluminium, gallium , indium, arsenic, and antimony; Hydrides of phosphorus, arsenic or antimony.
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CCL-controlled SME includes advanced, high-accuracy equipment specially designed for functions such as:

- Wafer handling
- Epitaxial growth

- Metal organic chemical vapor deposition (MOCVD) and plasma enhanced CVD
- Ion implantation
- Anisotropic plasma dry etching
- Mask making (including electron beam and ion beam direct writing, and their associated test equipment)
- Lithography
- Surface finishing, particle measuring and repair or trimming of ICs
- IC Assembly
- Testing of ICs and discrete component functionality and detection of defects
- Integration of controlled equipment into a complete system
- Computer aided design (CAD) of semiconductor devices or ICs
- Producing or purifying controlled materials Wafer handling
- Manufacture inspection and testing of electron tubes, optical elements and specially designed components, such as vacuum microelectronic devices; high electron mobility transistors (HEMT), hetero-bipolar transistors (HBT), quantum well and super lattice devices; "Superconductive" electronic devices)
- Determining the performance of focal-plane arrays
- Technologies for the development, production or use of controlled SME and materials.

CCL-controlled ICs include advanced components in the following categories:

- Analog-to-digital converters and digital-to-analog converters
- Electro-optical circuits
- Field programmable logic devices
- Neural network integrated circuits
- Custom integrated circuits
- Fast Fourier Transform (FFT) processors
- Electrical erasable programmable read-only memories (EEPROMs)

- Flash memories or static random-access memories (SRAMs)
- Microwave or millimeter wave components
- Electronically or magnetically tunable band-pass or band-stop filters
- Acoustic wave devices, Acoustic-optic signal processors
- High energy batteries, photovoltaic arrays, storage capacitors
- "Superconductive" electromagnets and solenoids
- Rotary input type shaft absolute position encoders

For a more detailed listing of specific materials and SME controls, see

### **Proposed changes to CCL rules**

On July 6, 2006, the Department of Commerce printed in the Federal Register proposed changes to the CCL entitled, “Revisions and Clarification of Export and Reexport Controls for the People's Republic of China (PRC); New Authorization Validated End-User.”<sup>21</sup> The new rules seek to “prevent exports that would make a material contribution to the military capability of the People's Republic of China (PRC), while facilitating U.S. exports to legitimate civil end-users in the PRC.” The specific changes involved would require US firms to confirm the commercial nature of customers and end users in China, with potentially severe penalties for exporting equipment or technology that was found to be supporting the production of Chinese military systems. For controlled items, exporters would be required to obtain an “End-User Certificate” from the PRC Ministry of Commerce. The proposed rules would also create a new blanket export and re-export authorization mechanisms for “validated end-users.” To be designated as a validated end-user, entities must be certified to have “exclusive engagement in civil end use activities” and agree to “on-site compliance reviews by representatives of the U.S. Government.” However, the exact review criteria, the administrative burden of certifying a validated end user and what a US firm could do to effect or expedite an export under this designation is not clear as of this writing.

The standard for review under the new rules would become a general policy of denial for items that would make a “material contribution to the military capabilities of the PRC” (undefined), rather than the old standard of review, which involved case-by-case judgments of whether an export will make a “direct and significant contribution” to electronic warfare, anti-submarine warfare, intelligence gathering, air superiority, or power projection. The standard of culpability for exports that benefit the production of Chinese military systems would be reduced from the current “actual or positive knowledge” to the possession of any information suggesting a potential military application. Liability for violations would be extended to anyone who “supports or facilitates” the export, potentially including banks, forwarders, lawyers and the like.

For the semiconductor industry, the proposed rule change would place new information-gathering requirements on US industry on SME and materials that are not

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<sup>21</sup> 71 FR 38313 of July 6, 2006

currently controlled. It would, in essence, act as a military catch-all regulation of SME and materials industry exports. For SME and materials companies, end use verification could be impossible, as these are general purpose equipment and materials that could be used to build any type of ICs, which themselves are general purpose devices. (Even in the US, the DoD cannot trace the origin of every IC in its military systems.) The ambiguity of the proposed rules confers potentially open-ended liability on US firms, based on subjective application by the Department of Commerce. This expansion of export documentation, investigation requirements for China, and potential liability would likely be unilateral, as other Wassenaar signatories have shown no interest in similarly tightening their implementation.

### **Deemed exports**

Deemed exports refers to the regulation that a license must be obtained by US entities before providing to foreign nationals information related to controlled technologies. Deemed exports have become an issue given the preponderance of foreign graduate students coming out of US university science and technology programs, and a huge growth in the number of quality Masters and PhD students graduating from Chinese universities.

Semiconductor companies contacted by this study indicated that deemed export licenses generally take about six months but sometimes much longer. Once approved, narrowly defined license conditions can make it difficult for controlled foreign national hires to provide the full benefit of their skills. At one facility, several foreign nationals are employed but segregated from all sensitive processing activity.

### **Radiation hardened ICs and ITAR**

Radiation hardened (radhard) electronics assure that space and nuclear systems can continue to operate in the most extreme, inhospitable radiation environments. RadHard electronic parts have been a focus of DoD attention since the beginning of the nuclear and space ages. In the 1950s and 1960s, DoD S&T focused on understanding nuclear and space radiation phenomenology and electronic effects. In the 1970s and 1980s, DoD S&T focused on devising designs and developing manufacturing processes that prevented microelectronic functionality from being disrupted when exposed to nuclear and space radiation. From the 1990s to today, DoD has sought ways to affordably meet its RadHard integrate circuit (IC) needs in the face of increasing production costs associated with growing microelectronics sophistication and rapid market obsolescence.

In nuclear applications, radhard parts were a central element of mutual deterrence as the US was assured that its nuclear forces and their control systems would continue to operate through a potential nuclear attack, and hence the Soviet Union knew that a preemptive nuclear strike that would not disable our ability to respond. In space applications, the requirements for radiation tolerance were generally lower but still vital for the reliable functioning of satellites in orbit, including critical military communications and reconnaissance systems.

RadHard electronics are controlled through the International Traffic in Arms Regulations (ITAR), which regulates trade in military items listed on the US Munitions List. The ITAR regime is much stricter than the CCL. Included in the ITAR are dual use technologies that have been “specially designed, modified or adapted” for a military use. Up until March of 1999, an IC had to meet five performance criteria as well as be explicitly designed for use in space or nuclear applications in order to be controlled.<sup>22</sup> In 1999, the ITAR was changed to include all ICs that met the five criteria, regardless of whether they were designed for use in space or nuclear applications. The five criteria are as follows:

1. A total dose of  $5 \times 10^5$  Rads (Si)
2. A dose rate upset of  $5 \times 10^8$  Rads (Si)/sec
3. A neutron dose of  $1 \times 10^{14}$  N/cm<sup>2</sup>
4. A single event upset rate of  $1 \times 10^{-7}$  or less errors/bit-day
5. Single event latch-up free and having a dose rate latch-up of  $5 \times 10^8$  Rads (Si)/sec or greater

US industry began expressing concerns in 2002 that continued shrinking of integrated circuit line widths, combined with the introduction of new materials and error-correcting software, could result in most standard commercial parts inadvertently meeting the ITAR criteria, even though they would not necessarily be reliable in space or nuclear

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<sup>22</sup> Electronics in space must cope primarily with trapped particle radiation belts that surround the earth. The inner radiation belt consists mostly of trapped protons that cause gradual degradation of electronics performance due to accumulated dose and single-event upsets due to single particle strikes. The outer radiation belt consists mostly of trapped electrons that cause damage from accumulated dose. In addition, electronics in space must cope with cosmic rays (comprised mainly of protons) and various high-energy, heavy nuclei, which can go to very high levels during solar flares. For electronics to survive a nuclear radiation environment, they must be able to withstand large x-ray and gamma ray doses in an intense, very short burst. Hence, dose rate effects predominate.

applications.<sup>23</sup> Most commercial 90nm silicon ICs currently meet all but the single event upset (SEU) thresholds. When line widths decrease to 65nm, it is expected that SEU performance will improve, and that if not at 65nm, then probably at 45nm the commercial ICs would meet all five ITAR criteria. However, future ICs would not likely be suitable for use in space because they will run at lower voltages than today, making them more sensitive to upset by lower energy particles that are present in background space radiation. Low-voltage, high-speed ICs designed for use in space will need to incorporate new design features—e.g., additional capacitors, redundancy, and new error correcting logic—in order to maintain acceptable SEU performance, even though such ICs will meet the ITAR criterion for SEU.

Furthermore, although elements of the radhard manufacturing process have traditionally been classified, radhard parts—including those designed to withstand nuclear weapons radiation effects—are increasingly available from several foreign suppliers. Specifically:

- Dassault Electronique: (France) offers Radhard ASIC design, microwave circuits, and packaging.
- IMEC (Belgium): ASIC prototype and small volume fabrication is offered in several technologies, including radiation hard BiCMOS (DMILL).
- ALCATEL Telecom/SDM (France): SDM is an ASIC design and test unit of Alcatel Telecom with expertise in Radhard mixed signal circuits.
- Atmel (France): RadHard devices for export include SPARC Microprocessors, DSP, SRAM, ASICS, FPGA, EEPROM and system on chip devices.
- Peregrine (Australia and Japan): Develops semi-custom communications ICs that meet the needs of satellite manufacturers for low-power, inherently radiation-hardened solutions. Leveraging commercial capability from its synthesizer and RF transceiver products, Peregrine can provide highly cost-effective Radhard ICs.

Restricting US sales of commercial microelectronics is based on a theory that an adversary could, in theory, buy large lots of standard parts and test them to try to find

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<sup>23</sup> DARPA's RadHard by Design Program recently demonstrated the ability to achieve nuclear RadHard properties for ICs using design techniques alone; i.e., employing standard commercial manufacturing processes.

ones that happen to meet their RadHard needs. Absent complex testing, no one knows whether any particular commercial semiconductor will meet all the ITAR criteria—and even with testing, one would not be certain, as the extreme complexity of modern ICs makes comprehensive testing infeasible. Radiation tolerance is not a control parameter for non-space parts, semiconductor manufacturers do not test their non-space products for radiation tolerance, and the US government does not require or perform tests on exported products that make no claims about radiation performance. However, if a US manufacturer shipped a semiconductor to, say, China that was later tested and found to meet the ITAR criteria, that manufacturer would be held in violation of US export control law, despite the fact that it would be folly for a builder of a commercial or military space system to risk the viability of the system on an IC that was neither designed, built nor tested to withstand extreme radiation effects.

The Semiconductor Industry Association has suggested changing the ITAR regulation on single event upset from  $1 \times 10^{-7}$  to  $1 \times 10^{-15}$  errors/bit-day. This change would effectively remove all microelectronics from potential regulation except those explicitly designed to withstand the most intense space nuclear weapons radiation environments. A compromise proposal from the Department of State is to change the SEU criterion to  $1 \times 10^{-10}$  errors/bit-day, which would likely make standard commercial ICs exempt from ITAR control for several additional years. Absent some accommodation, US commercial IC firms would likely be forced to introduce radiation vulnerability explicitly into their designs, in order to be able to continue doing business overseas. They would, in essence, likely have to introduce deliberate flaws into their ICs so that they would fail to meet the ITAR criteria but would still function as specified for their designed purposes. While such design practices are probably feasible and could be accomplished without a huge effort, it would represent essentially a waste of time and effort for IC firms, while also exposing their IC designs to unknown risks. It would also likely involve some compromise, giving US IC firms a competitive disadvantage in the world market.

### **Foreign export controls**

Multilateral export controls of dual use items are coordinated through the Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies (WA). The first of the four original elements provides that,

The Wassenaar Arrangement has been established in order to contribute to regional and international security and stability, by promoting

transparency and greater responsibility in transfers of conventional arms and dual-use goods and technologies, thus preventing destabilising accumulations. Participating States will seek, through their national policies, to ensure that transfers of these items do not contribute to the development or enhancement of military capabilities which undermine these goals, and are not diverted to support such capabilities.

The WA, which came into force in 1997, was the successor of the Coordinating Committee for Multilateral Export Controls (CoCom), which ceased operations in 1994. CoCom had been designed to keep advanced technology useful to the military from the Soviet Union and its Warsaw Pact allies. The WA retains the basic philosophy underpinning CoCom—member countries share a common interest in controlling the spread of military technology so as to ensure international security and to maintain national military advantage—but is more loosely structured, allowing much wider variance among members of the arrangement. For instance, while CoCom involved prior notification of proposed exports, WA nations exchange information post-hoc, semi-annually.

The WA is an “Arrangement,” not an “Agreement,” and hence has no binding force under international law. No nation has ratified the WA. As a matter of law, however, European Community Regulation 1334/2000 binds the member states to implement export controls in their own national legislation. 1334/2000 requires controls of the dual use items, in a listing that very closely matches the WA and in fact references the WA. As a result, the WA has effectively become part of EU law. The actual lists of controlled items closely match US lists. The EU recently studied 1334/2000 implementation and appears to be preparing to implement a number of recommendations toward the goal of internal harmonization of EU export control law, in terms of legal and administrative procedures, penalties, implementation of the military catch-all clause.

The WA objective of controlling militarily useful technology is in inherent tension with the fact that the same signatory countries also compete vigorously to sell both military and dual use goods and services. Consequently, while all benefit from restricting the flow of military goods to certain nations, there is a strong incentive to sell to nations outside the agreement. As suggested by a 2002 US Government Accountability Office (GAO) review:

The Wassenaar Arrangement lacks a “no undercut” rule, under which a Wassenaar member would agree not to permit the export of any listed item(s) that had been, within a specified period, officially denied an export license by another member. According to a senior Wassenaar

Arrangement official, implementing a no undercut rule would be the only realistic way to relieve competitive pressures to approve certain exports.<sup>24</sup>

US industry in general has complained that certain other parties to the WA have implemented their controls more liberally than in the US, conferring a competitive advantage. One SME firm produced copies of export control licenses from Netherlands and the UK that approve SME exports and manufacturing of spare parts in China. The Dutch license only says to “please take care that the machine will not be used for WMD purposes,” and it was approved in two weeks. The UK license took much longer but was also approved without significant conditions. In contrast, a comparable US license listed almost two dozen intrusive compliance requirements, and it took 6 months for approval. (Unlike EU members, the Japanese government is believed to be fairly strict in their implementation of export controls, especially to China. They place responsibility on equipment manufacturers to ensure compliance of their Chinese customers, and the companies do this by maintaining personnel on site.)

The GAO report generally concurred with the contention that export licenses for SME are easier to come by from other WA signatories:

The multilateral Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies has not affected China’s ability to obtain semiconductor manufacturing equipment because the United States is the only member of this voluntary arrangement that considers China’s acquisition of semiconductor manufacturing equipment a cause for concern.<sup>25</sup>

Additionally, the speed of license processing is claimed to be much faster in other countries, and even when it is not, SME firms claimed that their foreign competitors sometime give their customers guarantees of obtaining export licenses. A review of the German implementation gives some insight into how this can be done without extreme risk:

Responsible for granting/denying export licenses under the Foreign Trade and Payments Act and Ordinance is the Federal Office of Economics and Export Control, which is a subordinate agency operating under the jurisdiction of the Federal Ministry of Economics and Labor. The Federal Office of Economics and Export Control submits sensitive projects to the federal government for its assessment from a political perspective. The so-

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<sup>24</sup> GAO-02-620, *op. cit.*, p. 19.

<sup>25</sup> US Government Accountability Office, “Export Controls - Rapid Advances in China’s Semiconductor Industry Underscore Need for Fundamental U.S. Policy Review,” GAO-02-620, April 2002, pp 2-3.

called advance inquiry practice has become customary in the course of the past several decades. This practice lets companies know at an early stage whether, upon agreement on a sales contract, the required export license will be granted at a later point in time - assuming the circumstances of the transaction remain unchanged. Decisions on advance inquiries are taken in accordance with the same criteria as decisions on export license applications.<sup>26</sup>

and later in the document

In 2003, 104 applications for military equipment exports were denied. The total value of the denials came to €25.4 million. The figure does not include applications withdrawn by applicants prior to notification because of poor prospects of success. The relatively small ratio of formally denied applications is chiefly to be explained by the fact that, prior to the submission of a license request, applicants seeking to export to sensitive destinations make a formal or informal inquiry with the control authorities about their applications' prospects. Where the response to the inquiry is negative, a formal application is filed only in extremely rare cases, and the subsequent denial is then included in the attached statistical overview. As a rule, applications appearing to have no prospects of success are not submitted.<sup>27</sup>

A more complete description of foreign implementation of the Wassenaar Arrangement appears Appendix E: "The Wassenaar Arrangement and Its Implementation in Europe."

## **ECONOMIC IMPACTS OF EXPORT CONTROLS**

### **Quantitative Conclusions**

This study found that, since the inception of Wassenaar, US-based IC, SME and materials companies have not been severely impacted by export controls, but this may not be the case going forward. US implementation of semiconductor export controls burdens US semiconductor companies with more conditions on foreign sales and longer and less predictable waiting periods for license approval than that faced by competitors in Europe or Japan selling comparable products, but licenses are rarely denied. Companies contacted by this study and published reports cite only a handful of instances where sales were lost to a foreign competitor due to delays or conditions in US export licensing.

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<sup>26</sup> Report by the Government of the Federal Republic of Germany on Its Policy on Exports of Conventional Military Equipment in 2003 (2003 Military Equipment Export Report).

<sup>27</sup> *Ibid.*

A similar conclusion was reached by the US Government Accountability Office (GAO) in a 2002 report:

The majority of export license applications for semiconductor manufacturing equipment and materials for China are approved. From fiscal year 1997 through fiscal year 2000, 64.6 percent of export licenses for semiconductor manufacturing equipment (Category 3B) were approved, and 78.3 percent of export licenses for semiconductor manufacturing materials (Category 3C) were approved. Other data indicate that export license denials have not had a major economic impact on the industry. The U.S. government reviewed nearly \$1.6 billion worth of semiconductor manufacturing equipment and materials licenses for export to China from fiscal year 1997 through fiscal year 2000; only 0.4 percent and 0.5 percent of equipment and materials licenses, respectively, were denied as measured by dollar value.<sup>28</sup>

This study's interviewees confirmed this finding. Some companies have not had a single denied license, but most can cite a handful of denials. One IC manufacturer indicated that they had lost a few sales due to the long licensing period or the buyer's unwillingness to accept conditions contained in the approved license. Lost sales were also noted in the GAO report:

Despite the overall high approval rates for electronics goods and technologies, there are a few cases where licensing denials did cost some U.S. companies sales worth several million of dollars. We asked companies that are members of the semiconductor equipment and materials trade association to provide examples of cases where export license denials resulted in sales lost to foreign competitors. Of the six cases they identified, we were able to verify two. In May 1998, the Commerce Department denied an export license to Emcore Corporation of Somerset, New Jersey, to sell a metal organic chemical vapor deposition machine to the Hebei Institute of Semiconductors [of China]. The institute later purchased a similar machine from Aixtron GmbH of Aachen, Germany. In 2001, Hayward, California-based ETEC lost the sale of a mask pattern generating machine (ALTA 3000) to Shanghai-based Semiconductor Manufacturing International Corporation. Due to delays in the license approval process, the firm canceled its ETEC order and purchased a machine from Micronic of Taby, Sweden. The Commerce Department later approved the sale of a more advanced machine (ALTA 3500) to Semiconductor Manufacturing International Corporation.<sup>29</sup>

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<sup>28</sup> GAO-02-620, *op. cit.*, p. 27.

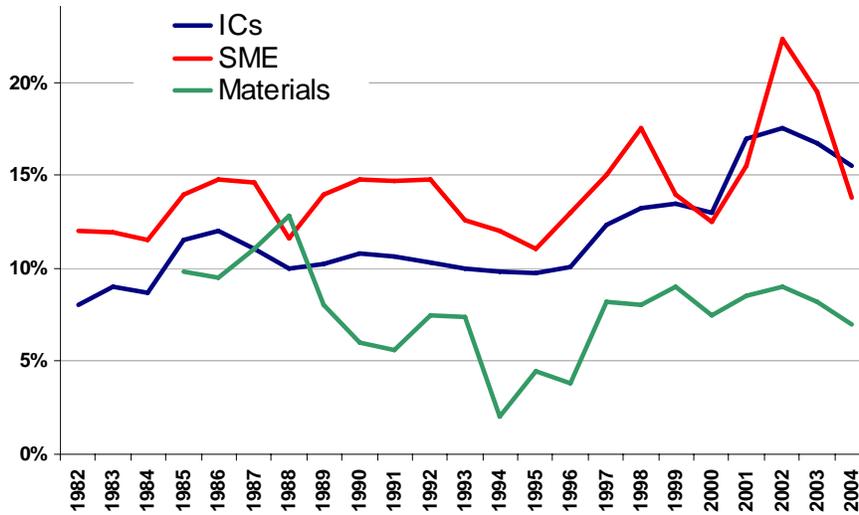
<sup>29</sup> *Ibid.*, p. 28

This being said, economic losses can go beyond lost sales as recorded in export control statistics. IC manufacturers spend considerable time and effort fine tuning their manufacturing processes to achieve the highest possible yield. SME companies strive to become what is known as the “tool of record” at an IC manufacturing site, which means that the customer’s integrated manufacturing process is qualified for that particular tool. If a lost sale inhibits the qualification process and a manufacturer decides to qualify a competitor’s tool, then the SME company may lose numerous other sales. If a lost sale represents a decision to qualify a different tool due to export control issues, then sales will be lost—without any license application—as their tool is replaced in all manufacturing sites worldwide where that particular manufacturing process configuration is used. If a foreign customer believes that an export license will not be forthcoming or will be too difficult to obtain from the US government, then US companies may not even be asked to bid on new business. *Licensing delays and uncertainties threaten to give US suppliers a reputation of being unreliable partners in the lean, “just in time” worldwide supply chains that increasingly characterize high technology industries.*

Staffing requirements and administrative burden of export controls represent a unilateral cost to US industry relative to its foreign competitors. The costs of compliance are rising and threaten to become a competitive disadvantage to US-based firms in the increasingly competitive international semiconductor industry. Along with lost sales, these costs translate into lost research and development (R&D). In research-intensive industries such as SME, a large percentage of profits—sometimes more than 20% of revenues—are often funneled back into R&D, in order to maintain competitiveness, as depicted in Figure 11. And R&D costs increase with each new generation of ICs. While the impact of reduced R&D on future innovation and competitiveness is not straight forward, the ability of SME and materials companies to fund the scope and scale of R&D required to continue advancing the state of the art is already being called into question, and significant consolidation of the industry is viewed as “inevitable.”<sup>30</sup> Absent increases in external R&D funding, reduced revenues and concomitant reduced R&D make it less likely that US companies will be able to remain independent, much less maintain technology leadership.

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<sup>30</sup> SEMI White Paper, “Semiconductor Equipment and Materials: Funding the Future,” October 2005.



**Figure 11. R&D spending as a percentage of revenues for various segments of the semiconductor industry** (Source: S&P, INFRASTRUCTURE Advisors, as quoted by SEMI)

### Qualitative Conclusions

The main concern of semiconductor companies is that unilateral US export controls will make them appear to be unreliable suppliers relative to foreign competitors, who are able to obtain licenses for comparable products and services relatively quickly and in some cases can have sufficient confidence in approval to guarantee licenses to their customers. In the SME industry, for instance, for any given step of the process, there are foreign alternatives to US companies, as indicated in Figure 12.

	Option 1	Option 2	Option 3, etc.
Etch	Lam	TEL	AMEC
CVD	Novellus	Jusung	ASMI
PVD	Applied	Trikon	Unaxis
Implant	Varian	SEN	Nissin
Lithography	ASML	Canon	Nikon
Resist Track	Sokudo (AMAT JV)	TEL	Suss Micro
Mask Making	Applied	Micronic	NuFlare
CMP	Applied	Ebara	Accretech
Process Control	KLA-Tencor	Leica	Hitachi

**Figure 12. Alternative suppliers of SME, by equipment type**  
(Source: Advanced Materials Corporation)

Some participants in the export control world believe that the proposed new CCL “China catch-all” rules could encourage mischief by foreign competitors, who will have

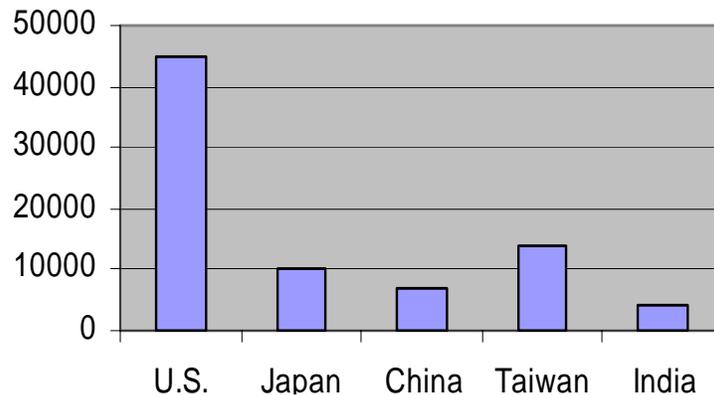
more opportunities to provide authorities anonymous allegations about the military nature or ties of a particular foreign consignee, knowing that once the allegations reach the Department of Commerce Office of Export Enforcement an "is informed" letter will be dispatched to the U.S. party. Once a US exporter received such a letter, contracts in process will have to be placed on hold while the company tries to prove the commercial nature of their Chinese customer, giving the Chinese customer an opportunity to cancel the sale.

In today's world of global corporations and corporate networks, moving product development overseas is much easier than in the past. US semiconductor firms have made significant foreign direct investments to date and have set up research facilities overseas. There are claims that some companies have moved manufacturing and product development overseas into foreign-incorporated subsidiaries in part to avoid US export controls. Due in part to the extreme sensitivity of this topic, the study team was unable to verify these claims. Nevertheless, such movement is likely occurring. (It has happened in other industries reviewed as part of the IDA study.) When US export controls interfere with high tech systems development, it encourages advanced technology investment to take place overseas.

The impact of export controls on R&D is most direct in the case of deemed exports. Semiconductor companies contacted by this study indicated that deemed export licenses generally take on the order of six months but sometimes much longer. Once approved, narrowly defined license conditions can make it difficult for controlled foreign national hires to provide the full benefit of their skills. This is true whether they are working in the US or at an overseas site. Some hires are lost, as they are unwilling to wait for approval, or a job offer had to be rescinded due to long processing time and conditions. SME companies cited specific cases where this occurred. One SME company indicated that they shy away from hiring controlled foreign nationals at all. Potential hires end up going to competitors in Japan or the EU. (In Japan, there are no deemed export requirements for dual use items.)

Deemed exports could impact US semiconductor companies in the nearer term as China produces increasing numbers of IC designers. The design standardization that underlies the increasing use of application specific ICs is creating a new breed of semiconductor company based on intellectual property and customer knowledge rather than manufacturing. As manufacturing in China continues to grow, an increase in indigenous design and research is likely, thanks in large measure to government support for infrastructure such as technology parks. In order to compete in the burgeoning

Chinese market, US firms are increasingly setting up research and design facilities in China. Currently the U.S. has about 45,000 integrated circuit designers, whereas there are only 7,000 IC designers in China and 14,000 in Taiwan (Figure 13).<sup>31</sup> Doubtless, this gap will close. According to the NSF<sup>32</sup> and others<sup>33</sup>, the US graduated 76,000 engineers in 2005, whereas China graduated about 250,000. NSF data indicated that in 2003, 31.6% of science doctorates and 60.3% of engineering doctorates were awarded to foreign-born temporary residents. Of the science and engineering Ph.D.s awarded to foreigners in the U.S., 45.5% of them were awarded to persons of East-Asian origin.



**Figure 13: Number of Integrated Circuit Designers in 2003, by Where They Work**

Beyond hiring, the longer-term impacts of US companies cutting themselves off from foreign technologists and scientist is difficult to ascertain, but it could be profound in terms of future innovation. As China’s research institutes and universities become world class, US firms could fall behind in important areas of semiconductor research. In nanotechnology, for instance, Chinese researchers are second only to US researchers in publications, according to the Science Citation Index. There are a large number of Chinese institutions doing nanotechnology research and development, including numerous institutes within the Chinese Academy of Sciences system. Although there is hardly any mention of military applications in the papers from China, the dual-use nature of nanotechnology is obvious. Many nanotechnologies can be used for civilian and military purposes interchangeably.<sup>34</sup>

<sup>31</sup> D. Radack, B. Cohen, and C. Lau, “Challenges Facing DoD IC Designers,” ISSCC, 2006.

<sup>32</sup> National Science Board (2006), “Science and Engineering Indicators 2006”, National Science Foundation, Arlington, VA.

<sup>33</sup> Paul, L.G. (2006), “Too Few Techies”, *Electronic Business*, Feb. 2006, p. 18.

<sup>34</sup> Clifford Lau, “Nanotechnology and China,” unpublished draft report, Institute for Defense Analyses, 2006.

Finally, in the case of radhard electronics, the advancing commercial state of the art and worldwide availability of advanced semiconductor fabrication make export restrictions increasingly moot. Global sources have the capabilities to produce ICs on commercial lines that, along with redundant designs, would achieve close to the same hardening result. Exposing the entire US semiconductor industry to rigorous export controls that suppliers from other countries do not face would raise a huge barrier to US firms. Also, the Department of State could be overwhelmed with license requests, not only for IC devices, but also for a range of downstream electronic products that incorporate such devices due to the “see through” rule: A system that incorporates a controlled component is itself considered controlled. In 2005, Boeing was fined forty seven million dollars for selling 96 planes to China that contained a dual use GPS module that included an embedded, controlled part. This same situation could occur if a commercial item (such as the next Intel processor product) is found to meet the ITAR criteria. US ICs are used in numerous US and foreign systems, leading to the perverse outcome of subjecting Japanese video games and European cell phones to US ITAR controls. The impact of restricting the sale of all electronic systems containing a US-made IC would be onerous, impacting most of the near-trillion-dollar electronics industry, while accomplishing very little in enhancing US security.

## **CONCLUSION**

*De facto* unilateral US export controls today are more an administrative burden and overhead cost than a serious problem with respect to lost business. However, the costs of compliance are rising and threaten to become a competitive disadvantage to US-based firms in the increasingly competitive international semiconductor industry. Qualitative factors—reputation for unreliability in supply, diversion of R&D funds to export control compliance, restricted access to foreign talent, barriers to developing a foothold in emerging markets such as China, etc.—are hard to assess but could soon be reflected in lost sales and competitiveness. If proposed tightening of CCL rules for exports to China are implemented, then a much broader scope of companies will be constrained. If radhard electronics control criteria are not updated, critical portions of the IC industry will come under control, with potentially debilitating effects. And if deemed export enforcement is tightened in such a manner as to cut US researchers off from their counterparts in China, then future innovation and leadership in emerging semiconductor technologies could be hampered (if it is not already).

In the final analysis, the current export control system, conceived during the Cold War, is not well matched to today's world of global technology and capital. Systems are often built up using components from a variety of countries, based on competitive advantages in niche areas. Countries that buy high tech products from the US typically do so because US firms offer the best value, not because the country could not, if it wanted to, reproduce the necessary technologies domestically. Selling internationally allows US firms to maintain their lead and discourage foreign competition. When US export controls interfere with high tech systems development, it encourages advanced technology investment to take place overseas. It is ironic that the competitiveness of US firms in certain technology areas is due in part to early support from the US government, whose indiscriminate export control actions in today's globalized work in are undermining that advantage.

#### **ACKNOWLEDGEMENTS**

The IDA semiconductor industry team wishes to thank the organizations and individual that provided data and insight for this study. Participants included IC firms IBM, Texas Instruments, Intel and National Semiconductor; SME firms Applied Materials, Lam Research and Novellus; industry associations Semiconductor Industry Association (SIA), Semiconductor Equipment and Materials International (SEMI), American Electronics Association (AEA), and the Electronic Industry Association (EIA); and individuals William Schneider, Ed Rice, and Don Weadon.

**ADDENDUM A: DETAILS OF THE DOD BASIC RESEARCH PROGRAM IN ELECTRONICS**

<b>Subarea</b>	<b>Army (A)</b>	<b>Navy (N)</b>	<b>Air Force (AF)</b>
<b>Solid-State and Optical Electronics</b> Detectors Lasers Semiconductors Nonlinear Circuits	IR and UV detectors Power switches Terahertz electronics Low-power and low-voltage analog electronics	Wide-gap semiconductors Magnetic thin films All-digital RF electronics Magneto-electronics 6.1-angstrom materials	Radiation-hard electronics Nonlinear optical materials High-temperature electronics
<i>Areas of Common Interest:</i> lithography (A, N); quantum transport (A, N); nanoscale and mesoscale electronics (A, N, AF); heterostructures (A, N, AF); multifunctional devices and micro-optics (A, N, AF); device reliability (N, AF); superconductors (N, AF); IR detector materials and IR lasers, (N, A); hyperspectral imaging (A, N, AF)			

<b>Subarea</b>	<b>Army (A)</b>	<b>Navy (N)</b>	<b>Air Force (AF)</b>
<b>Information Electronics</b> Modeling and Simulation Communications Processing and Data Fusion	Mobile, wireless multimedia distributed communications IR target recognition and image analysis Energy-efficient digital signal processing	Neural net circuits	None
<i>Areas of Common Interest:</i> modeling/simulation of circuits, devices, and networks (A, N); sensor fusion (A, N, AF); digital signal processing (A, N, AF); target acquisition (A, AF); adaptive array processing (A, N, AF)			
<b>Electromagnetics</b> Antennas Transient Sensing Tubes	Wireless and radar propagation Advanced MMW circuit and antenna integration Mobile tactical wireless and printed antennas	Dispersion-free beamsteering	Transient electromagnetics Secure propagation Distributed aperture radar
<i>Areas of Common Interest:</i> integrated transmission lines (A, N, AF); EM numerical techniques (A, N, AF); discontinuities in circuits (A, N, AF); EM scattering (N, AF); vacuum electronics (N, AF); optical control of array antennas (A, N, AF); power-efficient RF components (A, N, AF); adaptive arrays (A, N, AF)			

A significant portion of DoD S&T investment is managed by DARPA. The following table shows the DARPA 6.1 basic research investment (\$ in millions). Even though the investment is broken into four areas, there may be multidisciplinary research with overlap between the areas. For example, bio-info-micro sciences may involve electronic devices that directly interface with biological systems for information processing.

DARPA 6.1 basic research	FY05	FY06	FY07 planned
Bio-info-micro sciences	53.879	44.040	46.266
Information sciences	23.791	19.933	29.481
Electronic sciences	33.815	30.783	34.060
Material sciences	53.616	38.550	40.883
Total	165.101	133.306	150.690

The DARPA Electronic Sciences area comprises the following programs.

Program Title	FY05	FY06	FY07 planned
Carbon Nanotube RF Devices	0	0	3.000
MEMS Science and Focus Centers	0	0	4.452
Molecular Photonics	6.893	7.885	2.610
Photonics Technology Access Program	2.500	2.898	1.300
Quantum Entanglement Science & Tech	0	0	4.698
Focused Center Research Program (FCRP)	10.000	10.000	10.000
University Photonic Opto-Centers	7.072	8.000	8.000
Congressional adds	7.350	2.000	0
Total	33.815	30.783	34.060

Note that the FCRP program is a collaboration with the Semiconductor Industry Association which is supposed to invest \$20M each year. In addition to the 6.1 basic research programs, DARPA also has significant 6.2 applied research and 6.3 technology development funding in microelectronics technology. The following is a listing of DARPA microelectronics S&T programs.

- 3-D Micro Electromagnetic Radio Frequency Systems
- 3D Integrated Circuits
- Adaptive Focal Plane Array
- Adaptive Photonic Phase-Locked Elements
- Advanced Digital Receiver Technology

- Advanced Lithography
- Advanced Microsystems Technology Program
- Advanced Precision Optical Oscillators
- Analog Optical Signal Processing
- Analog to Information
- Architecture for Diode High Energy Laser Systems
- Chemical Engineering Molecular Scale
- Chip-Scale Atomic Clock
- Chip-Scale Wavelength Division Multiplexing
- Chip-to-Chip Optical Interconnects
- Clockless Logic
- Cognitively Augmented Design for Quantum Technology
- Coherently-Combined High-Power Single-Mode Emitters
- Data in Optical Domain – Network
- Electronic & Photonic Integrated Circuits
- Embedded Configurable High Performance Processing of Signals
- Energy Starved Electronics
- Focus Center Research Program
- Harsh Environment Robust Micromechanical Technology
- High Operating Temperature Mid-Wave Infrared
- Integrated Sensor is Structure
- Intelligent RF Front-Ends
- Laser Photoacoustic Spectroscopy
- Linear Photonic RF Front-End Technology
- Liquid Electronics Advanced Power Sources
- MEMS Exchange
- Micro Cryogenic Coolers
- Micro Gas Analyzers
- Micro-Electric Propulsion
- Microantenna Arrays: Technology and Applications
- Multiple Optical Non-redundant Aperture Generalized Sensors
- Navigation Grade Integrated micro Gyroscopes
- Non-Linear Mathematics for Mixed Signal Microsystems
- Optical Code Division Multiple Access
- Photon Counting Arrays
- Photonics Technology Access Project
- Radiation Hardening by Design
- Robust Integrated Power Electronics
- Scalable Millimeter-Wave Architectures for Reconfigurable Transceivers
- Space Time Adaptive Processing
- Sub-Millimeter Wave Imaging Focal-Plane Technology
- Super High Efficiency Diode Sources
- Supermolecular Photonics Engineering
- Technology for Agile Coherent Transmission Architecture
- Technology for Efficient Agile Mixed-Signal Microsystems
- Technology for Frequency Agile Digitally Synthesized Transmitters

- Terahertz Imaging Focal-plane Technology
- Ultra-Wideband Multifunction Photonic Transmit/Receive Module
- University Photonics-Based Research Centers
- Vertically Interconnected Sensor Arrays
- Wide Bandgap Semiconductor Technology, Thrust I-RF/Microwave/Millimeter-wave Technology
- Wide Bandgap Semiconductor Technology, Thrust II - High Power Electronics

The FCRP program in particular is focused on the most advanced research on silicon nanoelectronics and beyond. In 1997, SIA and DoD, in cooperation with members of the US semiconductor equipment, materials, software and services industry, launched a new initiative to expand pre-competitive, cooperative, long-range, applied microelectronics research at U.S. universities. The program was structured to address industry and DoD needs using the research university system, i.e. long-range, innovative applied re-search. At present there are five focused centers of research.

- Interconnect Focused Center (IFC) at Georgia Tech
- Gigascale Systems Research Center (GSRC).at the UC at Berkeley
- Materials, Structures & Devices (MSD) at MIT
- Circuits, Systems & Software (C2S2).at CMU
- Functionally Engineered Nanomaterials and Architecture (FENA) at UCLA.

Each center involves collaboration among multitude of universities, typically six or seven universities. Thus the following thirty four universities participate in the FCRP program.

- Arizona State University
- California Institute of Technology
- Carnegie Mellon University
- Columbia University
- Cornell University
- Georgia Institute of Technology
- Mass. Institute of Technology
- New York University
- North Carolina State University
- Pennsylvania State University
- Princeton University
- Purdue University
- Rensselaer Polytechnic Institute

- Stanford University
- Stony Brook University – SUNY
- Texas A&M University
- Univ. at Albany – SUNY
- Univ. of California/Berkeley
- Univ. of California/Davis
- Univ. of California/Los Angeles
- Univ. of California/Riverside
- Univ. of California/San Diego
- Univ. of California/Santa Barbara
- Univ. of Central Florida
- Univ. of Colorado/Boulder
- Univ. of Florida
- Univ. of Illinois/Urbana-Champaign
- Univ. of Massachusetts
- Univ. of Michigan
- Univ. of Minnesota
- Univ. of Southern California
- Univ. of Texas/Austin
- Univ. of Texas/Dallas
- Univ. of Virginia
- Univ. of Wisconsin-Madison

The Focus Centers themselves are "virtual" in that they consist of multiple universities. This allows for tapping of the best expertise at a number of institutions in order to build the greatest overall capability in a particular technology area. Each center is managed by a full-time university center director and addresses one of the major technology focus areas of the International Technology Roadmap for Semiconductors (ITRS). Heavy emphasis is placed on achieving key long-term research results. Although the needs identified by the ITRS provide a meaningful guideline for the research objectives, a measurable percentage of the effort also encompasses activities not envisioned by the Roadmap. The microelectronics industry relies heavily upon continuing advancements in semiconductor integrated circuit design and manufacturing technologies. The FCRP is a natural extension of the cooperation between industry, the US research university community, and the DoD.

## **ADDENDUM B: CONTROLLED MATERIALS AND SME**

Controlled materials include:

III/V compounds such as gallium arsenide, gallium-aluminum arsenide, indium phosphide, as well as Silicon-germanium alloy and Silicon-carbide

Photoresists optimized for photolithography as wavelengths less than 365 nm, as well as “positive resists” specially adjusted for use at wavelengths below 350nm

All resists designed for use with electron beams or ion beams, with a sensitivity of 0.01 coulomb/mm<sup>2</sup> or better; or designed for use with X-rays, with a sensitivity of 2.5 mJ/mm<sup>2</sup> or better; or optimized for surface imaging technologies, including silylated resists.

Organo-metallic compounds of aluminum, gallium or indium having a purity (metal basis) better than 99.999%; Organo-arsenic, organo-antimony and organo-phosphorus compounds having a purity (inorganic element basis) better than 99.999%; Hydrides of phosphorus, arsenic or antimony, having a purity better than 99.999%, even diluted in inert gases or hydrogen

Controlled SME includes

Equipment designed for epitaxial growth capable of producing a silicon layer with a thickness uniform to less than 2.5% across a distance of 200 mm or more; or a layer of any material other than silicon with a thickness uniform to less than 2.5% across a distance of 75 mm or more;

Metal organic chemical vapor deposition (MOCVD) reactors specially designed for compound semiconductor crystal growth by the chemical reaction between materials

Molecular beam epitaxial growth equipment using gas or solid sources;

Equipment designed for ion implantation, having a beam energy (accelerating voltage) exceeding 1MeV; specially designed and optimized to operate at a beam energy of less than 2 keV; with direct write capability; or a beam energy of 65 keV or more and a beam current of 45 mA or more for high energy oxygen implant into a heated semiconductor material substrate

Anisotropic plasma dry etching equipment, cassette-to-cassette operation and load-locks, and designed or optimized to produce critical dimensions of 180 nm or less with 5% 3-sigma precision; or designed for generating less than 0.04 particles/cm<sup>2</sup> with a measurable particle size greater than 0.1 μm in diameter; or

Plasma enhanced CVD equipment, with cassette-to-cassette operation and load-locks, and designed according to the manufacturer's specifications or optimized for use in the production of semiconductor devices with critical dimensions of 180 nm or less;

Automatic loading multi-chamber central wafer handling systems with interfaces for wafer input and output, to which more than two pieces of semiconductor processing equipment are to be connected; and designed to form an integrated system in a vacuum environment for sequential multiple wafer processing;

Lithography equipment with align and expose step and repeat (direct step on wafer) or step and scan (scanner) equipment for wafer processing using photo-optical or X-ray methods, having a light source wavelength shorter than 245 nm; or capable of producing a pattern with a minimum resolvable feature size of 180 nm or less;

Equipment specially designed for mask making or semiconductor device processing using deflected focused electron beam, ion beam or "laser" beam, having a spot size smaller than 0.2m; or being capable of producing a pattern with a feature size of less than 1 m; or an overlay accuracy of better than 0.20m (3 sigma); or multi-layer masks with a phase shift layer (except those designed for fabrication of uncontrolled memory devices).

Test equipment, specially designed for testing S-parameters of transistor devices at frequencies exceeding 31.8 GHz; for testing controlled microwave integrated circuits

Equipment specially designed for the manufacture of electron tubes, optical elements and specially designed components.

Equipment for producing controlled polycrystalline silicon and materials or purifying or processing controlled III/V and II/VI semiconductor materials such as:

- crystal pullers and furnaces;
- annealing or recrystallizing equipment other than constant temperature
- furnaces employing high rates of energy transfer capable of processing wafers at a rate exceeding 0.005 m<sup>2</sup> per minute;
- "Stored program controlled" crystal pullers rechargeable without replacing the crucible container; or capable of operation at pressures above 2.5 x 10<sup>5</sup> Pa; or capable of pulling crystals of a diameter exceeding 100 mm;

- "Stored program controlled" equipment for epitaxial growth capable of producing a layer thickness uniformity across the wafer of equal to or better than 3.5%; or rotation of individual wafers during processing;
- Molecular beam epitaxial growth equipment;
- Magnetically enhanced 'sputtering' equipment with specially designed integral load
- locks capable of transferring wafers in an isolated vacuum environment;
- Equipment specially designed for ion implantation, ion-enhanced or photo-enhanced
  - diffusion, having patterning capability; or beam energy exceeding 200 keV; or optimized to operate at a beam energy of less than 10 keV; or capable of high energy
- oxygen implant into a heated "substrate";
- "Stored program controlled" equipment for the selective removal (etching) by means of anisotropic dry methods (e.g., plasma), with end-point detection, other than optical emission spectroscopy types; or reactor operational (etching) pressure of 26.66 Pa or less; cassette-to-cassette and load locks wafer handling;

"Chemical vapor deposition" (CVD) equipment, e.g., plasma-enhanced CVD (PECVD) or photo-enhanced CVD, for semiconductor device manufacturing, operating below 105 Pa;

Electron beam systems specially designed or modified for mask making or semiconductor device processing having electrostatic beam deflection; shaped, non-Gaussian beam profile; digital-to-analog conversion rate exceeding 3 MHz; digital-to-analog conversion accuracy exceeding 12 bit; or target-to-beam position feedback control precision of 1 micrometer or finer;

Surface finishing equipment for the processing of semiconductor wafers specially designed equipment for backside processing of wafers thinner than 100 micrometer and the subsequent separation thereof; or specially designed equipment for achieving a surface roughness of the active surface of a processed wafer with a two-sigma value of 2 micrometer or less, total indicator reading (TIR);

Interconnection equipment specially designed to permit the integration of controlled equipment into a complete system;

"Stored program controlled" equipment using "lasers" for the repair or trimming of "monolithic integrated circuits" with positioning accuracy less than 1 micrometer; or spot size (kerf width) less than 3 micrometer.

Masks, mask "substrates", mask-making equipment and image transfer equipment for the manufacture of devices and components, with designs based on geometries of 2.5 micrometer or more; Hard surface (e.g., chromium, silicon, molybdenum) coated "substrates" (e.g., glass, quartz, sapphire) for the preparation of masks having dimensions exceeding 125 mm x 125 mm; or specially designed for X-ray masks;

Photo-optical step and repeat cameras capable of producing arrays larger than 100 mm x 100 mm, or capable of producing a single exposure larger than 6 mm x 6 mm in the image (i.e., focal) plane, or capable of producing line widths of less than 2.5 micrometer in the photoresist on the "substrate"; Mask or reticle fabrication equipment using ion or "laser" beam lithography capable of producing line widths of less than 2.5 micrometer; or equipment or holders for altering masks or reticles or adding pellicles to remove defects;

Equipment specially designed for computer aided design (CAD) of semiconductor devices or integrated circuits;

"Stored program controlled" equipment for the inspection of masks, reticles or pellicles with a resolution of 0.25 micrometer or finer; and a precision of 0.75 micrometer or finer over a distance in one or two coordinates of 63.5 mm or more;

Align and expose equipment for wafer production using photo-optical or X-ray methods, e.g., lithography equipment, including both projection image transfer equipment and step and repeat (direct step on wafer) or step and scan (scanner) equipment, capable of performing any of the following functions: Production of a pattern size of less than 2.5 micrometer; alignment with a precision finer than  $\bar{n}$  0.25 micrometer (3 sigma); machine-to-machine overlay no better than  $\bar{n}$  0.3 micrometer; or a light source wavelength shorter than 400 nm; Electron beam, ion beam or X-ray equipment for projection image transfer capable of producing patterns less than 2.5 micrometer; Equipment using "lasers" for direct write on wafers capable of producing patterns less than 2.5 micrometer.

Equipment for the assembly of integrated circuits, as follows:

- "Stored program controlled" die bonders specially designed for "hybrid integrated circuits" and with X-Y stage positioning travel exceeding 37.5 x 37.5 mm; and placement accuracy in the X-Y plane of finer than 10 micrometer;
- "Stored program controlled" equipment for producing multiple bonds in a single operation (e.g., beam lead bonders, chip carrier bonders, tape bonders);
- Semi-automatic or automatic hot cap sealers, in which the cap is heated locally to a
- higher temperature than the body of the package, specially designed for ceramic microcircuit packages and that have a throughput equal to or more than one package per minute.
- Filters for clean rooms capable of providing an air environment of 10 or less particles of 0.3 micrometer or smaller per 0.02832 m<sup>3</sup> and filter materials

Equipment specially designed for the inspection or testing of electron tubes, optical elements and specially designed components; for the inspection or testing of semiconductor devices, integrated circuits and "electronic assemblies":

- "Stored program controlled" inspection equipment for the automatic detection of defects,
- errors or contaminants of 0.6 micrometer or less in or on processed wafers, "substrates", other than printed circuit boards or chips, using optical image acquisition techniques for pattern comparison;
- Specially designed "stored program controlled" measuring and analysis equipment for the measurement of oxygen or carbon content in semiconductor materials; equipment for line width measurement with a resolution of 1 micrometer or finer
- Specially designed flatness measurement instruments capable of measuring deviations from flatness of 10 micrometer or less with a resolution of 1 micrometer or finer.
- "Stored program controlled" wafer probing equipment having positioning accuracy finer than 3.5 micrometer; capable of testing devices having more than 68 terminals; or capable of testing at a frequency exceeding 1 GHz.

"Stored program controlled" equipment specially designed for testing discrete semiconductor devices and unencapsulated dice, capable of testing at frequencies exceeding 18 GHz; integrated circuits and "electronic assemblies" at a 'pattern rate' exceeding 20 MHz or a 'pattern rate' exceeding 10 MHz but not exceeding 20 MHz and capable of testing packages of more than 68 terminals. (Excluded items include testers for memories; "electronic assemblies" for home and entertainment applications; and other uncontrolled ICs.)

Equipment specially designed for determining the performance of focal-plane arrays at wavelengths of more than 1,200 nm, using "stored program controlled" measurements or computer aided evaluation and using scanning light spot diameters of less than 0.12 mm; designed for measuring photosensitive performance parameters and for evaluating frequency response, modulation transfer function, uniformity of responsivity or noise; or designed for evaluating arrays capable of creating images with more than 32 x 32 line elements;

Electron beam test systems designed for operation at 3 keV or below, or "laser" beam systems, for non-contactive probing of powered-up semiconductor devices having stroboscopic capability with either beam blanking or detector strobing; an electron spectrometer for voltage measurements with a resolution of less than 0.5 V; or electrical tests fixtures for performance analysis of integrated circuits;

"Stored program controlled" multifunctional focused ion beam systems specially designed for manufacturing, repairing, physical layout analysis and testing of masks or semiconductor devices and having target-to-beam position feedback control precision of 1 micrometer or finer; or digital-to-analog conversion accuracy exceeding 12 bit;

Particle measuring systems employing "lasers" designed for measuring particle size and concentration in air capable of measuring particle sizes of 0.2 micrometer or less at a flow rate of 0.02832 m<sup>3</sup> per minute or more; and capable of characterizing Class 10 clean air or better.

Technologies for the development, production or use of controlled SME and materials, as well as: vacuum microelectronic devices; Hetero-structure semiconductor devices such as high electron mobility transistors (HEMT), hetero-bipolar transistors (HBT), quantum well and super lattice devices; "Superconductive" electronic devices; Substrates of films of diamond for electronic components; controlled material substrates electronic vacuum tubes operating at frequencies of 31.8 GHz or higher.

**APPENDIX C**

**IMPACT OF US EXPORT CONTROLS  
ON THE US MACHINE TOOL INDUSTRY**

**Paul Collopy**



## SUMMARY

Three reasons make the machine tool industry interesting and important to an examination of the economic impacts of export control:

- Machine tools have traditionally been an important export control concern. The 1976 Bucy report<sup>1</sup> emphasized that controlling manufacturing technology (the ability to make weapons) is more important than controlling weapon system operational technology. Machine tools embody manufacturing technology. The 1987 Toshiba affair (in which several advanced machine tools were exported from Japan to the Soviet Union to manufacture propellers for submarines) and the 2003 Mitutoyo debacle (Japanese Mitutoyo exported coordinate measuring machines without a license, and they wound up in Libya helping to make uranium refining centrifuges) are among the most significant export control violations, and they both occurred within the machine tool industry.
- Export control restrictions on machine tools have been significant and very consistent over the last half century, making the sector a good case for study of the long term impact of export controls on an industry.
- Today, China is the largest buyer of machine tools in the world and is the country to which most machine tool export restrictions apply. China buys about one-quarter of the world's tools. The current impact of export controls should be apparent here, if anywhere.

Machine tools have been vital to the nation's warfighting capability since the Civil War. Machine tools build the composite surfaces of modern aircraft, which confer light weight and, for military aircraft, stealth. Machine tools mill the titanium frames that provide the structure for these same aircraft. Complex parts such as centrifugal

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<sup>1</sup> "In 1976 a Defense Science Board Task Force issued a report, commonly called the Bucy report [*Defense Science Board Task Force on Export of U.S. Technology, An Analysis of Export Control of U.S. Technology--A DOD Perspective* (Washington, D.C.: GPO, 1976)] suggesting that the export control system should shift from a focus on products to a focus on critical technology. Basically the Bucy task force argued that, with the exception of technologies of direct military value to potential adversaries, effort to control exports should not focus on the products of technology but on design and manufacturing know-how. The report recommended that primary emphasis should be placed on (1) arrays of design and manufacturing know-how; (2) 'keystone' manufacturing, inspection, and test equipment; and (3) products requiring sophisticated operation, application, or maintenance know-how. The Bucy task force concluded that the preservation of the US lead in critical technological areas was becoming increasingly difficult but could be achieved, first, by denying the exportation of technology." p. 31, *Scientific Communication and National Security*, NRC Report (1982) by the Committee on Science, Engineering, and Public Policy of the National Academy of Sciences.

compressors in turbine engines, and precision parts such as germanium lenses in infrared vision systems all depend on specialized, high technology machine tools.

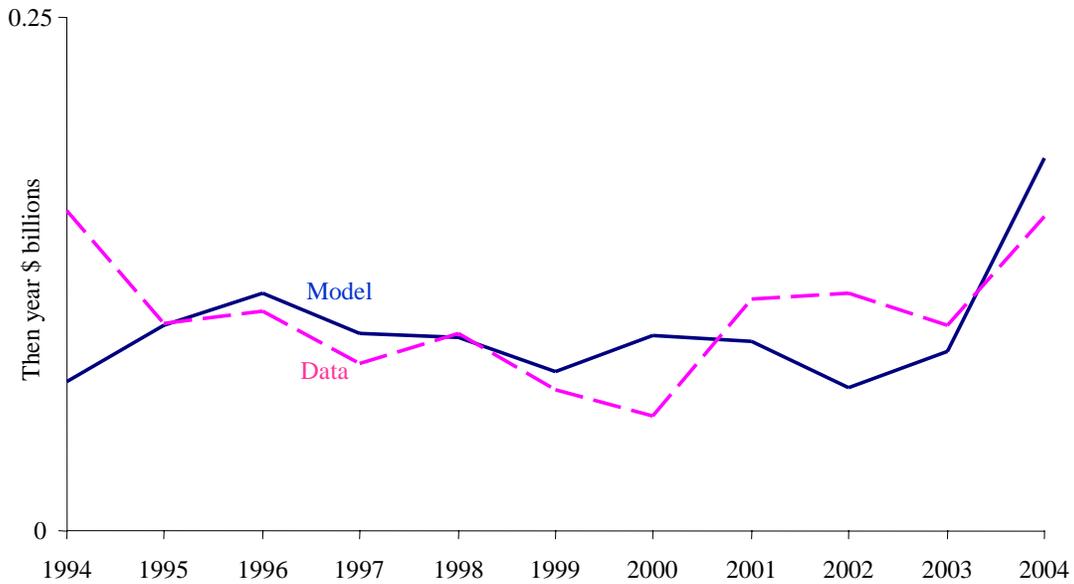
Machine tools are a small industry: about \$3 billion in tools are produced annually in the US. The US machine tool industry has shrunk from being the world leader in the 1950s and 1960s to being a second tier player today. The US now provides about 5% of the world's machine tools. Leading countries are Japan, Germany, Italy, China, and Switzerland. US machine tool production capabilities today are on par with Taiwan and South Korea.

Although export controls impact industry growth and health generally, **the demise of the US machine tool industry was not caused by export controls**—they were not even an important contributor to the prolonged contraction. The IDA study team found that export controls reduce the revenue of the US machine tool industry by 1% - 2%. (In addition, for companies that export, the process of screening customers and applying for licenses costs about 2% of revenue, although that percentage is substantially higher for some small firms.) To the extent that there is revenue loss, it is not due to prohibited sales. Instead, the losses are sales to potentially licensable Chinese customers. These sales are being lost to European competitors whose export control processes are swifter and more dependable. In many European countries (particularly Germany, Switzerland, Italy and Spain), the manufacturer can obtain preliminary judgments from export control authorities that permit them to confidently guarantee a Chinese customer at the time of sale that an export license will be granted. For US firms, approval of a license to export to China is never certain in advance. Furthermore, license approval in the European countries requires only a few weeks, while in the US, licenses to China usually take months. Partly as a result, European manufacturers command a 30% to 100% price premium in China, the largest machine tool market in the world.

The quantitative impact of export controls on US exports of machine tools to China was analyzed with a gravity model of international trade in machine tools. The gravity model predicts exports from one country to another based solely on the size of machine tool production in the exporting country, the size of machine tool consumption in the importing country, and the distance between the two countries. If there is an additional factor that strongly affects exports, such as export controls, it ought to appear as a discrepancy between actual exports and the exports predicted by the gravity model.

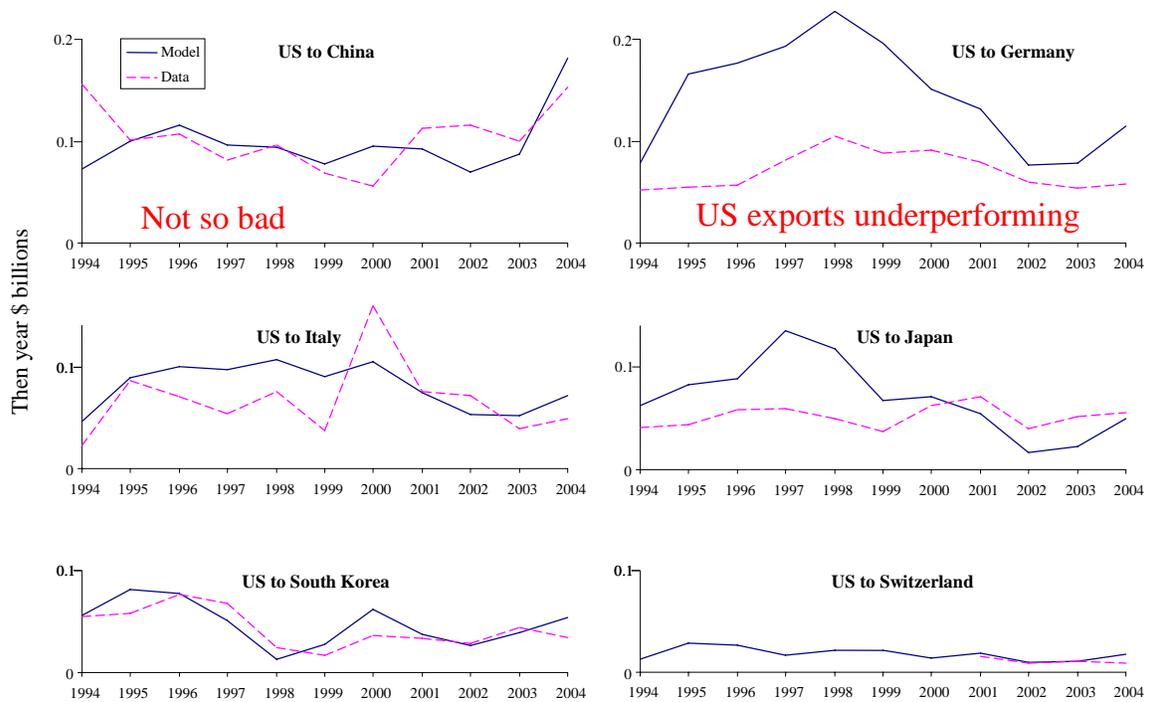
Figure 1 compares the gravity model with actual exports from the US to China. The line labeled “model” are predictions from the gravity model, based on machine tool

production and consumption of the eight major exporting countries. The line labeled “data” is actual new machine tool exports from US to China (not including parts and service). Actual exports are not significantly depressed compared to the model, which suggests that exports controls do not strongly impact the dollar volume of US machine tool exports to China.



**Figure 1. Gravity Model Comparison with Actual US Exports to China**

To confirm this result, Figure 2 looks at all exports of new machine tools to major consumer countries during the period of interest. Actual exports to Japan and Germany are significantly lower than gravity model predictions. This indicates that the US machine tool industry is being hurt by factors that restrict exports to Germany and Japan, but not particularly by export controls on exports to China. Several experts interviewed attributed the depression in exports to Germany to German nationalism. However, Italy and Japan export into Germany at approximately the rate projected by the gravity model, and Swiss exports to Germany are almost double the model predictions. These data suggests that the perceived quality of US machine tools is the factor which depresses exports to Germany and perhaps also to Japan.



**Figure 2. Gravity Model Analysis of US Exports to All Countries**

Despite the relatively small percentage of lost sales overall, **the export advantage held by the Europeans in China is beginning to deeply hurt US machine tool producers in the most advanced segments of the industry.** Most of the larger US machine tool firms are owned by multinational companies. Increasingly onerous US export controls to China is driving these multinationals to pull their technology development and product development investments out of the US and focus them in Europe, accelerating the technological decline of US machine tool technology relative to the rest of the world.

Given that the ultimate goal of national security export controls is to preserve technology leadership in areas that materially contribute to military capabilities, they have completely failed in the machine tool sector. US leadership has been lost, perhaps irrevocably. Whether this is a crisis or not depends on whether, in today's world, an indigenous capability to manufacture cutting edge technology tools is still a critical defense need.

## DESCRIPTION OF THE MACHINE TOOL INDUSTRY

### Definition and market information

Machine tools create metal, ceramic and composite parts by cutting or forming sheets or rough pieces or, in the case of composites, by carefully laying fiber tapes. They are typically stationary machines intended for use in a factory, though some are used in repair facilities and aboard ships. Types include milling machines, lathes, drills, band saws, presses, and grinders. (Non-powered hand taps and dies are not considered here.) Ordinary welding, brazing, and soldering equipment are not classed as machine tools, but electrical discharge machining equipment (also called spark abrasion), electron beam welding equipment, laser drilling machines and abrasive fluid jet cutters usually are. Coordinate measuring machines, which inspect parts after they are cut, are classed with machine tools because they are used in the same shops by the same workforce as cutting and forming tools.

The most sophisticated machine tools are computer numerically controlled (CNC) multi-axis milling machines and precision grinders. The best of these machines can contour complex surfaces in a single operation. Of medium sophistication are CNC lathes, followed by drills. Presses range from moderately sophisticated stamping machines to simple sheet metal bending presses. Band saws are the low end of the family and are normally used to cut a blank of material from bar stock prior to all other machining operations. In a separate class, ranging from complex to very sophisticated operation, are gear cutting machines. Gear shapes can be demanding, and tooth-to-tooth regularity is very important, but the highest degrees of precision are seldom required. A separate technology of gear cutting has developed, so that gears are generally not cut on standard milling machines.

The machine tool industry earns revenues from building new machines, remanufacturing old machines, and selling parts and service to support the installed base. Machine tools are a small industry. \$52 billion of tools were produced worldwide in 2005, of which \$3 billion were produced in the US. Japan and Germany led world production with \$13 and \$10 billion, respectively.<sup>2</sup> The industry is truly global. Twenty-three countries produced more than \$100 million of tools in 2004. In that year, the US

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<sup>2</sup> *Manufacturing & Technology News*, 4 April 2006, p. 8. Vol. 13 no. 7.

imported over \$3 billion of tools and exported over \$1 billion. 61% of the tools produced in 2004 were manufactured for export.<sup>3</sup>

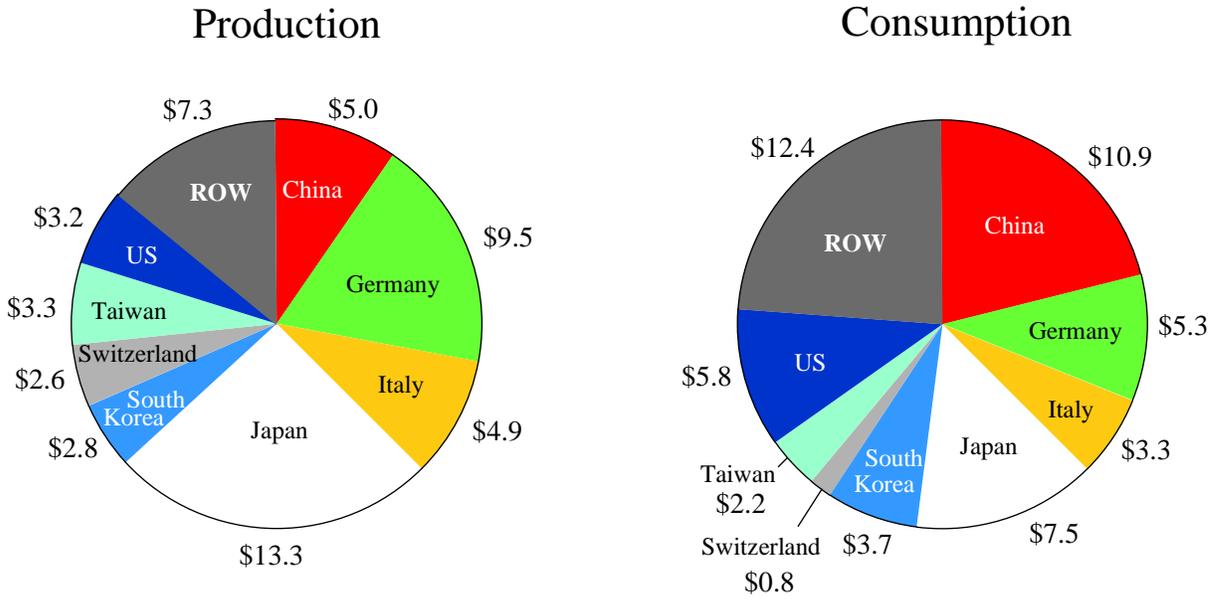
The United States had been the leading consumer of machine tools since the end of the Cold War, but in 2002 China and Germany surpassed the US. From 1995 to 2005, Chinese consumption of machine tools has grown at an average rate of 11%. Figure 1 shows production and consumption of machine tools by leading countries in 2005. The first tier includes Japan, Germany, China and Italy; second tier is Taiwan, US, and South Korea. Switzerland is in the second tier by total revenue but fits the characteristics of a first tier country insofar as they dominate the world market in high precision, high value machines, and they have the highest per capita machine tool production in the world.

Figure 2 categorizes the US firms that sell new machine tools. Here “US firms” means production facilities in the US that are owned by US corporations. Thus, it excludes Ingersoll (located in the US but owned by an Italian conglomerate) and Hauser (owned by US Hardinge but located in Switzerland). 40% of the firms identified in the survey summarized in Figure 2 are engaged in making premium machine tools; that is, tools that sell for over about \$100,000 per unit. 30% of the firms manufacture low cost tools, those which sell for under about \$10,000.

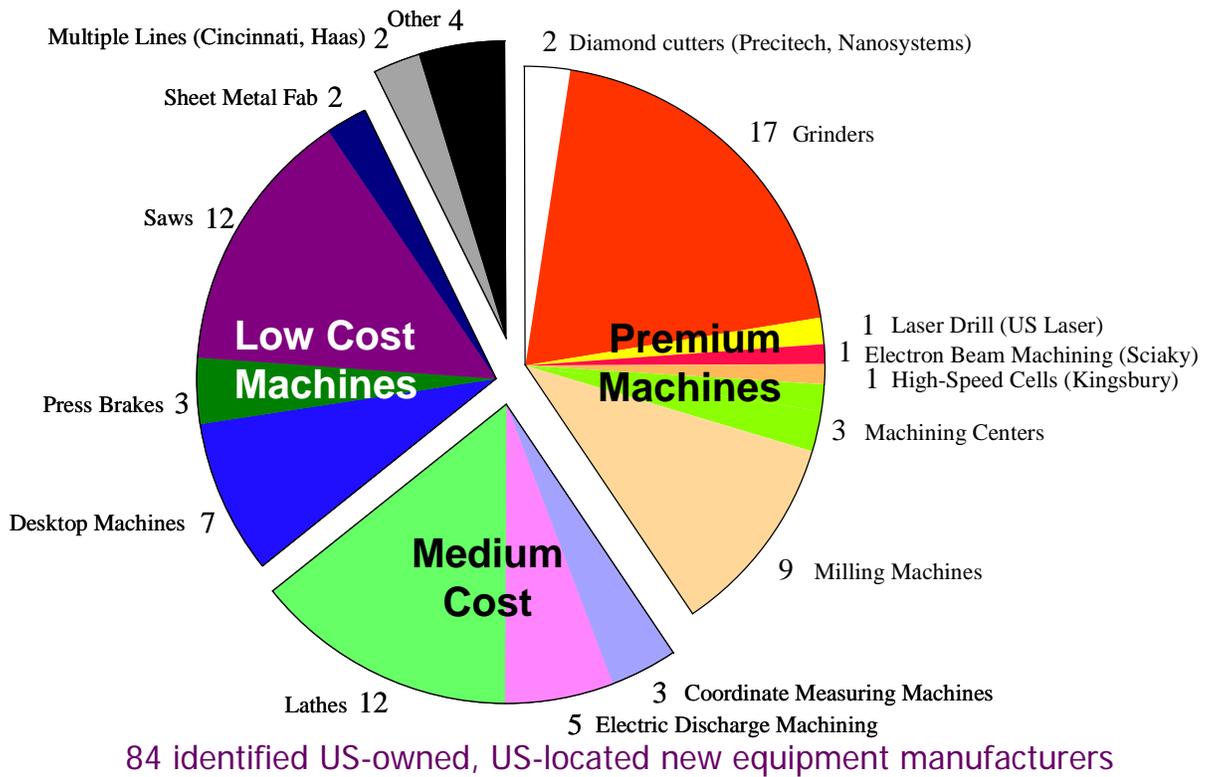
Machine tool firms have historically been founded by individuals within the industry with an idea for a better machine. Thus, companies begin as small, closely-held firms with less than 500 employees, and most US firms still fit this type. As companies grow and require capital for expansion and product innovation, they tend to be purchased by conglomerates with significant machine tool portfolios. In the US, all the large machine tool firms fit this description except Hardinge and Gleason (which became conglomerates themselves, buying up foreign firms) and Haas Automation (which has grown in two decades to be the largest US tool firm without buying up companies or being bought itself).

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<sup>3</sup> Statistics in this paragraph and through the rest of the section, except as noted, are based on data provided by the Association for Manufacturing Technologies.



**Figure 1. Production and Consumption of Machine Tools in 2005**  
 (Source: *Manufacturing & Technology News*, 4 April 2006, p. 8. Vol. 13 no. 7.)

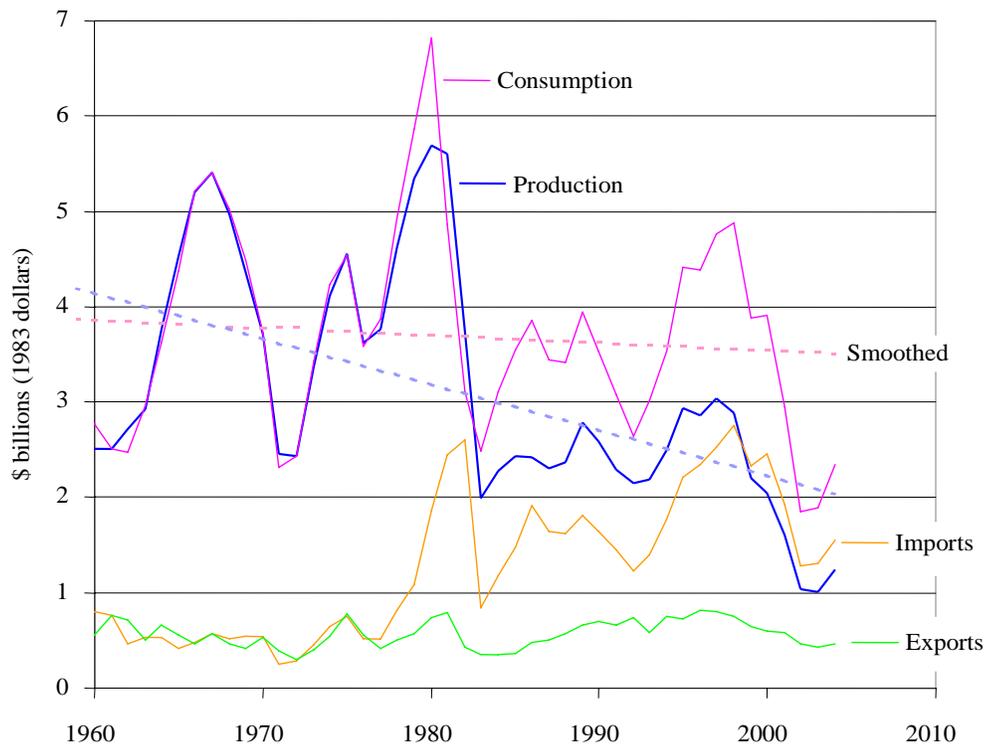


**Figure 2. US Machine Tool Firms**  
 (Source: Paul Collopy, compiled from web search and interviews)

The US machine tool industry has mainly followed customers in the US automotive industry and, to some extent, aerospace. While countries such as Switzerland and Japan have export-focused machine tool industries, most of the US industry has focused on the domestic market, as shown in Figure 3. Notice in Figure 3:

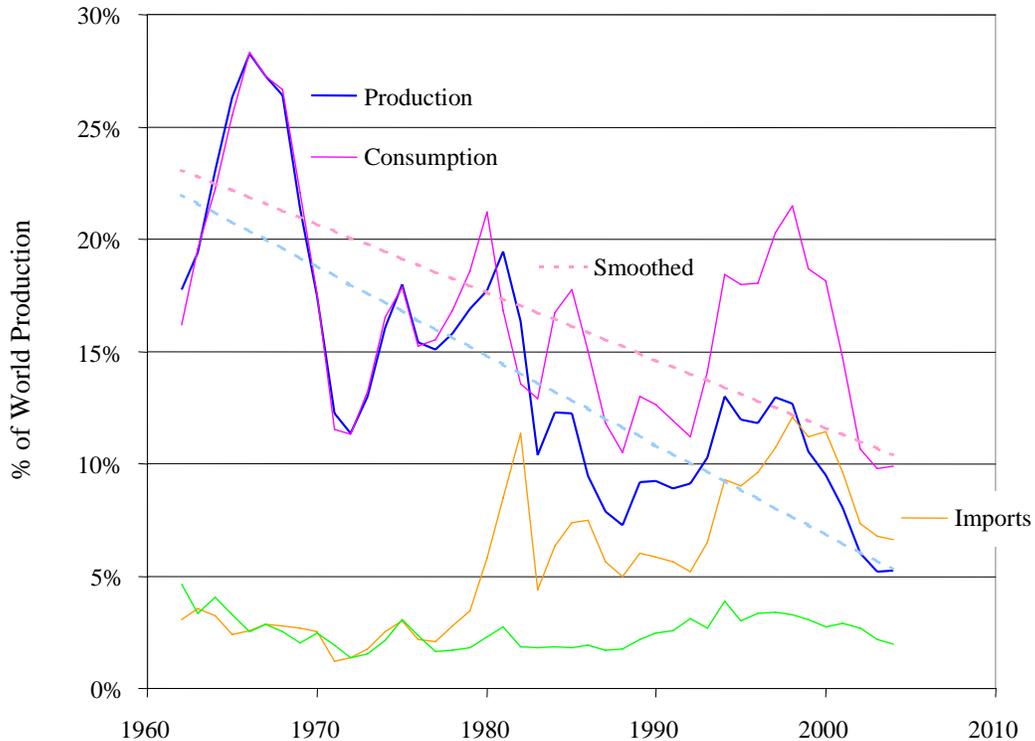
- Consumption is extremely cyclical. Machine tools are among the most cyclical industries, and demand collapses without warning in the earliest phase of a recession. Machine tools are the durable goods of the industrial sector.
- The dashed lines are linear fits to production and consumption to make long term trends visible.
- Over time consumption has shrunk, even though the US economy has grown by almost a factor of five. (Real GDP growth from 1960 to 2004 is 380%.)

During this same period, US machine tool production has shrunk from over 20% of world production to about 5% as shown in Figure 4.



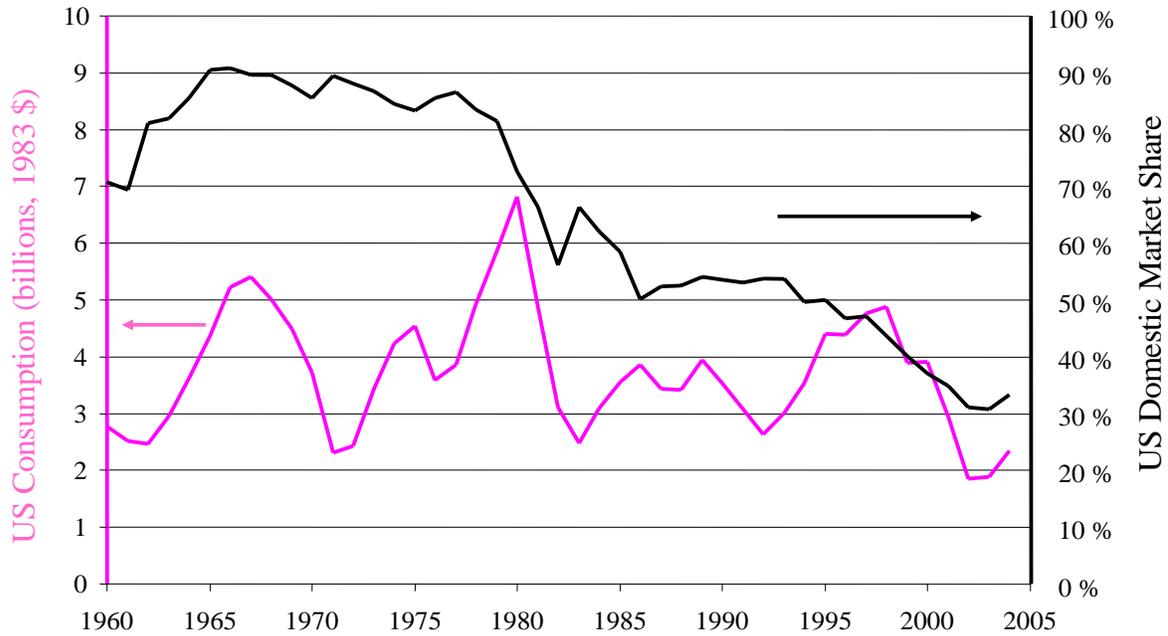
**Figure 3. US Machine Tool Sales Trends**

(Source: data provided by the Association for Manufacturing Technologies)



**Figure 4. US Machine Tool Trends versus World Production**  
 (Source: data provided by the Association for Manufacturing Technologies)

US Production closely followed consumption in the 1960s and 1970s. In 1980, production was unable to ramp up to meet the consumption peak. Imports filled in the gap, primarily from Japan. In the subsequent downturn, imports kept their market share. In the late 1990s, once again, imports seized business during the upturn and held it in the downturn in the early 2000s. The most striking characteristic of the machine tool industry in the US today is the impact of shrinkage and loss of market share, as depicted in Figure 5. Since 1960 the industry has shrunk 1.6% per year in real revenue, 5.0% per year as a fraction of gross domestic product, 3.3% per year versus the world industry, and 2.2% per year (geometric) in domestic market share. Most firms are fighting to maintain position and losing. The average age of the workforce in most facilities interviewed for this study is about 50 years. With few exceptions, product development is minimal. Success is avoidance of bankruptcy.



**Figure 5. Loss of US market share over time**  
 (Source: data provided by the Association for Manufacturing Technologies)

### The Contraction of the US Machine Tool Industry

There are a number of perspectives on the cause of the collapse of the industry.

- Broad macroeconomic forces:** Manufacturing in the US has been on the decline for decades, both in absolute terms and relative to the rest of the world. The absolute decline of US manufacturing reduces domestic demand for machine tools. Relative decline reflects other countries reaching parity and surpassing the US in manufacturing. Because machine tools are a manufactured product, the machine tool sector feels this impact directly (shrinkage relative to the rest of the world) at the same time that its customer base is shrinking. Some claim that industrial goods are most efficiently made in the country with the most appropriate balance of labor skills and labor cost, which explains the success of Taiwan, China, and South Korea. However, it is no longer a good argument for Japan's success, and labor cost was never a convincing reason for the dominance of Germany, Italy, and certainly not Switzerland.
- Consolidation:** Prior to the mid 1960s, almost all machine tool firms were dedicated to the machine tool business. Most were closely held, and many were family businesses.<sup>4</sup> In the late 1960s and throughout the 1970s, during booms in the industry,

<sup>4</sup> Holland, Max. *When the Machine Stopped*. Harvard Business School Press, Boston, MA, 1989. Page 59.

conglomerates bought up most of the machine tool industry (measured by revenue). Machine tool companies were attractive industrial properties then because the firms' order backlogs promised a reliable future stream of profits. Machine tool firms were conservatively managed and very cyclical, but machine tools experience cycles much sooner than most industries—they are the first to feel a contraction and the first to rebound in expansion—so they could provide somewhat counter-cyclical balance to a conglomerate's portfolio. Ownership by large corporations was attractive to machine tool firms as well. Conglomerates promised expansion investment, product development investment, and a cushion in hard times. Deep pockets helped firms survive cyclical downturns and expand production to exploit booms. Moreover, electronic controls were changing the industry, and most firms could not fund the necessary product developments from their own profits.

- **Aftereffects of 1970s boom:** The 1973 Arab oil embargo shocked the international petroleum market with a permanent increase in the price of oil. Americans turned to smaller, more fuel-efficient automobiles, and the Detroit automakers designed front-wheel drive cars. As a result, there was massive retooling in US auto plants in the mid to late 1970s, and demand for machine tools skyrocketed. From 1977 to 1980, for instance, consumption of machine tools in the US increased 80%, and machine tool companies developed up to five years order backlogs. The automakers bought tools in huge lots. To service these large contracts, most machine tool makers let their smaller customers suffer and these small customers turned to Japanese machines. Although their factories had been designed for American equipment, Japanese quality was reaching parity with US tools and the prices were low. When the auto plants were finished retooling and the boom ended, these buyers often stayed with Japanese suppliers. US machine tool companies also abandoned their distribution networks. Selling was easy during the late 1970s. With a contract for 200 machines to Ford, who needed distributors? More than one interviewee told of automakers placing essentially open orders for large numbers of machines, working out the specifications later. There was hardly a need for an internal sales force. For example, in 1978 the head of a customer firm said Jones & Lamson was the Cadillac of lathes, and he wanted a Jones & Lamson. Deal closed. Jones & Lamson had 1200 employees in 1978 but did not survive the 1980s. Another similarly situated firm had 1500 employees in the 1970s, versus 150 employees today. By the standards of the US machine tool industry today, they are a success.

- **Special orders versus standard products.** Another contributing factor was machine tool firms' predilection toward customized machines. Customized machines commanded higher prices, and many firms depended on special orders to maintain overall profitability. When the Japanese penetrated the US market around 1980, they sold standard machines. Customers were required to provide more accommodation for a standard machine in their shop, but standardization was key to the Japanese strategy of low prices and high quality. Quality control was much more difficult in US machine tool shops where no two machines were alike. US tool makers were aware of the impact of Japanese standard tools, but most could not wean themselves off custom orders with their premium prices. In a process that corresponded closely to Clayton Christensen's description of disruptive technologies, the culture of the US firms prevented them from directly competing with the lower-value, lower-margin Japanese products which in fact offered a better deal to industry customers.<sup>5</sup> Moreover, as CNC tools became widespread, these standard machines could be customized in software, and the advantage of special order tools eroded.
- **Lean Manufacturing.** In the 1990s, US automakers became enamored with the Toyota Production System, also known as Lean Manufacturing. Lean Manufacturing reorganized the factory floor into manufacturing cells with continuous parts flow, rather than batches. Highly automated high speed machines that processed large batches of parts were obsolete. Lean Manufacturing called such machines "monuments," the worst possible way to manage inventory. In their place, Toyota used standardized programmable machines—Japanese machine tools. US automakers, by and large, purchased the same machine tools to implement Toyota's system in their plant. More directly, Japanese automakers built many North American plants in the 1980s and 1990s. Where possible, these plants used the same equipment as their parent plants in Japan, including Japanese machine tools.

### **Drivers of Innovation**

Although managers in the 1970s and 1980s were most concerned with ramping up and down to match business cycles, the long term shortfalls that most impacted the industry were in the area of innovation. The conglomerates that came to own US machine

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<sup>5</sup> Christensen, Clayton. *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*. Harvard Business School Press, Boston MA, 1997. An indicator of the applicability of the Christensen model is the case of Haas Automation, the largest and most successful machine tool firm in the US today. Founded in 1983, after the Japanese penetration into the US market, their product looks much more like a Japanese machine than a traditional US tool.

tool companies tended to focus on short-term financial performance rather than product innovation. High interest rates and inflation discouraged investment in research, as spending money to solve the next decade's problems did not provide an attractive return on investment. High technology machines only served a small market. American machine tool makers refocused their product lines to use the technology already in their pipeline to make medium-technology machines that could be sold to the automotive industry in high volumes. Meanwhile, Japan introduced high quality, low cost machine tools, and followed with a CNC system that revolutionized metal cutting in industry. US firms tried, but could not match these innovations, at least until Haas Automation emerged in the 1990s.

Two innovation processes have dominated in the US machine tool industry over the last half century.

- Tinkering. An engineer (often the owner of a small firm) works with a customer to design a variation of a machine tool to address a particular manufacturing concern. This process brought about virtually all machine tool innovations in the 19<sup>th</sup> and early 20<sup>th</sup> centuries, and is still a common source of new features.
- Innovation sponsored by the Department of Defense (DoD). The Manufacturing Technology (ManTech) program has provided a great deal of research and development funding for new machine tools. In addition, specific weapons programs have funded tool development for producing particular weapon components.

Tinkering's has been very successful in producing commercially successful technical innovations because it is incremental and because it emphasizes interaction with customers. DoD innovation has been much more radical, but the track record for transition to commercial viability has been poor. An example is the introduction of numerically controlled machines through a DoD-MIT project in the 1950s:

In 1955, the Air Force decided to subsidize commercial development [of numerically controlled (NC) machines] by creating a market. It announced procurement of more than one hundred NC milling machines, a decision that raised the federal government's NC investment to an estimated \$62 million. ... The attention of the machine tool industry was finally concentrated on NC. Yet in a sense the government program was a mixed blessing, for it created almost as many problems as it intended to solve. Most builders knew there was a big difference between machines for the government-subsidized aerospace industry and machines they might conceivably market to civilian manufacturers. There would be little incentive to keep costs down because aerospace industry profits were generally a percentage of costs. This would leave machine tool builders

with products far more sophisticated than any thing a civilian manufacturer might need, or be willing to pay for.<sup>6</sup>

Industry experts confirmed this phenomenon. The US machine tool industry over the last several decades split into two product lines: high performance, complex, high cost machines were manufactured for the government applications and for government prime contractors; medium performance, moderate cost, simple machines were built for the automotive industry and everyone else. Flow down of technology from the government sector to the industry sector was the exception rather than the rule. Table 1 identifies the current status of US machine tool technology versus the rest of the world.

Technology	Leader	US Status
Diamond Cutting	US	3 yr lead
Composite Fiber Placement Machines	US	1 yr lead
Large Gantry Machines	US, Spain, France	Parity <sup>1</sup>
Grinding	Switzerland	Parity in some specialties, 4th in \$ volume
Gear Cutting	Germany	4th place <sup>2</sup> , 1 firm
Laser Drilling	Switzerland, UK	4th place <sup>2,3</sup>
Machining Centers	Japan	4th place tie w/ ROK <sup>2</sup>
Milling	Japan	7th place <sup>2</sup>
Lathes	Japan	7th place <sup>2</sup>
Electron Beam Welding	Germany	1 firm
Controls	Germany, Japan	none <sup>4</sup>
Sensors	Germany	none
Spindles	Germany	none <sup>5</sup>

<sup>1</sup> Parity in technology, 4th or 5th in machines produced

<sup>2</sup> Rank in machines produced, measured by dollar value

<sup>3</sup> Minor product line at one firm

<sup>4</sup> Hardinge dropped out of the controls business “because of export control impact”

<sup>5</sup> Haas makes spindles in the US for their own consumption

**Table 1. Leadership in Machine Tool Technologies**  
(Source: Paul Collopy, compiled from web search and interviews)

However, this dichotomy appears to be changing. We found several firms who have developed commercial applications within the last ten years for machine tools originally conceived for military needs. The drawdown in military production volume

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<sup>6</sup> Holland, op cit. p. 35.

necessitated defense-oriented machine tool firms to find commercial applications. In each of these cases, the commercial market is now driving the machine tool technology to more demanding levels than are required by the military. This trend will be discussed in more detail in the next section.

Also, during the 1990s, a second wave of restructuring has occurred, but this time it is driven by globalization: foreign conglomerates are purchasing US firms, and US firms are making foreign acquisitions. Among the significant acquisitions of the last dozen years are:

- US holding company Maxcor purchases the US machine tool business of Cincinnati Milacron, Lamb Technicon, Ex-Cell-O and the metal cutting properties of German firm Thyssen Krupp, which include three major German machine tool firms plus US firms Giddings & Lewis, Fadal, and Turmatic. In 1995, Thyssen Krupp Metal Cutting had been the largest machine tool organization in the world.
- New York lathe manufacturer Hardinge acquires Swiss grinder manufacturer Hauser Tripet Tschudin and Swiss firm Kellenberger, as well as establishing production subsidiaries in Taiwan and China.
- New York gear cutting machine manufacturer Gleason acquires German gear firms Hurth and Pfauter, with a Swiss and US subsidiary, and acquires additional production bases in UK, India and China.
- UK metrology firm Taylor Hobson acquires the only two US diamond cutting machine firms, Precitech and Pneumo. They are combined and later spun off as Precitech.
- Swedish firm Hexagon Metrology acquires the leading US manufacturer of coordinate measuring machines, Brown & Sharpe.
- Italian holding company Camozzi Group purchases Ingersoll of Illinois.

All these companies view themselves as international operations. Capital is allocated to the facility that can earn the highest return. Today, differential application of export controls result in a higher profit for exports to China of machine tools from Europe than from the US. However, this advantage can only be obtained if the machine is designed and built in Europe. Hence, international firms are beginning to focus technology product development in Europe rather than in US.

## Importance to Defense Industrial Base

Machine tools have always been an important component of the defense industrial base. The Bucy report<sup>7</sup> in 1976 recognized that the technologies required to support America's military power are not weapons themselves but the capability to manufacture weapons and the knowledge required to do so. For example, US intelligence agencies credited Japanese five-axis CNC milling machines with enabling the Soviet Union to produce quieter submarine propellers in the mid 1980s.<sup>8</sup> Machine tools not only manufacture the components of weapon systems but also components of other machine tools. Hence, a nation without machine tools must bootstrap itself into producing weapon systems. As weapon systems become more sophisticated, so do the machine tools required to produce them.

Every firm interviewed by this study produced machines to support military capabilities. In many cases, the development of basic technology was funded by the government, but once commercial applications were found they drove further innovation. One firm had its beginning in high precision T-based lathes for machining segments of plutonium for nuclear weapons. The precision tooling experience led to a line of very high precision jig grinders. These have been used for military products such as centrifugal compressors for turbine engines, but now the primary application is machining commercial molds for plastic injection molding machines. Precision grinding led to diamond grinding and diamond cutting machines for ultra-precision forming of infrared optics for military night vision systems.<sup>9</sup> Today, the driving application in the diamond cutting ultra-precision industry is molds for plastic lenses for cell phone

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<sup>7</sup> *Ibid.*

<sup>8</sup> "Congressman Duncan Hunter ... estimated that it would cost the West \$330 billion to regain superiority lost from the [Toshiba] sale and that with the new propellers the Soviet submarines could get within ten minutes of missile flying time from the U.S. coast.." Page 269 in Gary K. Bertsch and Steven Elliott-Gower. *Export Controls in Transition: Perspectives, Problems, and Prospects*. The Center for East-West Trade Policy, University of Georgia. Duke University Press Durham, NC, 1992 Also " In March 1987, the Pentagon released a study on recent improvements in Soviet submarine technology. The study implicated Toshiba." Page 40 in Stuart Macdonald, *Technology and the Tyranny of Export Controls: Whisper Who Dares*. St. Martin's Press, New York, 1990.

<sup>9</sup> One government application for diamond cutting tools is a fly cutter to machine ultra precision optics for Pockels cells used by high power lasers in the National Ignition Facility, a fusion experiment led by Lawrence Livermore National Laboratories. The Pockels cell optical component is a 41 cm square window of potassium dihydrogen phosphate (KH<sub>2</sub>PO<sub>4</sub>) crystal. Thickness on this piece must be controlled to within 150 nanometers, and surface roughness must be less than 1 nanometer root-mean-square. This crystal has an average intermolecular spacing of 0.65 nanometers, so the finish is smooth at the level of one or two units of the crystal.

cameras and DVD lasers. Because these optics operate in the visual and ultraviolet bands with shorter wavelengths, accuracy requirements are much more stringent than for infrared optics. Thus, the technology available today is a few generations beyond what military applications require.

An important current application of machine tools is composite fiber placement machines to form composite structures of aircraft. The skin of the Joint Strike Fighter is formed by these machines. Composite structures formed by these machines are essential for stealth properties and are essential for missile production. However the demands of commercial applications, particularly the Boeing 787, Airbus A380, and new ultra light jets, are driving the technology today.

## **EXPORT CONTROLS ON THE MACHINE TOOL INDUSTRY**

The general licensing requirements placed on machine tools are in Section 2 of the Commerce Control List (CCL). Roughly, the CCL requires licenses for

- All computer numerically controlled machine tools;
- Multi-axis lathes that are accurate to six microns;
- Five-axis milling machines accurate to six microns;
- All five-axis grinders;
- Three-axis grinders that are accurate to four microns;
- Two-axis electrical discharge machines that do not use wires for shaping;
- Multi-axis cutting tools accurate to 0.003 degrees that use lasers, electron beams, or fluid jets;
- Gear cutters that can cut hardened steel gears larger than 1.25 meters in diameter.

There are many specific additions and exceptions to this list, and there are additional requirements placed on machines that are specially designed to produce critical parts of missiles, nuclear reactors, and nuclear fuel processing equipment. Essentially all high quality machine tools require export licenses to countries such as China, India and Russia. Some machine tools can be configured so that export controls will not apply. For instance, a machine may be designed with four-axis capability, but if a Chinese application is only for two dimensional parts, the machine can be built with motion in only two axes. Therefore, controls that apply to machines with three or more axes do not come into play.

## ECONOMIC IMPACT OF EXPORT CONTROLS

China constitutes 24% of the world market for machine tools and created over one-third of the growth in the world market between 2000 and 2004. Exports of high quality machine tools from the US to China require export licenses, so all US machine tool firms that are technology leaders and pursue the world market are impacted by export controls.<sup>10</sup> The Association for Manufacturing Technologies indicated that there are seventy companies in the US that are interested in exporting machine tools. Russia and India are the only other significant machine tool export markets subject to a similar level of control, but each constitutes about 1% of the world market. Thus, the quantitative impact of export controls on the US machine tool industry is almost entirely about exports to China.

### Analysis method

The quantitative impact of export controls on US exports of machine tools to China was analyzed with a gravity model of international trade in machine tools. The gravity model predicts exports from one country to another based on the size of machine tool production in the exporting country, the size of machine tool consumption in the importing country, and the distance between the two countries. If there is an additional factor that strongly affects exports, such as export controls, it ought to appear as a discrepancy between actual exports and the exports predicted by the gravity model. (The details of the model are discussed in Addendum C. The results are summarized here.)

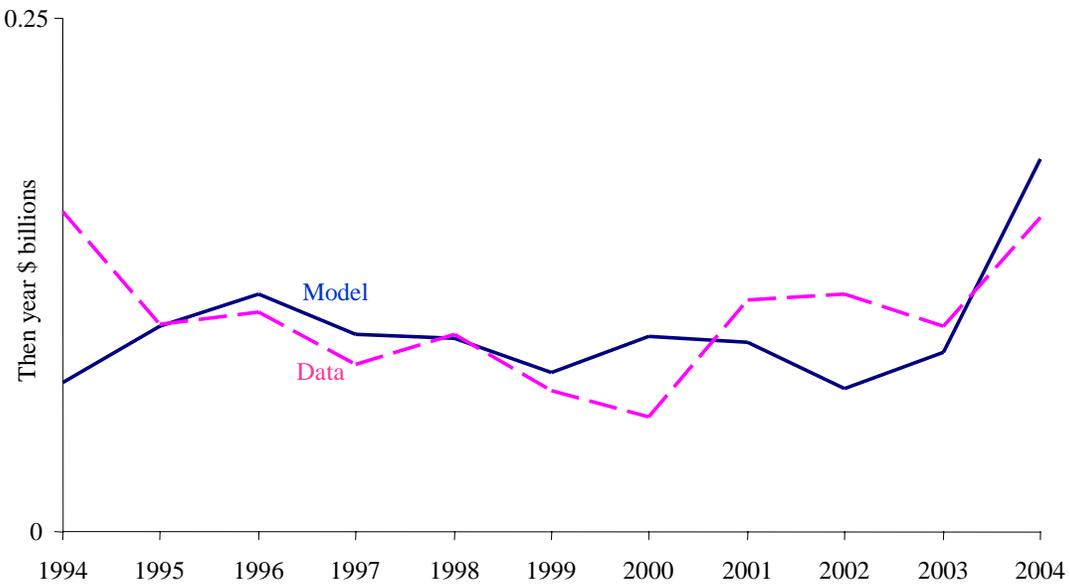
Data collected by the Association for Manufacturing Technologies were used for country by country production and consumption. A time series of data for the years 1994 to 2004, inclusive, were used in the analysis. All data were in then year US dollars. Only the top eight countries in machine tool trade were considered. Exports from each of these countries to the others were used to calibrate the model. However, exports to and from China were not used in the calibration, to avoid washing out the difference between model predictions and actual Chinese trade.

Figure 6 compares the gravity model with actual exports from the US to China. The line labeled “model” are predictions from the gravity model, based on machine tool production and consumption of the eight major countries. The line labeled “data” are actual new machine tool exports from US to China (not including parts and service).

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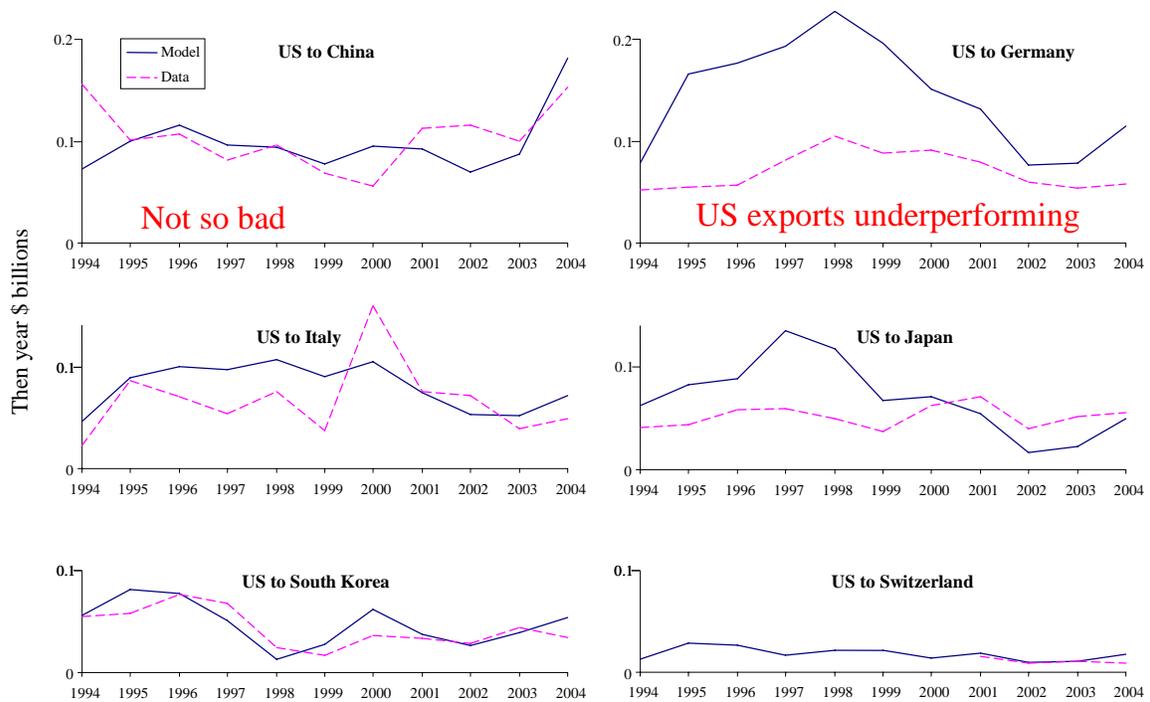
<sup>10</sup> The traditional orientation of the US machine tool industry has been toward the domestic market, and many machine tool makers do not pursue the high quality end of the market (see Figure 2).

Actual exports are not significantly depressed compared to the model, which suggests that exports controls do not strongly impact the dollar volume of US machine tool exports to China.



**Figure 6. Gravity Model Comparison with Actual US Exports to China**

Figure 7 looks at all exports of new machine tools to major consumer countries during the period of interest (again not including parts and service). Actual exports to Japan and Germany are significantly lower than gravity model predictions. This indicates that the US machine tool industry is being hurt by factors that restrict exports to Germany and Japan, but not particularly by export controls on exports to China.



**Figure x-7. Gravity Model Analysis of US Exports to All Countries**

Several experts we interviewed attributed the depression in exports to Germany to German nationalism. However, Italy and Japan export into Germany at approximately the rate projected by the gravity model, and Swiss exports to Germany are almost double the model predictions. These data suggests that the perceived quality of US machine tools is the factor which depresses exports to Germany and perhaps also to Japan.

### **Quantitative conclusions**

The impact of export controls on an industry is usually cited in terms of revenue loss and cost incurred. For the machine tool industry, revenue loss should primarily be felt in exports to China. The study team identified revenue losses on the order of 1.5% of the total industry revenue caused by differences in export control processes between the US and European exporters with respect to China. In absolute numbers this is \$50 million per year, which is about 50% of actual exports to China in a typical year; that is, with uniform export control policies, US machine tool exports to China could be 50% greater than they are. On the other hand, the gravity model analysis indicated that US exports to China are very healthy compared to exports to the rest of the world. In any case, 1.5% revenue loss in itself should not be broadly detrimental to the industry; the danger is that these losses are occurring in the most technologically advanced US tool firms and are actively discouraging further innovation in these firms.

With respect to costs, our interviews indicated that, for machine tool firms who engage in exporting to China, export control processing costs amount to 1% to 2% of sales. Costs are higher for some small firms.

### **Qualitative conclusions**

Members of the machine tool industry are perturbed by the \$50 million or so lost in sales to China not because the amount is so large, but rather because the loss seems wholly avoidable. The lost sales reported to us are sales to Chinese customers who are licensable—that is, if the order were given to a US firm, a license would probably be obtained, but the sales are lost because the US licensing process is more onerous than the typical European process. In Europe, export licenses are processed in weeks rather than months, and, more importantly, are often guaranteed prior to the sale. US firms are never certain of receiving a license. As a result, a US manufacturer cannot risk building a custom machine tool until the license is granted, several months after the sale. In Europe, the machine can be built while the license is being processed. As a result, Europeans have the advantage of several months lead time in their quote. Also, when the Chinese customer chooses the European machine, delivery is guaranteed. With US machines, delivery is never certain until the license is granted.

Sales are also lost in China due to the extensive and intrusive data requirements of the US process, relative to the European processes. For example, one Chinese firm purchased a US machine and was required to document, for every part that was to be made on the machine, the process for manufacturing the part. The firm intended to make over 200 different parts on the machine. Some parts would not be made until two years hence, and no production planning had been done, but US export procedures required the firm to do production planning for all the parts and submit it to the machine manufacturer. In another case, a condition of the license was that the machine constantly provide online monitoring fed back to the US so that the tool manufacturer could determine what was being manufactured on the machine and how the part was being processed. Some Chinese customers either will not tolerate intrusive financial questions and manufacturing process questions, or cannot perform the work necessary to collect the data.

Much more significant than lost sales is the impact on product development and technology development. Because it is easier for German, Swiss, and Italian firms to sell machine tools in China, multinational firms in the industry are moving their research and development funding out of the US and into Europe. A reduction in product development

will accelerate the loss of technology leadership by US firms, and in the long term will further erode US market share.

## **Anecdotal evidence**

### **Obtaining US Export Control Licenses**

Among the firms interviewed, the fastest approvals for licenses to sell controlled machine tools into China were eight to ten weeks. The slowest were six to twelve months. The firms emphasized that the interval that matters to their business is the time from the sale until the license is issued. They said the government often only tracks the part of that interval when the license application is in their possession, not the time it takes a company to respond to requests for additional information or clarification, which is a frequent occurrence and often more than once during the application process. Therefore, government officials believe that the process is faster than it actually is.

Because of the expense of applying for an export license, some companies only attempt to license exports to customers they have prescreened. One firm applies for licenses without prescreening and had their licenses for Chinese customers denied 95% of the time. One firm was denied a license to ship a machine tool to Hong Kong. A college professor there wanted to start a business. When his business site was examined during the licensing process, it was an empty, run down warehouse. The buyer protested that he had not started his business yet, but US officials were of the mind that the company was a sham.

### **Lost Sales Due to Export Controls**

One firm completed a sale to a Chinese customer, but the customer said they would never again buy a US machine because the process is so difficult and the licensing process is so onerous. We were told that Hardinge refuses to export their high end lathes from the US to China because the export control process is too much of a hassle.

### **Getting Around Export Controls**

In the 1990s, utility machine tools (highly flexible machines) became much faster. This bears on the export control guidelines, because a machine can produce significantly greater accuracy if it is run much slower than rated speed. Therefore, a user who is prohibited from buying a US machine with 4 micron accuracy can legally buy a numerically controlled three-axis machine with 7 micron accuracy that is set up to run very fast feed rates, slow it down, and obtain 4 micron accuracy. The slow speed equals the state of the art speed for an equivalent machine from 15 years ago.

### **Advantages Conferred by European Export Controls**

A British firm directly competes with a US firm in a particular type of specialty tool. The UK firm only sells these tools in India and China, where they enjoy a marketing advantage due to differential export control processes. The UK license for Chinese export requires six weeks, and there is no uncertainty about whether the license will be granted. Because of the rapid, low risk licensing process, the UK machine sells for twice as much as an identical US machine. The UK firm has sold twenty machines in China, which is most of one year's production for the US competitor.

During the 1980s, 50% to 60% of Swiss grinder manufacturer Hauser's market was Eastern Bloc countries to which the US firm Moore could not export. During this period, Hauser subsidized its Western sales with profits made in the Eastern Bloc where margins were high due to CoCom export controls. In 1989, Hauser was a \$20 million firm. However, they were holding about \$6 million of Soviet Union receivables when the government collapsed, and they were unable to collect, driving them to near bankruptcy. In 1997, one interviewee was told by Hauser that they have never been denied an export license, and can get a license in 48 hours. The same source believes that, today, a Swiss firm requires two weeks to obtain a license. In either case, Hauser is able to sell high precision machines in China for 30% more than the same machines sell for in the US, while US competitors have no price advantage in China. Our interviewee attributes the entire 30% price advantage to differences between US and Swiss export control processes. One source was told by Swiss firm Starrag-Heckert that a license for a top-of-the-line five axis machine requires one week for a customer in China or Iran.

### **Impact of Export Controls on Critical Technologies**

Hardinge dropped out of the digital controls business because of the negative impact of export controls, leaving the US without a domestic source of control systems for machine tools (though Haas Automation makes controls for their own machines). Control technology is critically important to machine flexibility, and the current generation of precision machine tools extensively use compensation algorithms in the controls to provide machining accuracy. Thus, digital controls are among the most critical machine tool technologies, and almost all US tool manufacturers import their controls.

## CONCLUSION

“Export controls and COCOM ... had the specific purpose of protecting a U.S. and Western lead in strategic technologies.”<sup>11</sup> In the cold war, the West was outnumbered in soldiers and conventional equipment by the Eastern Bloc. The US pursued a strategy of maintaining a one or two generation lead in critical technologies to compensate for the deficiency in quantity. Our superior technology would provide kill ratios that would balance out the enemy’s tanks and troops. Midway through the cold war, US thinking evolved toward believing that protecting manufacturing know-how was more critical than protecting the design of weapon systems themselves. A technology lead in manufacturing technology was critical to securing the nation.

Export controls cannot be blamed for the decline of the US machine tool industry, as they have only reduced overall revenues by 1% - 2%. Europeans win about \$50 million in sales to China that otherwise would have been won by US firms if the customer were willing to tolerate the uncertainty and delay of dealing with the US process. Because the European licensing process is so favorable, in direct competitions of equivalent products, Chinese firms will pay 30% to 100% more for a European product. The \$50 million loss compares to about \$100 million of US machine tool annual sales to China. Although export controls do not cause an important loss of revenue to the US machine tool industry as a whole, they do hurt a small number of companies at the leading edge of the industry who are deeply involved in exporting tools to China.

As a policy, export controls have failed to protect the US technology lead in machine tools. In the 1950s and 1960s, the US without question led the world in almost all aspects of machine tool technology. Today, we lead in few areas. For the most part, top technology is to be found in Germany, Japan and Switzerland. The US export control process is allowing European firms a significant advantage in the Chinese market, where 24% of the world’s machine tools are purchased. The difference between European and US export control processes on exports to China is also directly contributing to the US slip in technologies because multinational firms are relocating technology development and product development from the US to Europe to exploit the advantages of exporting

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<sup>11</sup> Henry R. Nau, “Export Controls in a Changing Strategic Context,” p. 321. In *Export Controls in Transition: Perspectives, Problems, and Prospects*, edited by Gary K. Bertsch and Steven Elliott-Gower. The Center for East-West Trade Policy, University of Georgia, Duke University Press, Durham NC 1992.

from Europe to China. Several of these firms are opening manufacturing operations in China.

### **ACKNOWLEDGEMENTS**

We would like to thank Cincinnati Machines, Kingsbury Corporation, Monarch Lathes, Moore Precision Tools, Nanotechnology Systems, Precitech, and Vermont Machine Tool for permitting us to interview their executives. We would also like to thank the Association for Manufacturing Technologies for providing extensive interviews and access to their comprehensive sets of economic data.

## ADDENDUM C: GRAVITY MODEL ANALYSIS OF THE MACHINE TOOL SECTOR

We performed a quantitative analysis of trade in the machine tool sector to explore the impact of export controls on US machine tool exports to China. The analysis used national production and consumption data and international trade data collected by the Association for Manufacturing Technology. A gravity model of machine tool trade was created and fit to the data. The model estimates exports between countries based on their production and consumption. Model estimates are compared with actual export data to explore whether export controls (which are not in the model) appear to decrease exports compared to the model. This addendum will discuss what a gravity model is, and how it works. It will then present the gravity model analysis of eleven recent years of trade data and draw conclusions. A separate analysis of the machine tool industry in the 1980's is presented. The findings of both analyses are then summarized.

### What Is a Gravity Model?

A gravity model is a simple trade model, patterned after Isaac Newton's law of gravity. The force of gravity between two bodies is proportional to the mass of each body and inversely proportional to the distance between them as shown in Equation (1), where G is Newton's gravitational constant.

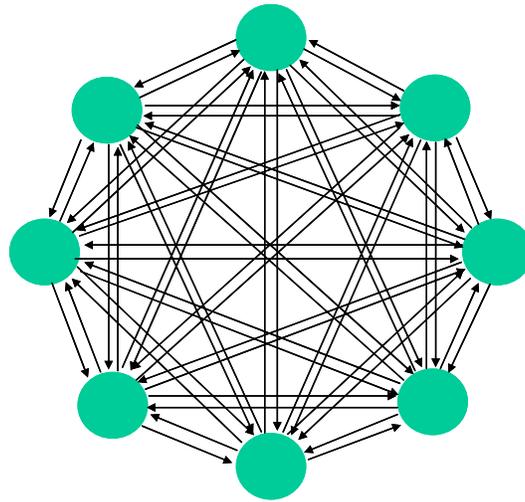
$$\text{Gravitational Force}_{1,2} = G \cdot \frac{\text{mass}_1 \cdot \text{mass}_2}{\text{distance}_{1,2}^2} \quad (1)$$

Gravity models use the economic activity in two physical areas as analogs for mass. Trade is proportional to the product of the activity in both areas and inversely proportional to the square of the distance between them. Because machine tools have a relatively high value per pound, transportation cost should not be as great a factor as it would be for trade in rice or coal. Therefore, the effect of distance might be smaller. For this analysis, equation (2) was used as the gravity model. A and b were free coefficients that were fit to the data by regression, so that the data determined the distance exponent.

$$\text{Export}_{1 \rightarrow 2} = A \cdot \text{Production}_1 \cdot \text{Consumption}_2 \cdot \text{Distance}_{1,2}^{-b} \quad (2)$$

The data set began with a set of the most active nations in the machine tool trade and a range of years. The data set contained production and consumption data for each nation for every year. Physical distance between the capitals of nations were incorporated into the set. Distances were measured along great circle routes. For China, Shanghai was

used rather than Beijing for the nominal location of the country, because China is large and Shanghai is closer to the center of industry. The data set also contained a slot for export data from every nation to every other nation (Figure C-1 illustrates the large number of export links between a fairly small number of nations). Data were not available for every slot in the data set, but a majority of the slots were filled, as detailed below.



**Figure C-1. Gravity Model Estimates All Export Links**

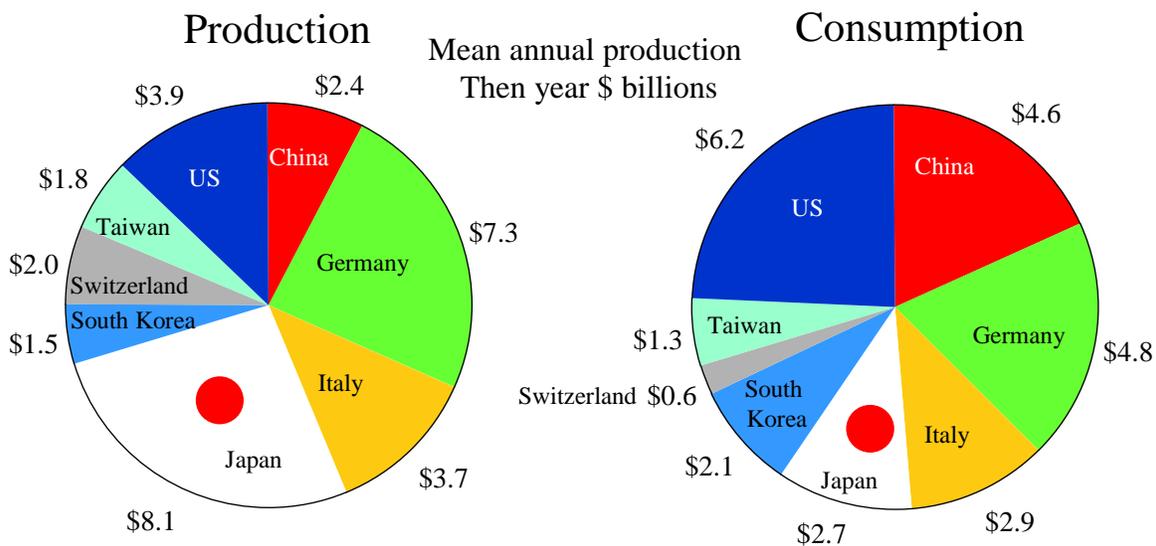
Development of the model consisted of assigning values to coefficients A and b. This was done by using the model to estimate exports, comparing estimated exports to actual exports in the data set, and choosing coefficients that reduced the sum of the absolute value of the errors between estimated and actual exports. Often, for regression, the square of the errors is used rather than the absolute value. However, the goal of this model was to highlight the major disparities between model estimates and data. By using squares, the coefficients would mostly be fit to the few largest deviations between estimates and data, and would wash out the size of the deviations. Absolute values were used to reduce this effect.

### **Gravity Model Analysis of Recent Trade**

To study the impact of export controls on machine tool exports from the US to China, a data set was constructed for the period 1994 to 2004, using trade among the top eight machine tool producing and consuming countries: China, Germany, Italy, Japan, South Korea, Switzerland, Taiwan, and the US. 2005 data was not used because, at the time of the study, it was less complete than the other years. 1994 was chosen as a start

date because it corresponds to the end of the COCOM export control process and the initiation of the Wassenaar Agreement. (See page **Error! Bookmark not defined.**)

Figure C-2 shows production and consumption of the eight countries in the data set averaged over the years 1994-2004. The remainder of the world produced \$6.4 billion and consumed \$10.4 billion for a world total of about \$44 billion in both categories. During this period, China consumption grew at a double digit rate, and now leads the world (24% of world consumption in 2005). The US has slipped to sixth place in current production, just behind Taiwan, and is now third in consumption, behind China and Japan.

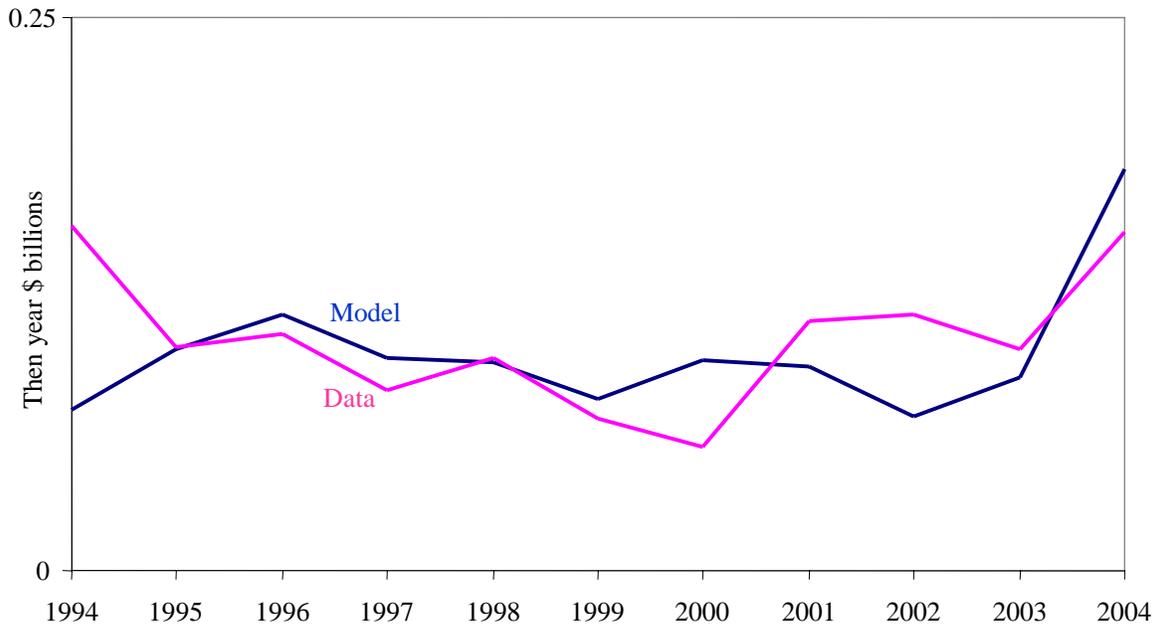


**Figure C-2: Machine Tool Industry 1994 – 2004**  
(Source: *Manufacturing & Technology News*)

To fit parameters A and b in the gravity model (A is an overall coefficient and b is a distance exponent), regression was performed using 273 export data in the data set. All imports to China and all exports from the US were excluded from the regression to improve the quality of the comparison of these data with the model results. Given these exclusions, there were 473 export data slots, of which 273 were filled with actual data (the remaining data were unavailable). Thus, 58% of the potentially useful data was actually available for parameter fitting.

The result was  $A = 0.000263$ , and  $b = -0.433$ . With these parameters, the gravity model could estimate exports. Compare export data to these estimates suggests whether the actual exports are more or less that what would be expected, given the trading nations production and consumption.

Figure C-3 shows the time series of US machine tool exports to China over the years in the data set. Adverse impact of export is suggested when the purple line is significantly or persistently below the blue line. In Figure C-3, the purple line is below sometimes and above sometimes. Overall, it is not clear that the actual data falls short of the model—the analysis does not point out an adverse impact of export controls on US machine tool exports to China.



**Figure C-3. Analysis of US exports to China**

To take a broader view, US exports to China are compared to US exports to other major nations in the machine tool industry in Figure C-4. Actual data falls significantly below the model in the trends for US exports to Japan and especially exports to Germany. Compared to these, the China data is very close to the model. Perhaps export controls adversely affect exports to China, but whatever is detracting from exports to Japan and Germany seems to have a much stronger negative impact on US industry.

In Figure A-5, US exports to China are compared to other nations' machine tool exports to China. Like Figure A-4, all the data in the figure is plotted to the same scale. The most obvious impression is that Germany, Japan, and Taiwan all export much more to China than we do. Next, comparing the actual exports with the model estimates, Germany does somewhat better than the model prediction, Japan does somewhat worse, and Taiwan does far better—in fact Taiwan exports many times the value in machine tools that the model predicts.

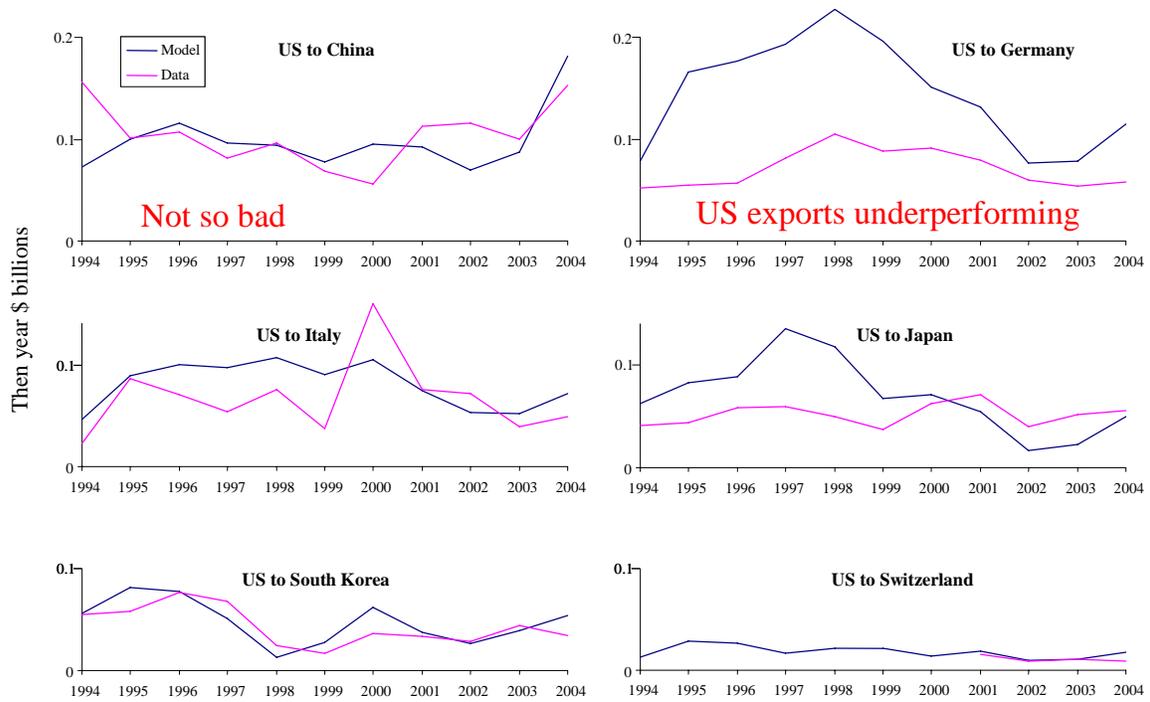


Figure C-4. Exports to China vs. Other US Exports

New machine tools,  
excluding parts and service  
All graphs to same scale

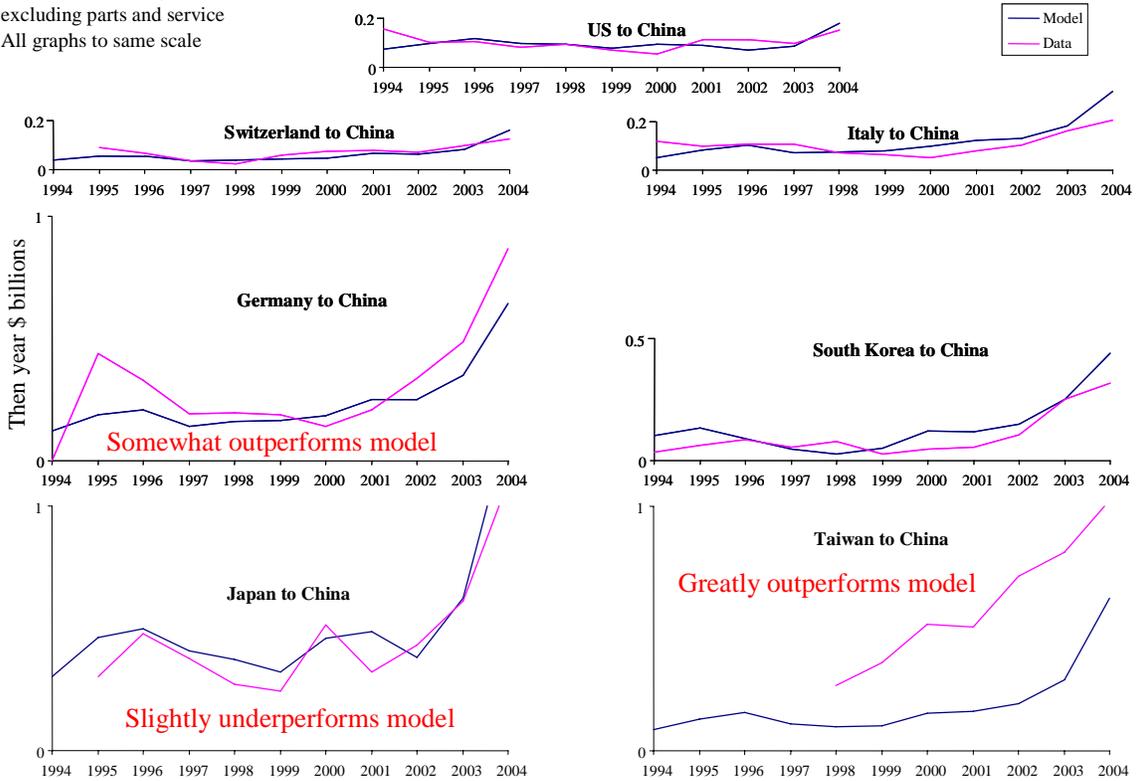
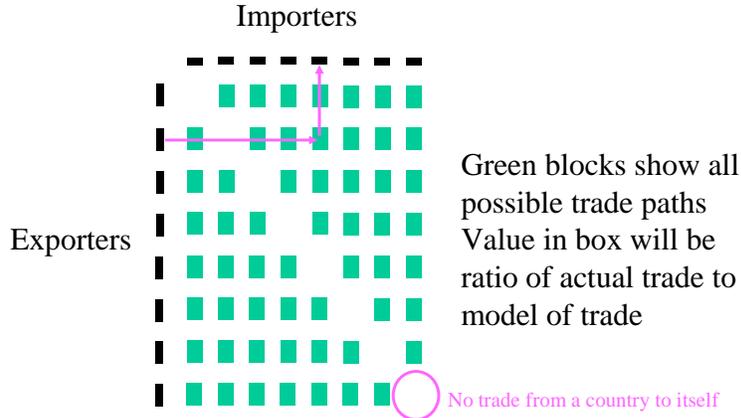


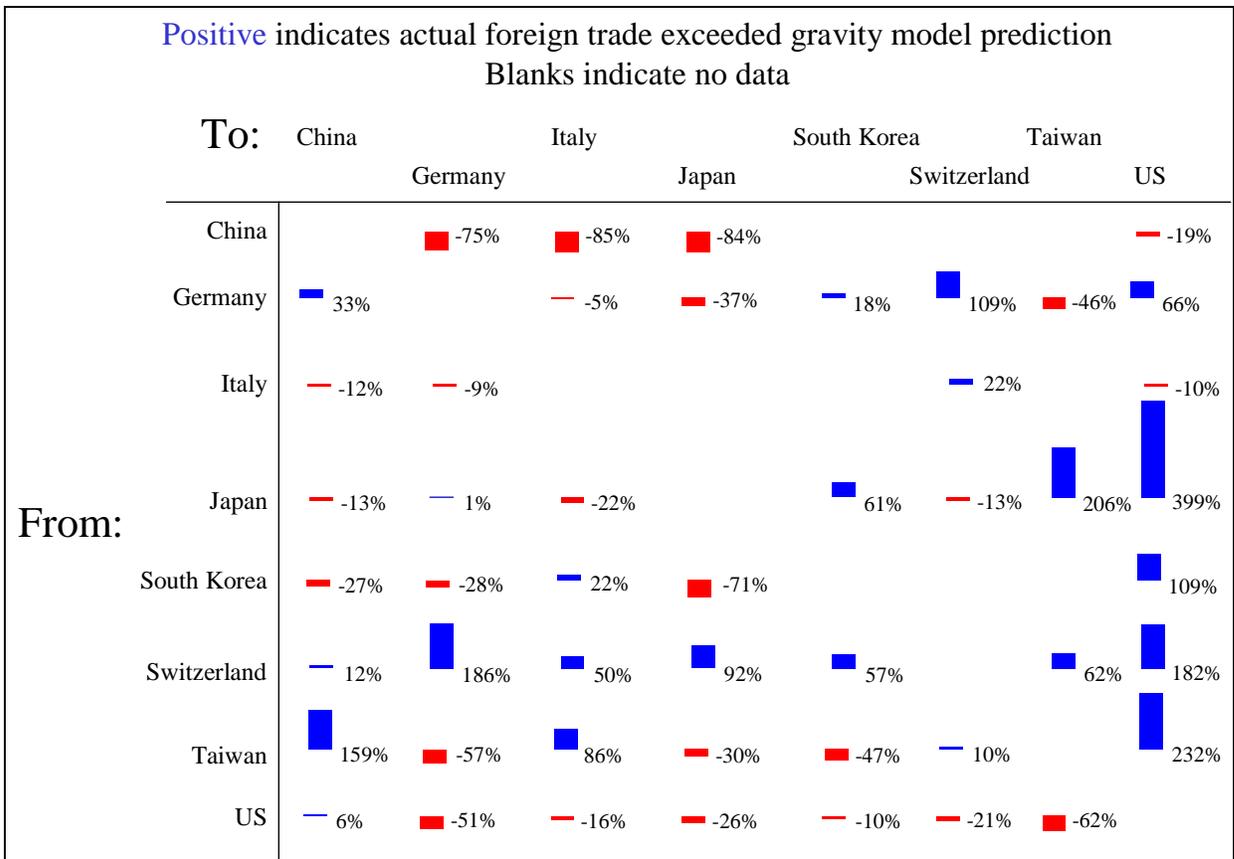
Figure C-5. US vs. Other Exporters to China

To grasp the overall picture, it would be useful to see all the actual-versus-model comparison for all the export paths at once. Figure C-6 illustrates how all the export paths can be represented on a grid.



**Figure C-6. Plot Format to Capture all Export Links at Once**

In Figure C-7, all the export paths are shown in one grid.



**Figure C-7. Summary of Gravity Model Analysis: 1994 - 2004**

The major differences between actual exports and the model predictions are

- China's actual exports fall far below model estimates to all countries. Exports to the US are low, but not nearly as low as exports to Germany, Italy and Japan.
- The US loves to import. Imports to the US exceed model expectations for all exporting nations except China, and the shortfall in Chinese imports is far smaller than the shortfall in Chinese exports to everyone but the US.
- Switzerland has an export-based machine tool industry.
- Taiwan greatly exceeds model predictions for exports to China.

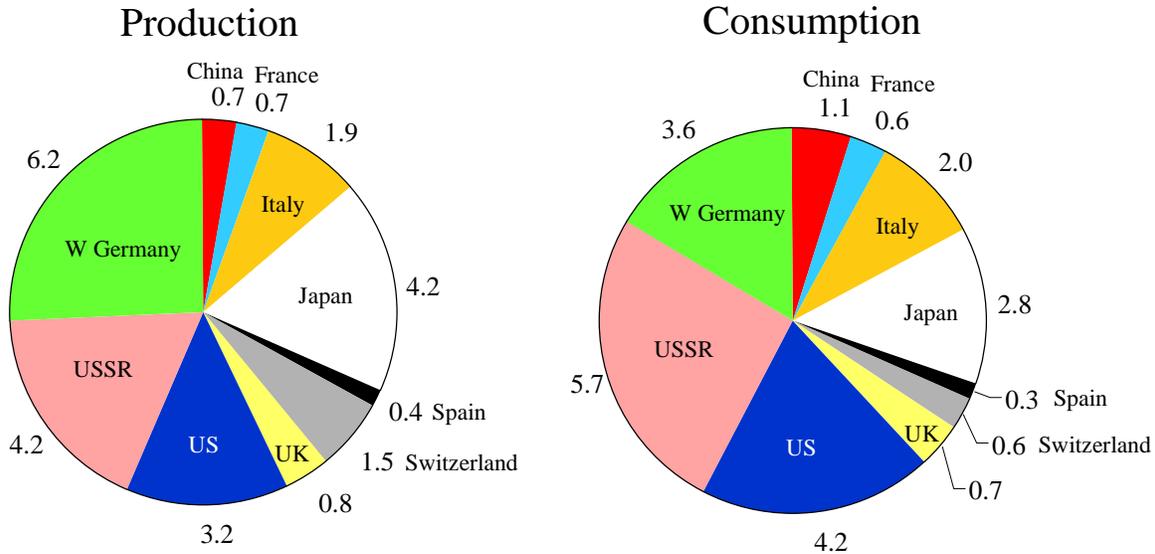
The following points are suggested by the overall analysis:

- The only country to which the US has relatively high exports is China, although even in China exports are not high by a significant amount.
- US exports to Germany and Taiwan are low.
- US imports much more than would be expected, particularly from Japan, Taiwan, South Korea and Switzerland.
- Germany and Japan resist importing, except from Switzerland. US inability to export to German and Japan is far more financially consequential than export controls into China.

### **Gravity Model Analysis of the 1980's**

Today, the leading consumer of machine tools is an export-restricted country: China. Does this mean that export controls on machine tools are more consequential now than in the past? To explore this question, the gravity model was used to look at the period 1980 to 1988, the last phase of the Cold War. For this study, the data set was built on ten nations: China, France, Italy, Japan, Spain, Switzerland, the UK, the US, the USSR, and West Germany. These ten were the leading nations in machine tool industry during the period. Their production and consumption of machine tools is graphed in Figure C-8.

Mean Annual National Production and Consumption, \$ billions  
 Leading nations in production and consumption  
 New machine tools, excluding parts and service  
 Then year dollars



Currency issues may overstate the size of USSR industry

**Figure C-8. Machine Tool Industry 1980 – 1988**

According to the data, the leading consumer of machine tools in this period was, once again, an export controlled country: the USSR. Due to the difficulty in valuing the ruble during the Soviet regime, USSR consumption may be overstated, but the USSR was certainly among the largest users of machine tools in the 1980's. Aside from political and ideological issues, any machine tool producer would have benefited greatly from having the USSR as an export customer.

To perform the gravity model analysis, the parameters A and b were fit to the new data set. China and USSR trade were excluded from the regression to improve the comparison between the model and their data. Japanese exports were also excluded because they were very unusual and very dynamic in this period. The resulting data set had 490 slots for annual export data, of which data was available for 288 slots, or 59%.

The composite summary of the model data comparisons are shown in Figure A-9.

Red indicates actual foreign trade less than model predicted

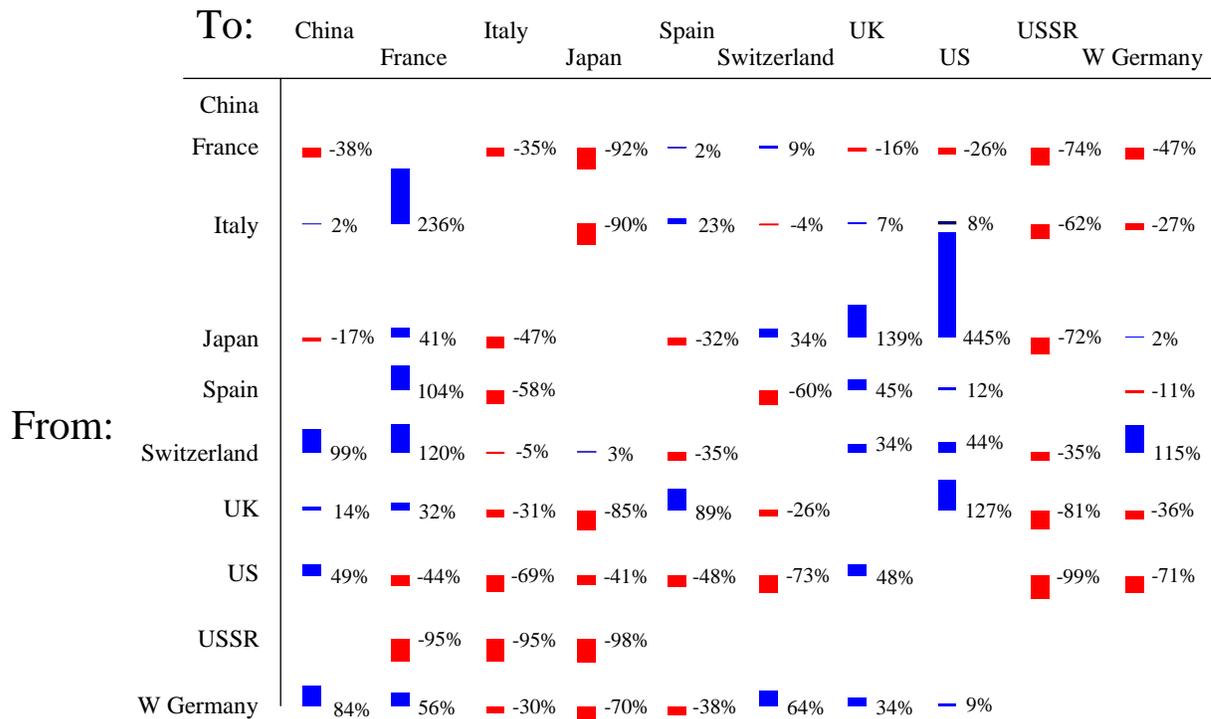


Figure A-9. Gravity Model Analysis: 1980 – 1988

The following points are apparent from the results:

- The US was, even in the 80's, under the norm in exporting to all countries except China and the UK.
- The USSR did not export machine tools. Perhaps they were unable to export machine tools for quality reasons, or perhaps their planned economy chose to not engage in machine tool exports.
- USSR imports of machine tools were severely curtailed except from Switzerland, even though the USSR was, nominally, the largest consumer in the world. Western Europe exported some tools to the USSR, although far less than the gravity model estimated. The US did not export machine tools to the USSR.
- The largest deviations, measured as a logarithm of percentage or measured in absolute amounts, are Japan's exports into the US (high), USSR exports (very low), and US exports to the USSR (essentially zero).

## **Conclusions**

The gravity model analysis does not show adverse impact of export controls on the US machine tool industry today. US exports to China fare better than exports to other countries such as Germany and Japan even though export controls restrict exports to China. On the other hand, export controls and a general reluctance to export to the USSR may have hurt US industry in the 1980's.

This being said, the US machine tool industry has never depended on exports. In both periods that were examined, 1994 – 2004 and 1980 – 1989, the US was a weak exporter and heavy importer compared with other nations with billion-dollar machine tool industries. The US has surprisingly low levels of exports into Germany and Japan. Several industry experts explained the deficit with Germany as the result of German nationalism: German industry only wants to buy German machines. However, Switzerland does very well exporting to Germany, and Japanese and Italian exports to Switzerland match model predictions (Figure C-7). Perhaps German consumers have a preference for high quality machines, and US machines are not perceived, in general, to be of high quality.

In Figure C-5, the one important nation in the industry that seems to have difficulty exporting machine tools to China is Japan. Industry experts said the region around Nanjing is very reluctant to buy goods from Japan because of ill feelings dating to the Japanese occupation in World War II.



**APPENDIX D**

**ECONOMIC IMPACTS OF EXPORT CONTROLS  
ON THE ADVANCED MATERIALS INDUSTRY**

**Nicholas S.J. Karvonides  
Richard H. Van Atta**

**January 2007**



**Economic Impacts of Export Controls on the  
Defense Industrial Base  
Appendix D**

**Economic Impacts of  
Export Controls on the  
Advanced Materials Industry**

**Nicholas S.J. Karvonides  
Richard Van Atta**

**Institute for Defense Analyses  
Alexandria, VA**

**January 2007**

## Study Task

Assess the economic impacts and effects of U.S. export controls on a highly “globalized” and equally distributive, dual-use, U.S. industrial base for Carbon Fiber-Reinforced, Polymer Matrix Composite Materials (CF-PMCs) relative to its Aerospace-Defense (A&D) subsector and aerostructures applications.

## Summary Findings

The U.S. CF-PMC industrial base today is robust and growing, but major U.S. firms are concerned that barriers to emerging export markets and related impediments to internationally distributive value (supply) chain relationships will threaten U.S. market leadership positions, encourage alternative foreign manufacturing sources and shift advanced R&D offshore.

The current impacts and effects of export controls on this strategic and economically important U.S. industrial base is not meaningfully measured by the modest loss of traditional export sales of physical products. More important are the broader effects on internationally dynamic supplier collaborations, industry-government cooperation, future competitiveness and implications at the global supply chain level of a highly distributed manufacturing and R&D enterprise.

# Outline

- Section 1. CF-PMC Advanced Materials & Industrial Base**
- Study Focus on CF-PMC Materials & the Aerostructures Industry
  - Industry Metrics and Impact Measures
  - Material Characteristics, Manufacturing Aspects & Value (Supply) Chain Dynamics
  - Industry Globalization and Its Impacts
  - Industry Economic & Financial Picture
  - U.S. Defense Industrial Base & Its Importance
- Section 2. Global Intensity of Material Suppliers & Value Chain**
- Global Intensity of Material Suppliers in A&D Subsector and Projected Markets
  - International Business Activities Triggering Export Controls
- Section 3. Form and Applications of Export Controls**
- Commerce Department Export Administration Regulations (EAR)
  - State Department International Traffic in Arms Regulations (ITAR)
- Section 4. Effects & Impacts of EAR-ITAR Export Controls**
- Effects & Impacts on Materials Suppliers & Value Chain
  - Effects & Impacts on Technology Development & Know-How
  - Additional Effects & Impacts on Extended Industry Value (Supply) Chain
  - Implications of Export Controls for the U.S. Defense Industrial Base
  - Conclusions on Effects & Impacts of EAR & ITAR Controls on Dual-Use Materials & Know-How
- Section 5. Interview Contacts & Selected References**
- Industry Value (Supply) Chain Contacts
  - Key Institutional & Subject Matter Experts
  - Selected References
  - Case Study on the Sartomer Company, Inc. (attached)

**Section 1.**  
**CF-PMC Advanced Materials & Industrial Base**

# Why Focus on the CF-PMC Materials Sector?

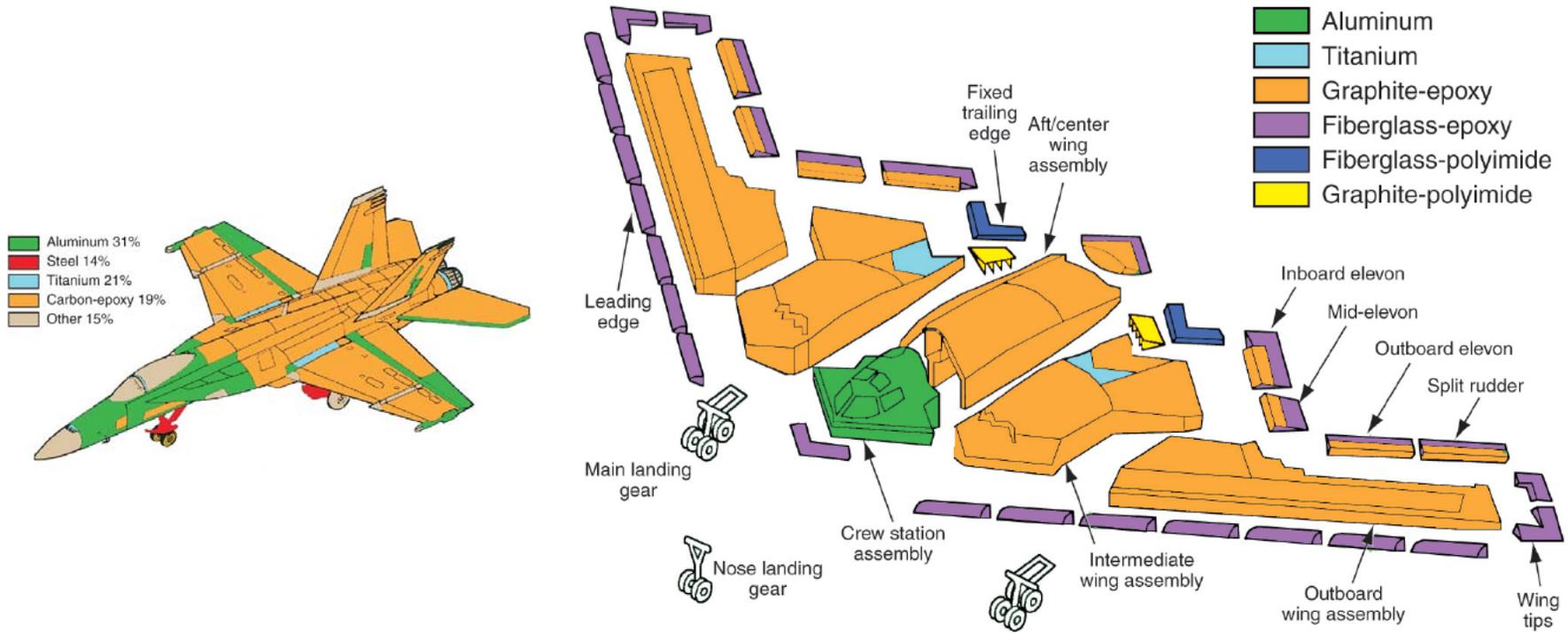
- **CF-PMCs are the most pervasive of advanced materials of importance to DOD (vast majority of applications), and,**
  - .... are highly significant for affiliated dual-use markets
  - .... are highly affected by export controls
- **Other advanced materials are more specialized and more limited in application although some are highly controlled**
  - .... addressing CF-PMC controls could benefit other advanced materials

# Why Concentrate on CF-PMC's Aerospace-Defense (A&D) Subsector and Dual-Use Aerostructures?

- Largest, fastest growing, most diverse and important application of advanced materials for DOD
- Value chain is closely coupled and interdependent on dual-use markets and heavily reliant on a globally distributive manufacturing and R&D enterprise
- This industry is more broadly impacted by export controls than other advanced material sectors

**Addressing the effect of export controls on CF-PMC aerostructures can provide spillover benefits (relief) to other advanced material sectors**

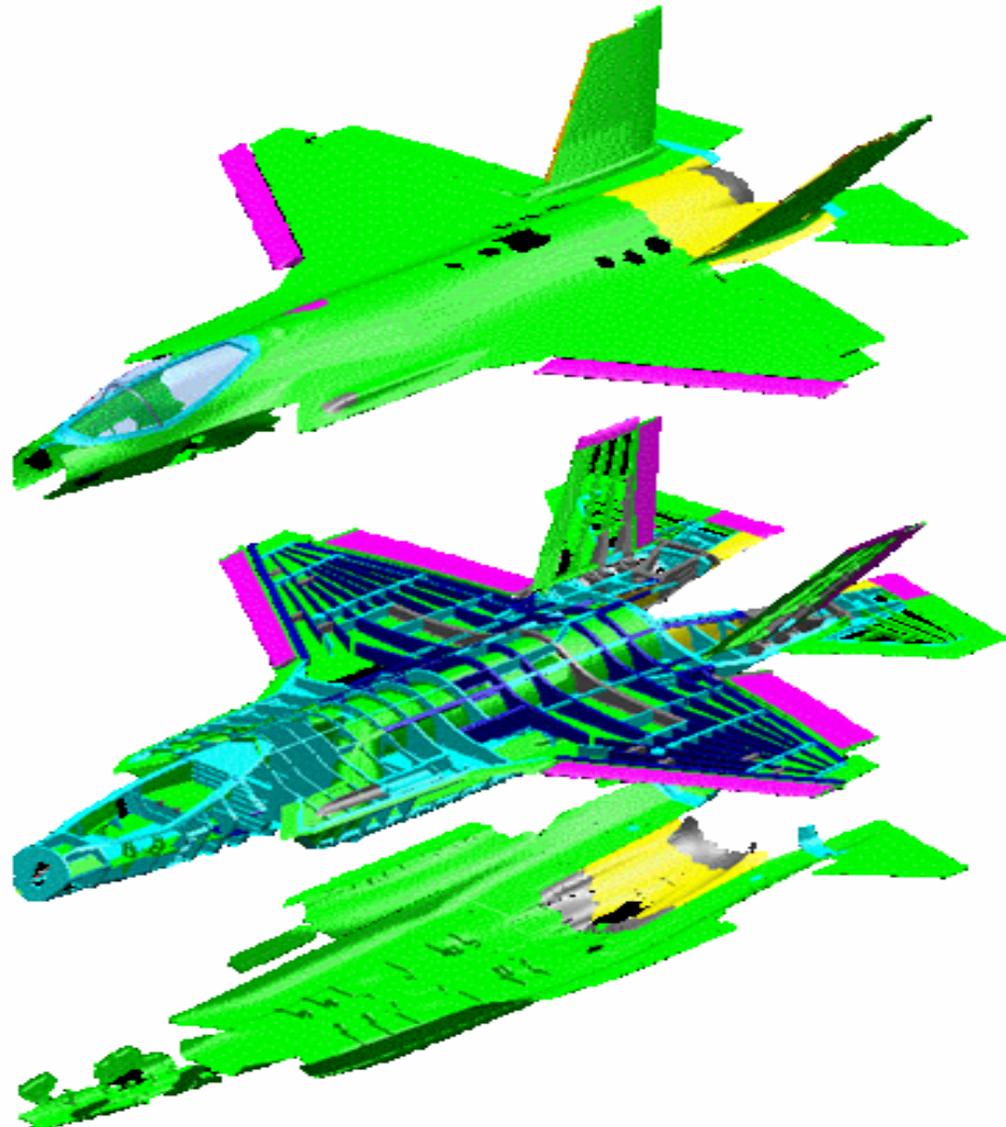
# Diverse CF-PMC Applications in Current U.S. Military Aircraft



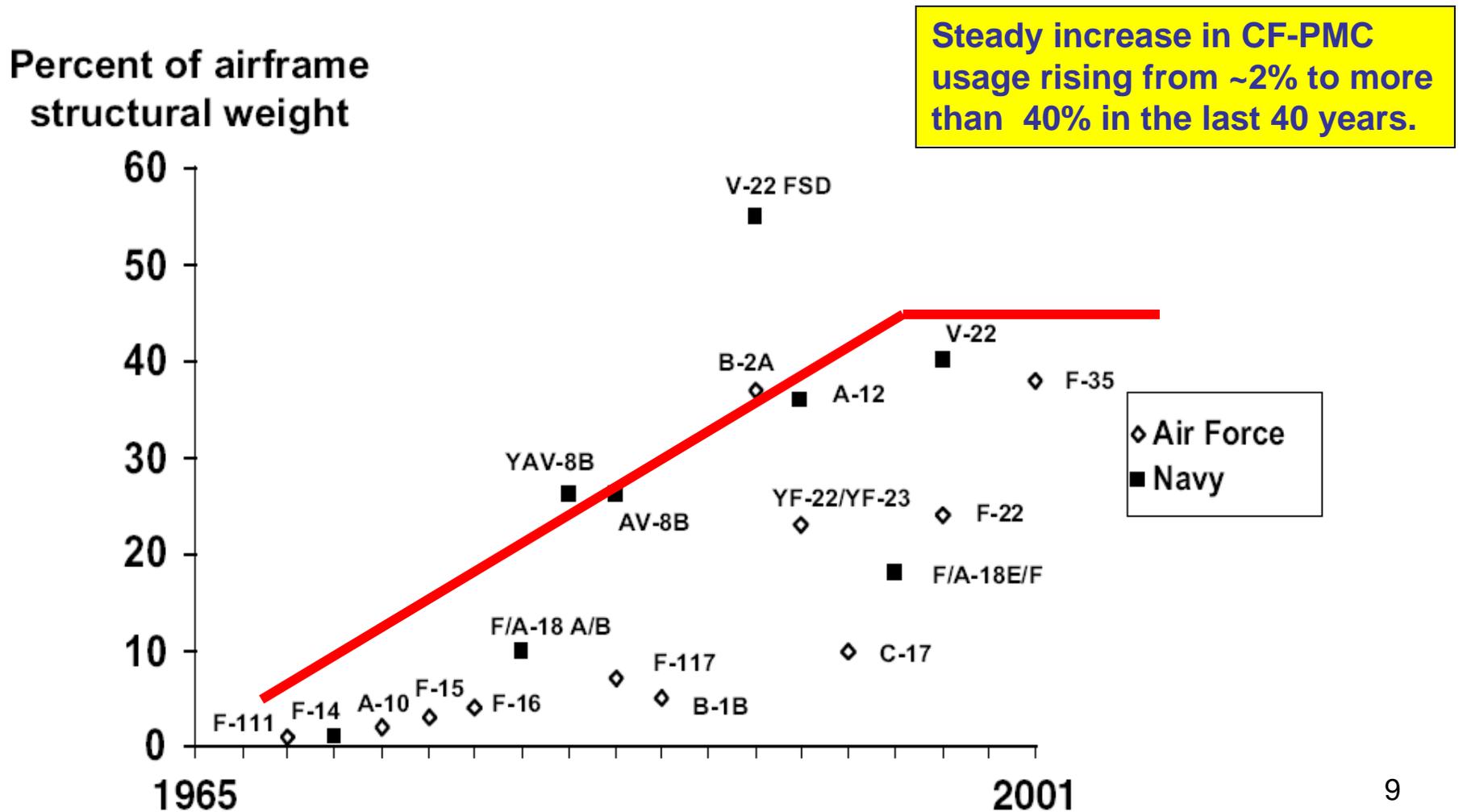
# Expanded CF-PMC Applications in Future U.S. Military Aircraft

Composite materials' content in the new F-35 JSF will exceed 35% of the vehicle's overall structural weight

Blue	Aluminum-Lithium
Cyan	Aluminum
Green	CF-PMC
Yellow	CF-PMC (Hi-Temp)
Grey	Titanium
Pink	Other PMCs



# Growth of CF-PMC Usage in U.S. Military Aircraft Aerostructures



# **Industry Metrics & Impact Measures**

# Metrics for CF-PMC's Industry Topography

## *Limited Data & Metrics Exist for Assessing Industry*

- Financial and market data not closely tracked by trade (professional) associations for dual-use CF-PMC aerostructures industry
- Data collected from independent consultants and private research firms on CF-PMC aerostructures market demand and forecasts vary widely
- Industry-wide CF-PMC international trade data and impacts of export controls not monitored as other sectors (machine tools, electronics, IR)
- Limited to no availability of current and in-depth, industrial base studies on advanced material sectors generally nor specifically for CF-PMC's aerostructures value chain for dual-use markets

# Metrics Applied to Benchmarking CF-PMC Industry and Market

- **CF-PMC Constituent (Fiber) Materials:** Worldwide production volumes and growth trends as well as market demand and forecasts
- **CF-PMC Intermediate (Prepreg) Materials for Aerostructures :** Worldwide production value and market share of leading A&D material producers
- **CF-PMC Fabrication:** Worldwide production volumes, growth trends and manufacturing costs as well as market demand and forecasts
- **CF-PMC Aerostructures:** Worldwide production volumes, growth trends & manufacturing costs as well as market demand and forecasts

# Measuring The Impact of Export Controls On Industry Is More Than Just Measuring Export Sales

## Expanded Measures of Global International Business Intensity:

- Conventional export sales of goods from the U.S. to foreign customers
- Offshore imports of U.S. goods, exported back to the U.S. for later re-export
- Cross-border, intra-company material transfers and knowledge-sharing
- Foreign direct investments (FDI) & international joint ventures (JVs)
- Global industry consolidation, mergers & acquisitions (M&As)
- Distributive manufacturing supply chains & R&D (offshoring & onshoring)
- Export trade offsets (revenue sharing)

**Global exchange of labor, relationships, ideas, enterprises, goods & services -- are essential business functions impacted by export controls**

## **Broader CF-PMC Market**

# Worldwide Carbon Fiber Demand

Region:

Region	1999	2004	2009
<b>United States</b>	6,900	8,400	13,900
<b>Europe</b>	2,600	5,200	10,000
<b>Japan</b>	2,600	2,900	4,100
<b>Other</b>	4,600	5,400	5,530
<b>Total Production</b>	16,700	21,900	33,530

(MT)

Subsector:

Market Segment	1999		2004		2009	
	MT	% Mkt Share	MT	% Mkt Share	MT	% Mkt Share
<b>Industrial</b>	<b>8,100</b>	<b>49%</b>	<b>11,400</b>	<b>52%</b>	<b>19,100</b>	<b>57%</b>
United States	1,900	23%	3,100	27%	5,300	28%
Europe	1,100	13%	2,700	24%	5,800	30%
Japan	1,700	21%	2,200	19%	3,100	16%
Other	3,500	42%	3,400	30%	4,900	26%
<b>Aerospace &amp; Defense</b>	<b>4,000</b>	<b>24%</b>	<b>5,600</b>	<b>26%</b>	<b>10,700</b>	<b>32%</b>
United States	2,800	70%	3,400	60%	6,400	60%
Europe	1,000	24%	1,800	33%	3,300	31%
Japan	200	4%	200	4%	600	5%
Other	100	2%	200	4%	400	4%
<b>Sporting Goods</b>	<b>4,500</b>	<b>27%</b>	<b>4,900</b>	<b>22%</b>	<b>3,730</b>	<b>11%</b>
United States	2,200	49%	1,900	40%	2,200	39%
Europe	500	12%	70	14%	900	16%
Japan	700	16%	500	10%	400	7%
Other	1,100	23%	1,800	36%	230	39%

(MT)

While the largest market subsector is industrial, the A&D subsectors is growing the fastest with a 12% vs. 6% compounded annual growth rate (CAGR). The combined growth forecasted for all major subsectors is projected at 8%

Metric Tonnes (MT)

15

Sources: CM Reports & ACMA

# Worldwide Carbon Fiber Supply

## By Region:

( production output )

Region	1999		2004		2009	
	MT	% Mkt Share	MT	% Mkt Share	MT	% Mkt Share
U.S.	6600	40%	7000	32%	11400	36%
Europe	2500	15%	4000	18%	6700	21%
Japan	7000	42%	9700	44%	11600	37%
Other	600	4%	1200	5%	2000	6%
<b>Total</b>	<b>16700</b>		<b>21900</b>		<b>31700</b>	

(MT)

## By Company:

( production capacity )

\* Hexcel 2007 figures revised with updated projections.

True factory capacity is approximately ~70% of reported values due to product mix (such as small diameter fiber yielding lower output vs. higher production volume of larger fiber)

				2005	2006	2007
<b>Regular</b>	Toho Tenax	Japan		3,700	3,700	3,700
		USA		0	700	700
		Germany		1,900	3,400	3,400
		<b>Total</b>		<b>5,600</b>	<b>7,800</b>	<b>7,800</b>
	Toray	Japan		4,400	4,400	6,600
		USA		1,800	3,600	3,600
		France		2,600	2,600	2,600
		<b>Total</b>		<b>8,800</b>	<b>10,600</b>	<b>12,800</b>
	Mitsubishi	Japan		3,200	3,200	3,200
		USA		2,000	2,000	2,000
		<b>Total</b>		<b>5,200</b>	<b>5,200</b>	<b>5,200</b>
	Hexcel*	USA		2,300	2,300	3,000
		Spain		0	0	700
		<b>Total</b>		<b>2,300</b>	<b>2,300</b>	<b>3,700</b>
	Cytec		1,800	1,800	1,800	
FPC		1,850	3,000	3,000		
Others		0	0	0		
<b>Total</b>		<b>25,550</b>	<b>30,700</b>	<b>34,300</b>		
<b>Large</b>	Toho Tenax		2,600	1,300	1,300	
	Fortafil		-	-	-	
	Zoltek		2,800	3,800	3,800	
	Others		3,250	3,250	3,250	
	<b>Total</b>		<b>8,650</b>	<b>8,350</b>	<b>8,350</b>	
<b>Grand Total</b>				<b>34,200</b>	<b>39,050</b>	<b>42,650</b>

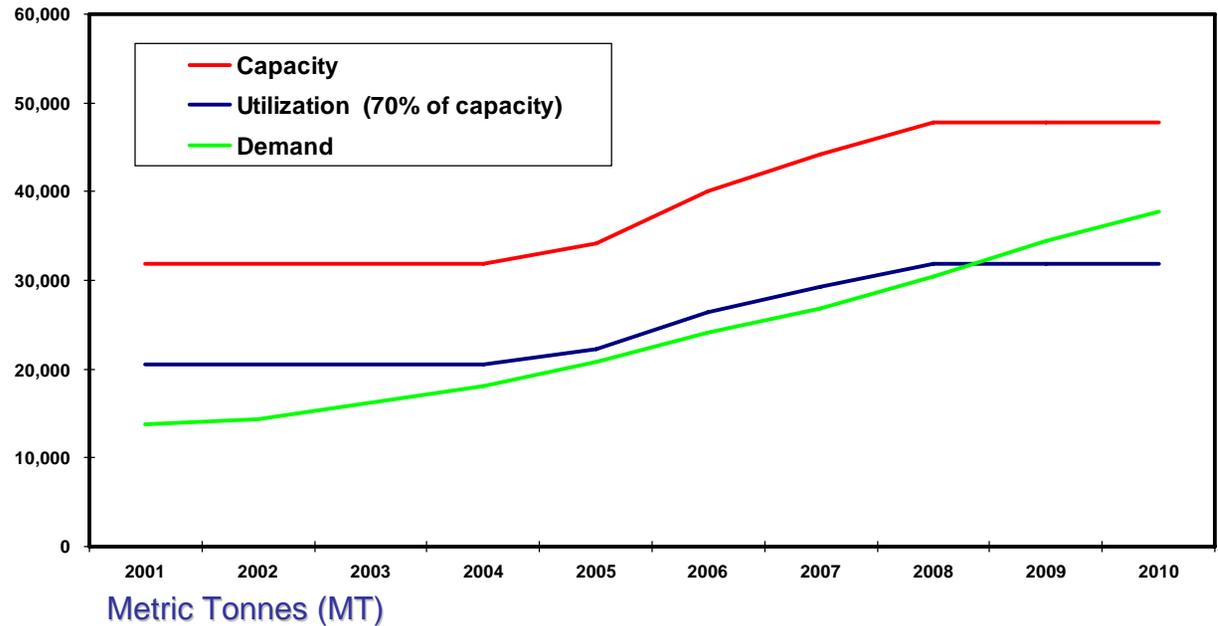
(MT)

16

Metric Tonnes (MT)

# Carbon Fiber Supply & Demand Trends

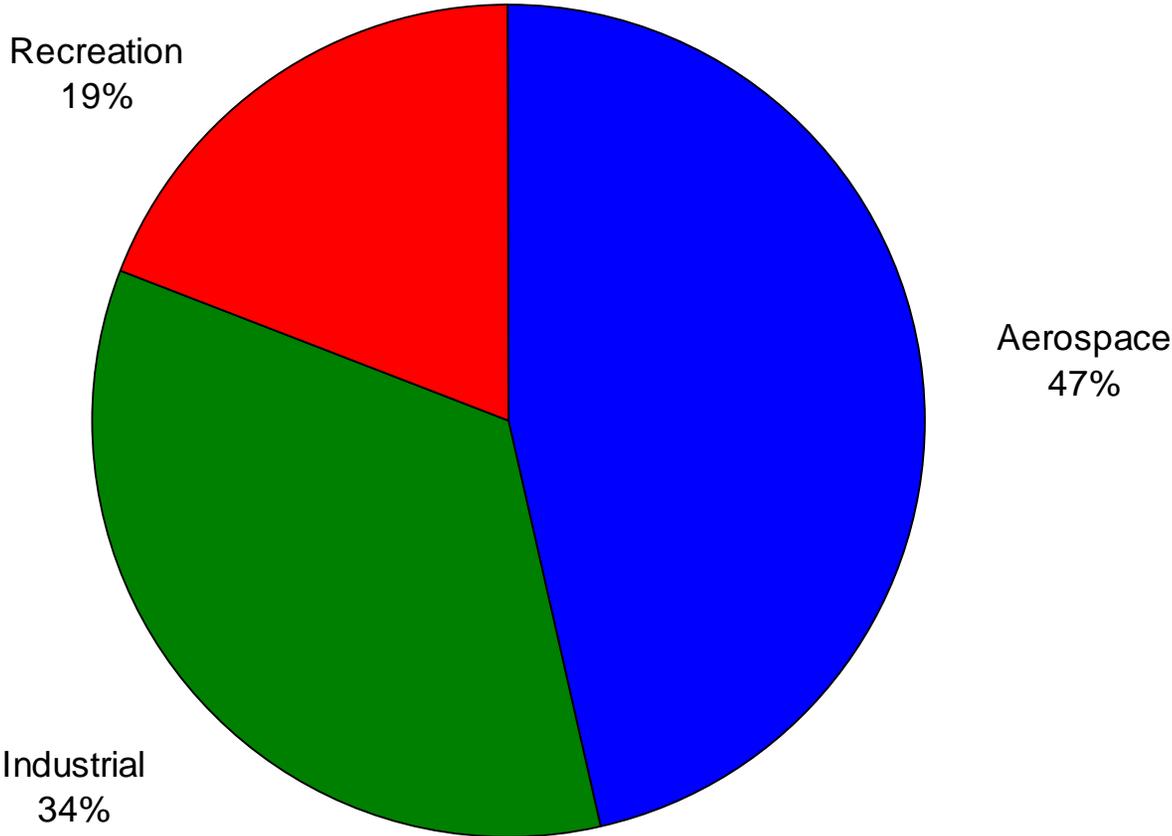
Carbon fiber demand is projected to exceed supply for the next several years. Although increased carbon fiber production capacity is being brought on-line, no anticipated excess supply capacity is expected given strong, long-term demand forecast (Source: Toho).



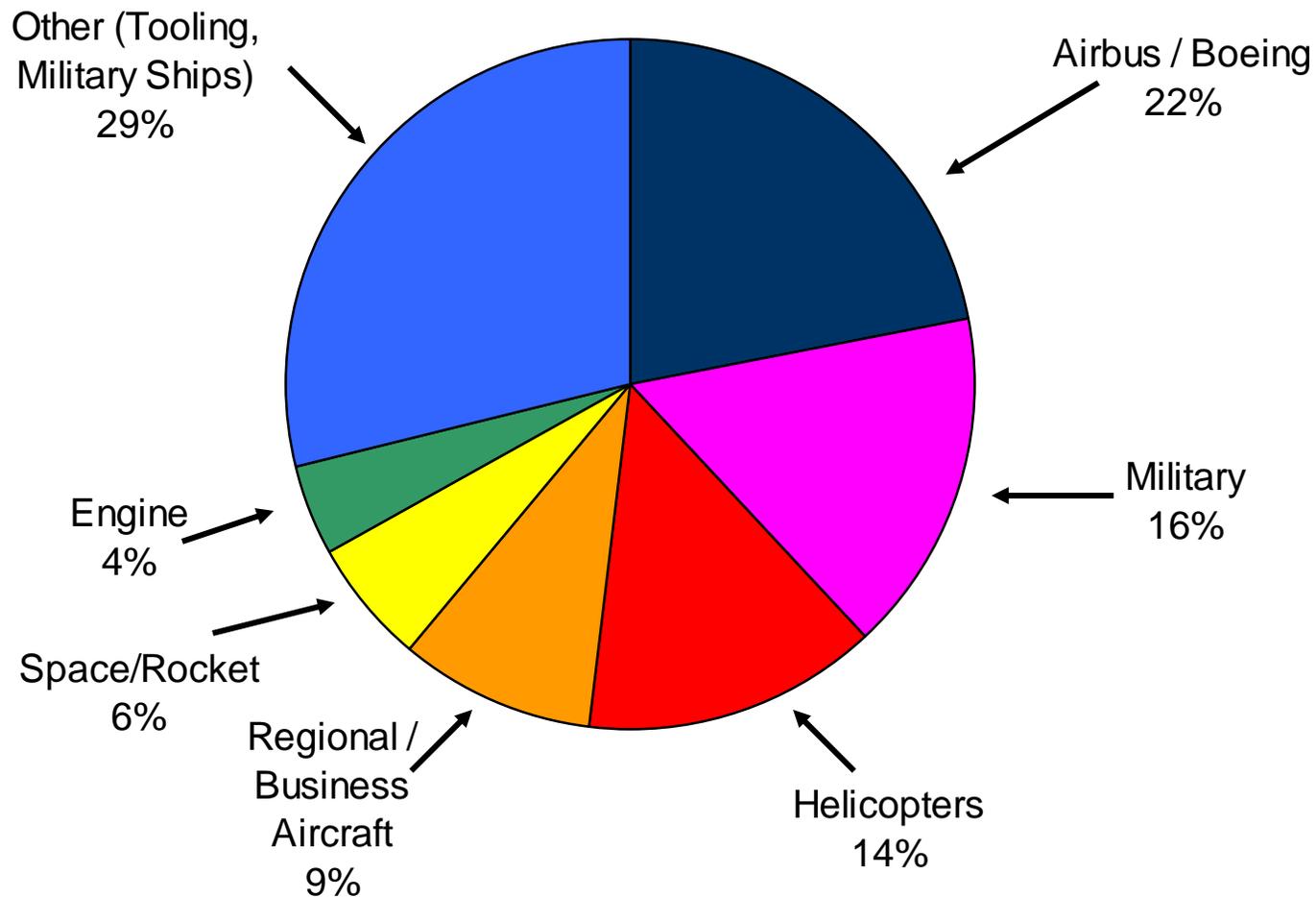
Subsector Demand	2003	2004	2005	2006	2007	2008
Industrial	8,360	11,410	12,640	14,000	15,000	17,180
Aerospace & Defense	4,590	5,680	6,500	7,410	8,450	9,640
Sports & Recreation	6,950	4,820	4,950	5,140	5,270	5,450
<b>Total Demand</b>	<b>19,900</b>	<b>21,910</b>	<b>24,090</b>	<b>26,550</b>	<b>28,720</b>	<b>32,270</b>

Metric Tonnes (MT)

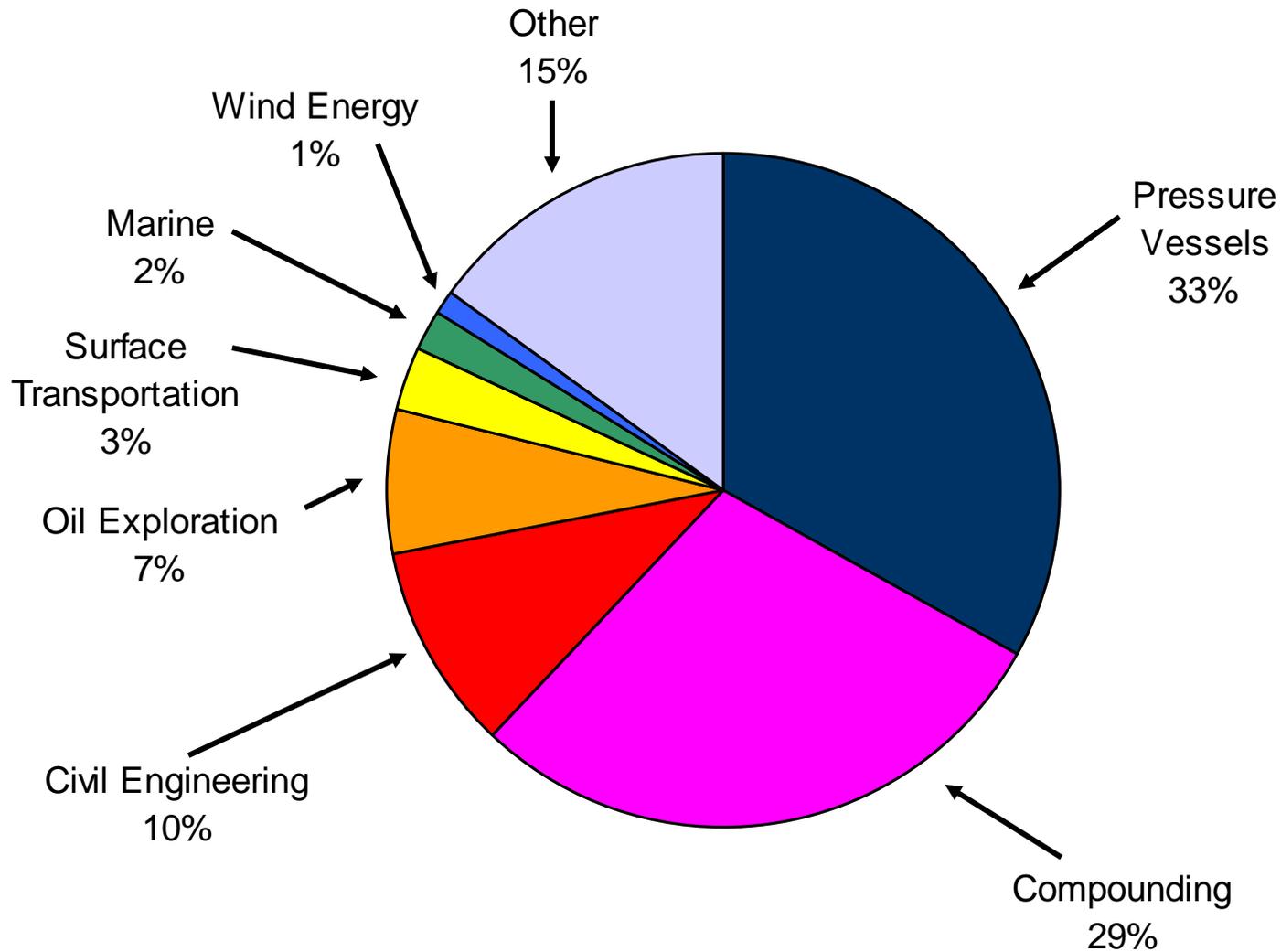
# North America Carbon Fiber Demand By Major Market Subsectors



# North America Carbon Fiber Demand For Aerospace & Defense (A&D) Subsector



# North America Carbon Fiber Demand For Industrial Subsector



# **Material Characteristics & Manufacturing Aspects**

## Definition of CF-PMC Materials =

### *High Performance, Carbon Fiber (CF) Reinforced, Polymer Matrix Composites (PMCs)*

- **Advanced Composites:** A two-phase material consisting of high performance, fiber reinforcements incorporated in a resin matrix
- **Fiber Reinforcements:** Carbon fiber reinforcements of typically standard or intermediate strength and modulus and commonly produced from a polyacrylonitrile (PAN) fiber precursor
- **Resin Matrixes:** Polymer resins (mostly thermoset vs. thermoplastic) with common use of epoxies for aerostructures and limited use of various specialty resins, such as polyamides, for high temp applications

# CF-PMC Material Characteristics

- Extraordinarily high stiffness and high strength-to-weight-ratio
- Highly controlled engineering of desired material properties and tailorable to specific application requirements
- Freedom of design to fabricate complex shapes & integrated structures
- High damage tolerance and resistance to fatigue, wear, vibration, impact, fracture and crack propagation
- Resistance to high temperatures and corrosion for certain applications
- Tailorable thermal conductivity and insulation, electrical resistivity & low coefficient of thermal expansion
- Potential for “multifunctionality” through integration into other material, mechanical and electrical systems (system-of-systems opportunities)
- Disadvantages include high manufacturing costs, repairing damage, temperature capability vs. metals / ceramics & anisotropic strength

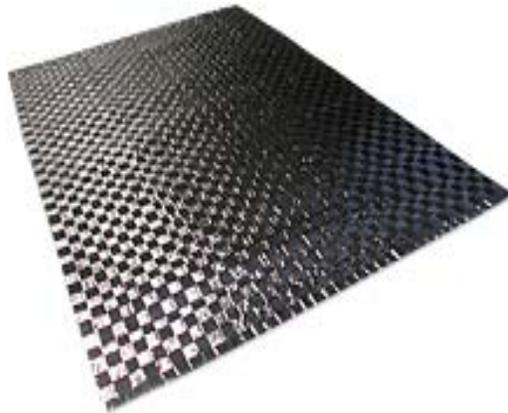
# Material Forms & Manufacturing Processes

- **Fiber**: Manufacturing of PAN-based, fiber precursor and carbonization (graphitization) of carbon fibers
- **Textiles**: Weaving of two directional (2D) carbon fiber textiles (woven cloths and tapes)
- **Preforms**: Weaving multidirectional (3D+) woven and braided fiber preforms and integrated woven structures
- **Resins**: Formulating customized fiber sizings (coatings) and application-specific resin matrices
- **Prepregs**: Partially cured, resin impregnated, unidirectional (1D) fibers (tows) and 2D textiles
- **Automation**: Automated fiber placement, tape laying and filament winding of partially cured (prepreg) or dry textiles
- **Densification**: Resin infusion and curing of woven / braided textile structures (RTM, VaRTM, SCRIMP, autoclave)

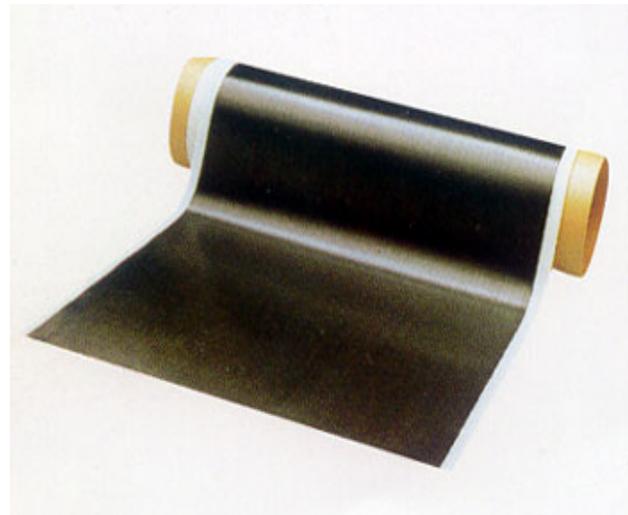
# Examples of CF-PMC Constituent & Intermediate Materials



Carbon Fiber



Woven Carbon Fiber Fabric (2D)



Resin Impregnated CF Fabric Prepreg



Fiber (non-CF) Braiding



Complex Carbon Fiber Preform



Integrated Carbon Fiber Preform

## Examples of CF-PMC Fabricated Parts



# Greater Affordability Through Automation

## Resin Transfer Modeling:

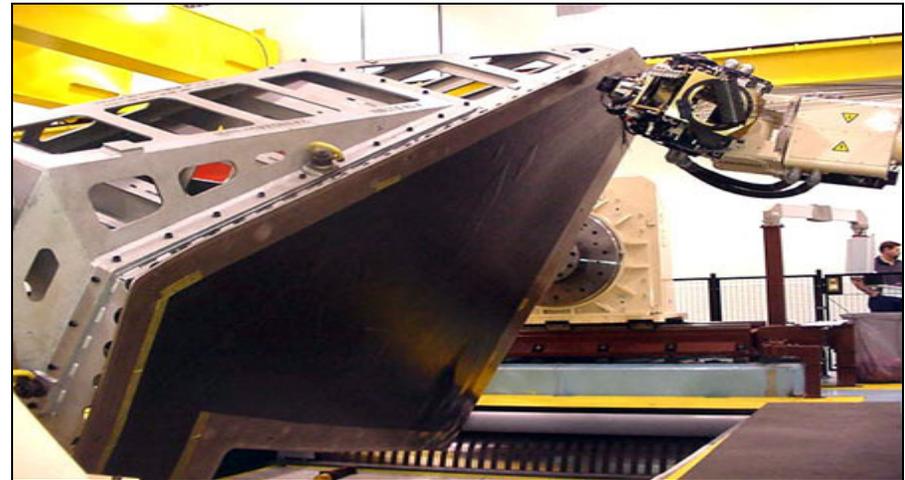


CF Woven Net Shape Preform  
(Techniweave)

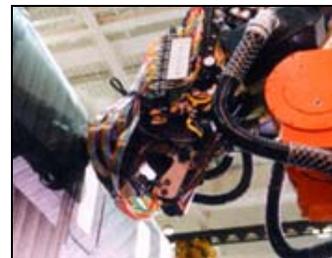


Densified CF Woven Preform  
(Techniweave)

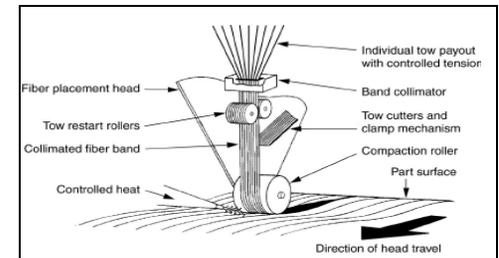
## Automated Fiber Placement:



F-35 Wing Skin Fiber Placement Machine (Vought)



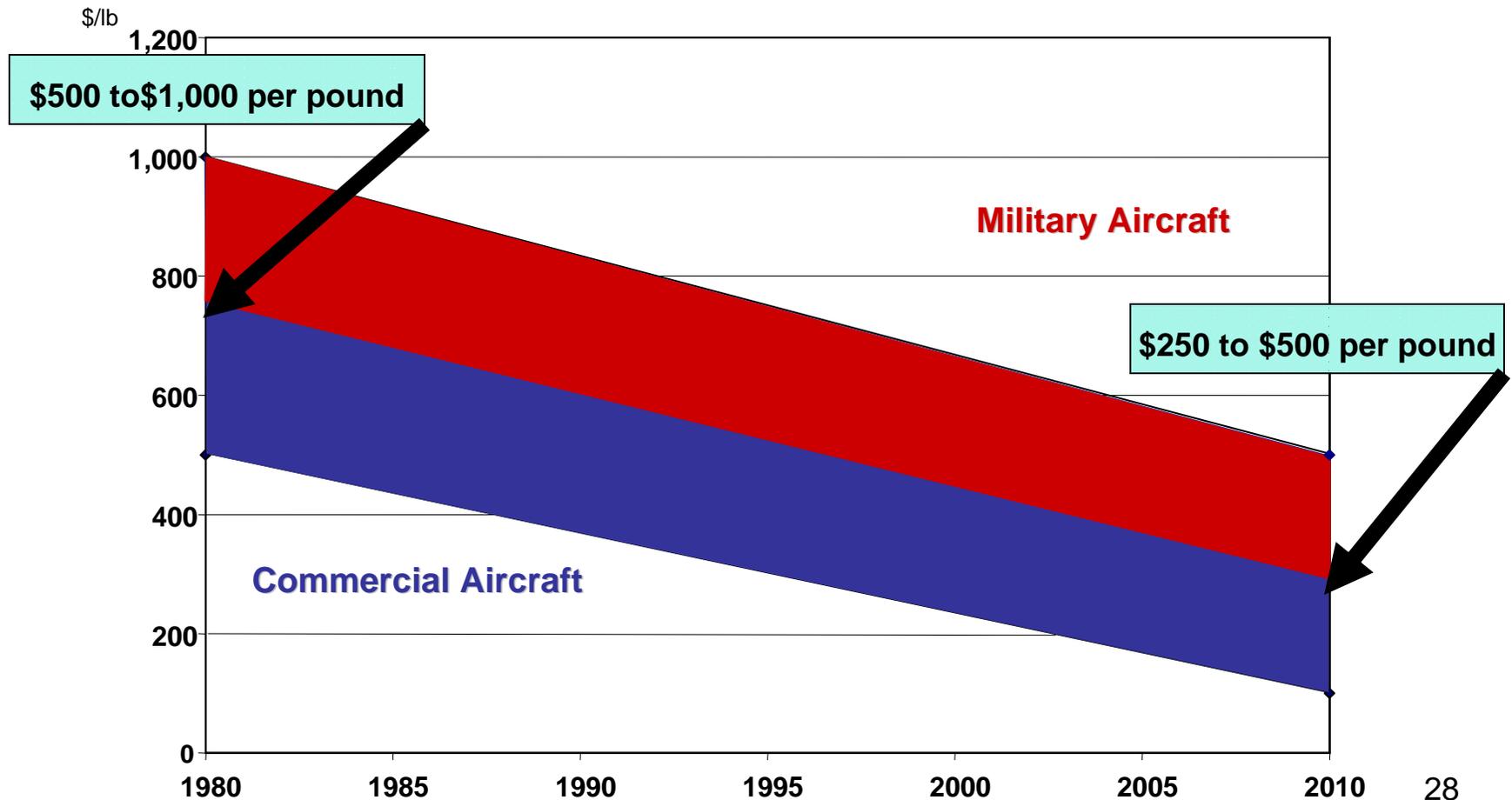
Fiber Placement System  
(Cincinnati Machine)



Fiber Placement Schematic  
(Project Air Force RAND)

# Growing Affordability Trends in CF-PMC Aerostructures Manufacturing Costs

## Estimated Per Pound Composite Fabrication Costs



# Technology Development & Commercialization Issues

Industry is at a crucial threshold of the “next level” of larger scale CF-PMC commercialization & innovation -- R&D issues impacted by export controls?

- S&E workforce skills and technical expertise (Know-How) involving the development of materials, products, applications and manufacturing processes
- Computer-aided simulation and modeling of materials & processing
- Automated equipment for fiber manufacturing, filament winding, fiber placement, tape laying, complex weaving, prepregging and testing (NDT)
- Leap ahead advancements in nanomaterials, fiber-resin interface, joining / fastening, automation, affordability & system-of-systems integration

**Advanced materials R&D is very dependent on highly interactive public-private partnerships which today are more globalized than ever and increasingly encumbered by export controls.**

# **Aerostructures Value (Supply) Chain**

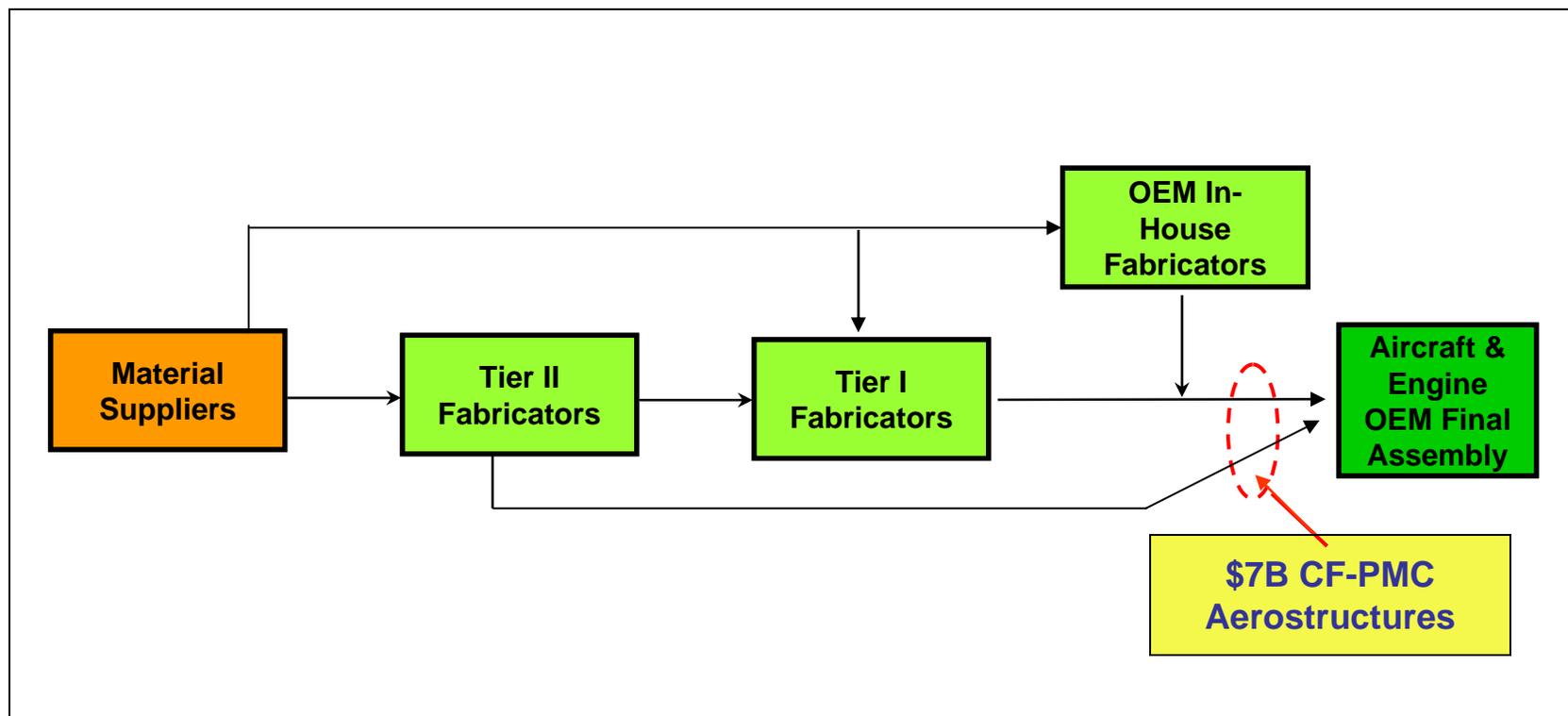
# CF-PMC Value (Supply) Chain

## Components of the A&D Subsector for Aerostructures

- **Constituent Materials**: Manufacturers of fiber, resin & related materials
- **Intermediate Materials**: Producers of textiles, prepreg and preforms
- **Composite Fabricators**: Finished (primary & secondary) aerostructures
- **System Integrators**: OEM assemblers of subassemblies & platforms
- **Machine Vendors**: Automation OEMs for fiber placement, tape laying, filament winding, prepregging, infusion molding, testing & tooling products
- **Service Providers**: RDE&T support, professional development and software tools (design & simulation) as well as universities & federal laboratories supporting industry innovation and S&E workforce needs

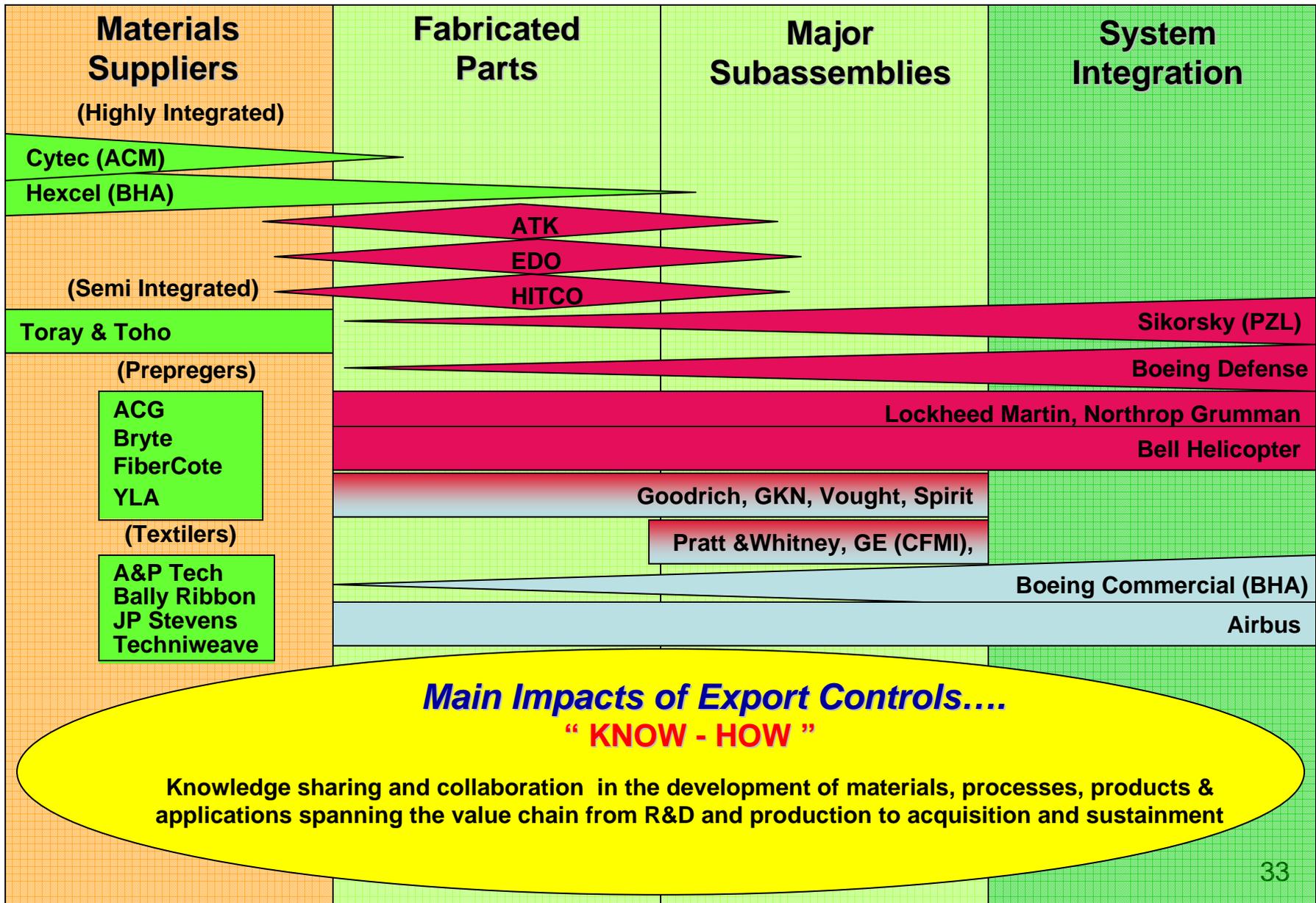
**Export controls of CF-PMC materials span the full spectrum of the industry's manufacturing & technology development "value chain"**

# Flow of CF-PMC Aerostructures' Manufacturing Value (Supply) Chain



Excludes distributors, automation OEMs, tooling vendors, technology / laboratory services

# Examples of Value Chain Company Positions



# Leadership Positions of Major, A&D-Grade Material Suppliers (Carbon Fiber and Prepreg)

- Cytec and Hexcel (U.S.) are highly vertically integrated producing CF fiber, resin, prepreg, textiles and CF-PMC fabricated parts
- Toray and Toho (Japan) are partially vertically integrated (within the U.S) producing CF fiber, resin and prepreg
- These 4 suppliers support 90% of worldwide A&D material demand for fiber and prepreg (estimated value of \$1.5 B annually).
- Of this amount some 65% is estimated for A&D commercial applications and about 35% for A&D military uses
- Cytec and Hexcel support an estimated 90% of U.S. defense needs in prepreps and fiber (respectively)
- Toray and Toho support an estimated 80% of worldwide A&D-grade fiber markets for commercial applications and 50% of non-DOD military demand
- Hexcel and Cytec support an estimated 80% of worldwide prepreg markets for commercial and military A&D applications
- Global A&D sales make up 65% to 90% of overall U.S. business activities

# Major Tier I A&D Fabricators of CF-PMC Aerostructures

- At present heavily concentrated in the U.S. and EU with balance in Japan
- Leading defense fabricators located within the U.S. include:
  - Vought** (U.S.) \$1.3B in revenues with 63% commercial, 37% military and 10% export (Airbus)
  - GKN** (UK) \$2.1B total revenues from diversified business units with estimated \$340M in aerostructures revenues
- Leading commercial fabricators located worldwide include:
  - U.S.:** Spirit, Vought and Goodrich
  - Europe:** Airbus mostly fabricates in-house while leading EU fabricators include Aircelle, GKN, Alenia, Fisher and Stork
  - Japan:** Fuji, Kawasaki and Mitsubishi

## Leading U.S.-Based, Niche A&D Fabricators of CF-PMC Aerostructures

- Tier I & II fabricators (70 - 100 worldwide) range from small and mid-sized (>\$100M) to large firms (<\$3B). U.S.-based examples include:

ATK (Alliant)	Sparta	Hitco	EDO
Techniweave (AI)	Fiber Dynamics	ACI	GD ATP

- A number of these firms are highly integrated (producing wovens, preforms & prepregs) and many also serve as integrators and assemblers of large subassemblies and major system platforms
- Many firms are well diversified in both defense and commercial sectors as well as participate in numerous foreign markets

# Leading OEMs & Integrators of CF-PMCs for A&D Platforms and Major Subassemblies

- **U.S.:** Boeing, Lockheed, Northrop, Bell, Sikorsky, P&W, GE Engines
- **EU:** EADs, BAE, RR, Finmeccanica, Daussault, SMECMA, DASA, CASA
- **Canada:** Bombardier
- **Brazil:** Embraer
- **ROW:** China, Russia, India
- **OEM / Integrators Outsourcing:** Historically a high percent of fabrication kept in-house but growing use of international outsourcing

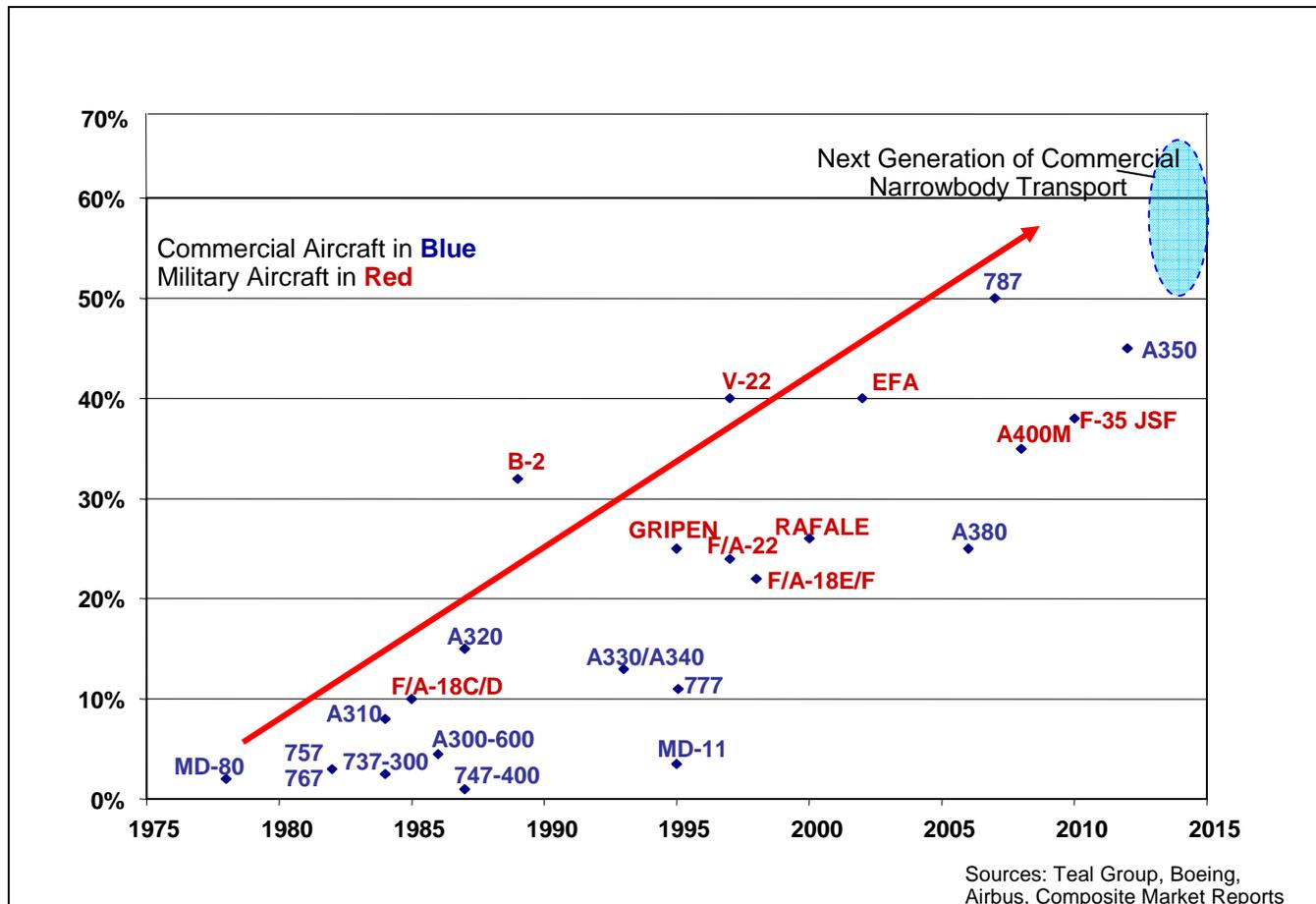
**CF-PMC's A&D Value (Supply) Chain is Becoming Highly Globalized and Increasingly Constrained by Export Controls ....**

# **Industry Globalization & Its Impacts**

# CF-PMC Globalization

- CF-PMC market and CF-PMC end-users increasingly global
- Trends are increasingly incongruent with export controls
- Impact will be greatest in newly emerging markets, such as China and India, and thus prospective, uncertain and risky for both material suppliers and consumers
- This uncertainty is leading firms to seek ways to get out from under export control constraints at all levels of the industry's value chain

# Accelerating Growth of CF-PMC Usage In Commercial Aerostructures



Composite Content as Percent of Structural Weight

# Additional Globalization Factors

- Smaller & mid-sized U.S. firms, traditionally focused on U.S. sales, perceive local markets as mature and foresee better opportunities abroad
- New foreign suppliers of aerostructures, materials, software, equipment & tooling are forming in low-cost regions of Eastern Europe & East Asia
- Offsets are fueling interest from foreign countries to not only manufacture but to develop indigenous CF-PMC R&D and innovation capacity
- Concerns of U.S. S&E skill shortage, high R&D costs, declining public S&T investment and ITAR “tainting” further pushes innovation offshore
- U.S. OEM and Tier I suppliers have an expanding presence overseas through offsets, teaming, JVs, green field and or acquired subsidiaries
- Domestic material suppliers have ridden severe down cycles (late 80s, early 90s) and continue to diversify -- increasingly in emerging countries

# **New, Highly Globalized (High CF-PMC Content), U.S. Commercial & Military Aircraft Initiatives**

## **Commercial: Boeing 787**

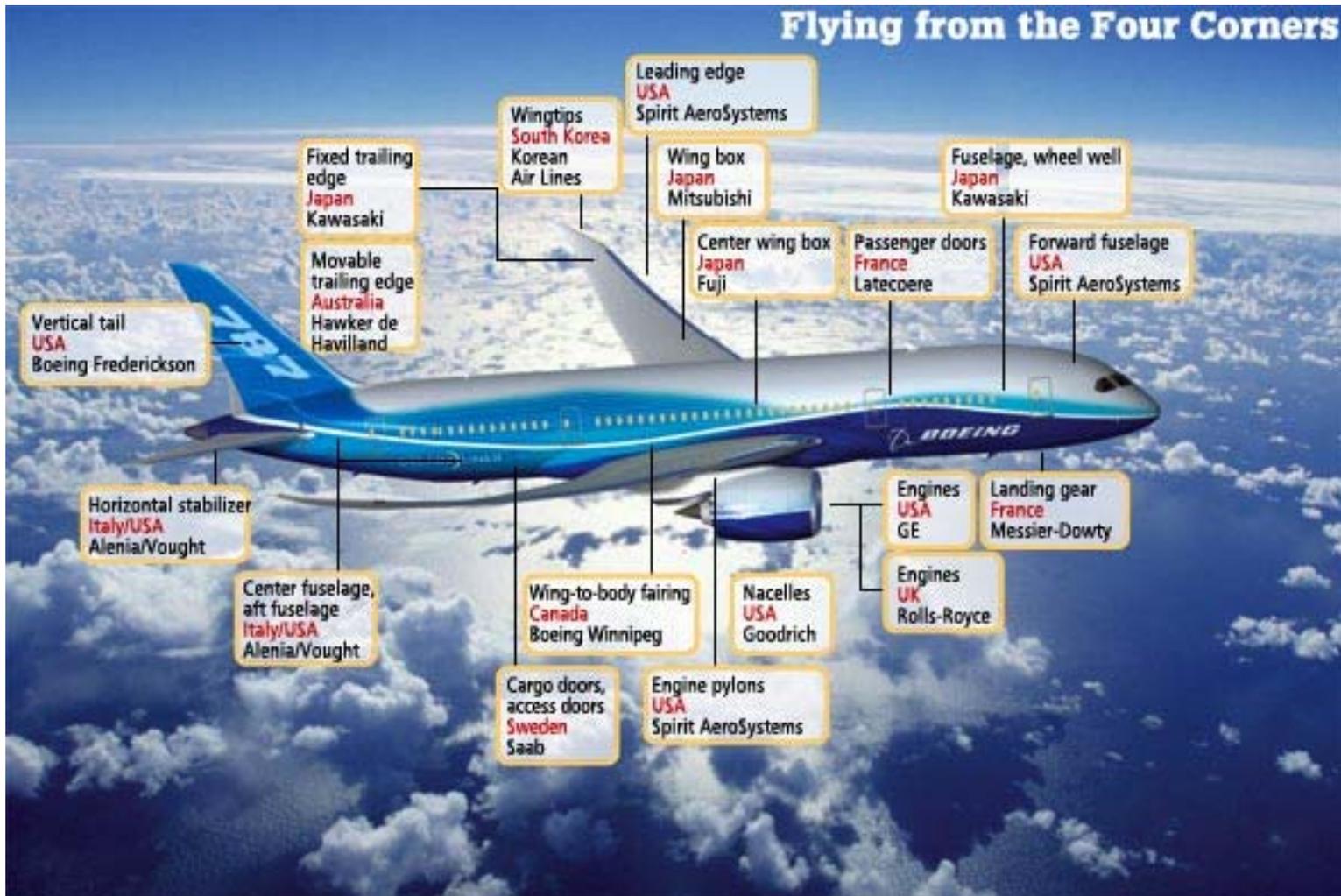
Vast amount of manufacturing and development outsourced through revenue sharing (offsets) to a highly globalized and worldwide supply chain including an estimated 200 foreign firms **(50% composites content by weight)**

## **Military: F-35 (JSF) Lightning II**

Significant manufacturing and development is globally distributed through 9-country consortium with over 100 foreign suppliers **(35% composites content by weight)**

# Boeing 787

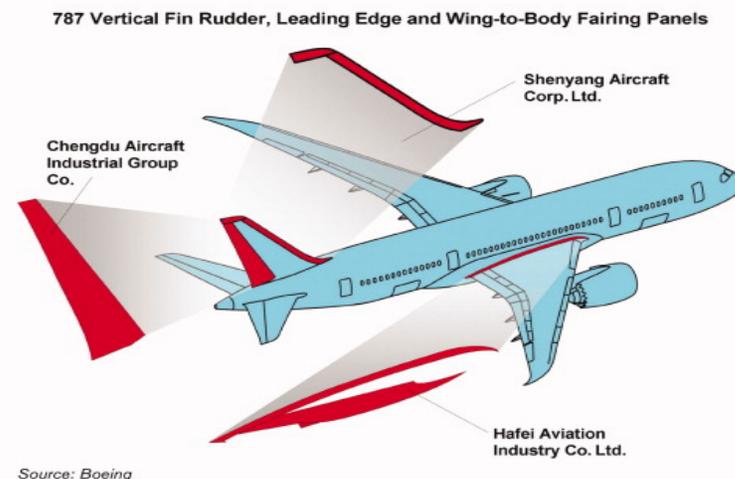
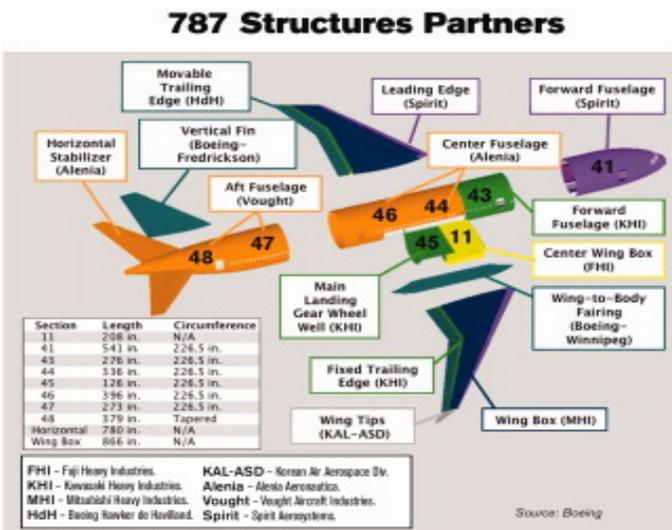
## Global Value (Supply) Chain Partners

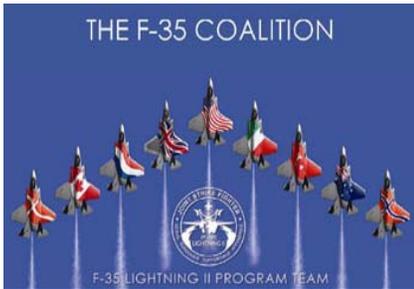


# Boeing 787

## International Partners & China Workshares

- Composites will make up a record 50% of structural weight
- Major savings in fuel and maintenance costs
- Strong sales with 400 international orders booked (biggest sales in category)
- Major shift in business model with growing overseas sourcing and foreign content (70% of content up from 2% on 727 in the 60s).
- Boeing imports now 45% of what it exports from the U.S. (up from 5%)
- Extensive use of offsets (Boeing is the largest U.S. offset holder)
- Boeing & Hexcel leverage China CF-PMC industrial base (sourcing & JV)





# JSF's Global Value (Supply) Chain

8 International Partners & Over 100 Foreign Suppliers



Foreign JSF CF-PMC Fabricators Underlined Above

# Examples of the Global “Fusion” of the U.S. CF-PMC Industrial Base

Value chain’s growing international face is driven by globalization of ownership, JVs, acquisitions, subsidiaries, licensing deals, vertical integration & product teaming with goals of greater market access, cost reduction and profit maximization

- EU Primes / Tier I suppliers have an extensive domestic presence and share of U.S. commercial & military programs (EADs, BAE, SNECMA, Rolls Royce)
- “Aero Composites Parts Manufacturing” (BHA) commercial A&D manufacturing joint venture between Boeing, Hexcel (U.S.) and AVIC 1 of China (Boeing 787)
- Sikorsky decides on global manufacturing of *International* Black Hawk from Poland through MOU-FDI with Polish government enterprise, PZL Mielec
- “Global Aeronautica” commercial A&D manufacturing joint venture between Vought (U.S.) and Alenia Aeronautica (Italy), (Boeing 787)
- Spirit (U.S), a spin-off of Boeing Wichita commercial composites manufacturing, is purchased by Onex (Canada), which later acquires BAE Aerostructures (U.K)
- GKN (UK), establishes U.S. plants and other overseas operations, such as Australia, serving DOD (F-35 JSF) -- GKN purchases Boeing St. Louis commercial composites manufacturing (U.S.) and Dow-UT (U.S.) composites manufacturing business

# **Industry Economic & Financial Picture**

# Industry Economic & Financial Data

## Commodity Grade PMCs (mostly fiberglass-based, composites):

- \$7 *trillion* value of structures & assembly
- \$55B to \$60B value in material
- 12 billion pounds of material produced annually
- \$3 to \$9 per pound of value added
- 6% compounded annual growth rate (CAGR)

## High Performance PMCs (principally CF-based, composites):

- \$12B value of structures & assembly (estimates range \$7B to \$24B)
- \$2.77B in materials (\$1.17B fiber & \$1.5B prepreg)
- 100 million pounds of material produced annually (CF, S2, aramid, other)
- \$125 to \$500 per pound of value added A&D vs. \$40 to \$150 industrial
- 14% to 16% A&D CAGR (constrained by tight fiber production)

***The A&D Subsector (Aerostructures) is the fastest growing CF-PMC market worldwide***

\* Market size and forecasted demand figures originate from multiple sources and data varies widely.

# **Industry Economic & Financial Data:**

## **.... Worldwide A&D Subsector & CF-PMC Aerostructures**

- \$7B value of fabricated aerostructures & assembly (estimates up to \$24B)\*:
  - \$3.3B new commercial aircraft construction
  - \$1.8B sustainment, MRO, (60% commercial & 40% military)
  - \$1.6B new military aircraft construction
- \$1.5B value in A&D constituent & intermediate materials (fiber, prepreg)
- 40 million pounds of material produced annually (CF and other non-CF)
- \$250 to \$500 per pound of CF-PMC fabricated value added
- 14% CAGR vs 4.7% growth in CF-PMC vs. conventional aerostructures materials
- Market projected to double in 10 years (\$14B), quadruple in 20 years (\$30B)
- Growing base of U.S. sales (+11% to \$542M CYT-EM) (8% to \$1.16B HXL)\*\*
- Rising operating income margins (+11% to 19% CYT-EM) (+32% to 10.5% HXL)\*\*

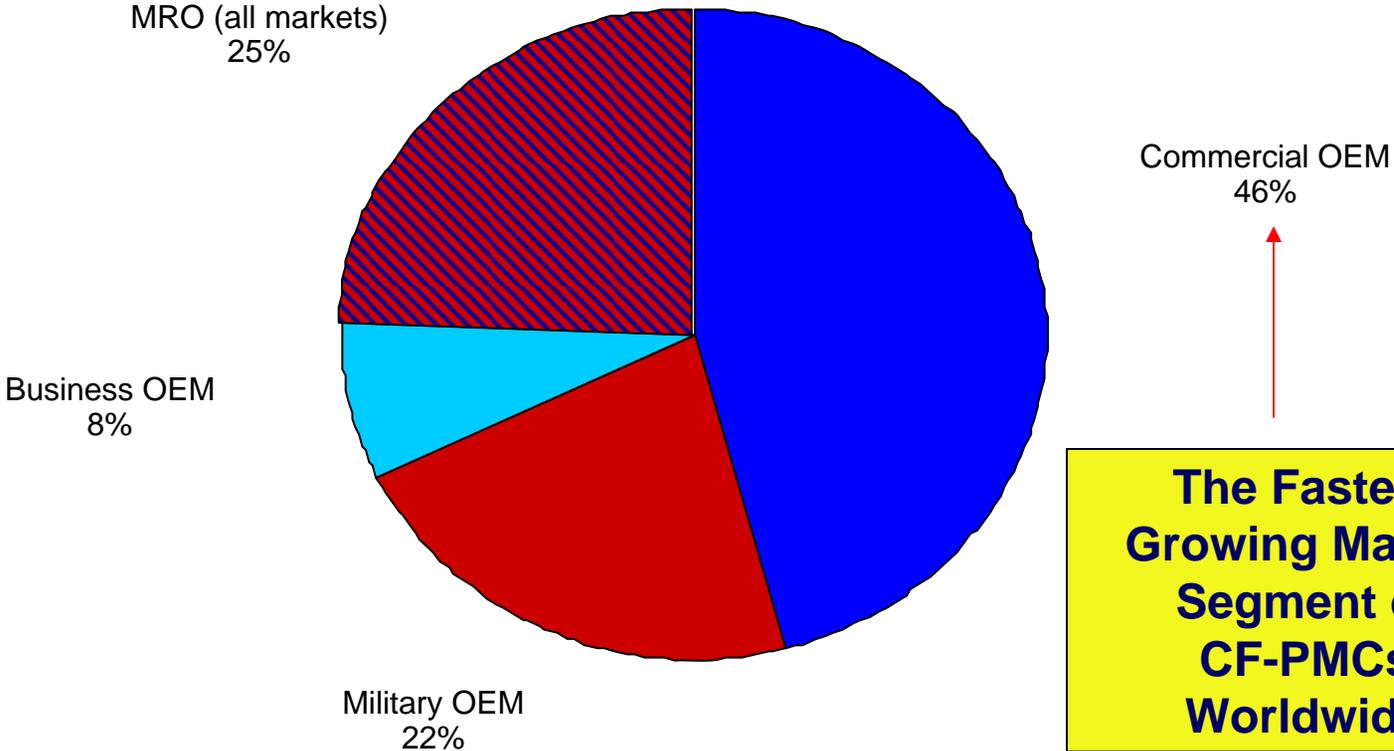
**U.S. DOD demand for CF constitutes less than  
10% of overall domestic CF usage & 4% of worldwide usage**

\* Market size and forecasted demand figures originate from multiple sources and data varies widely.

\*\* Cytec and Hexcel sales figures and operating income margins (HXL adjusted) reflect 2005 - 2004 data

# Current Global A&D Subsector Market Segments

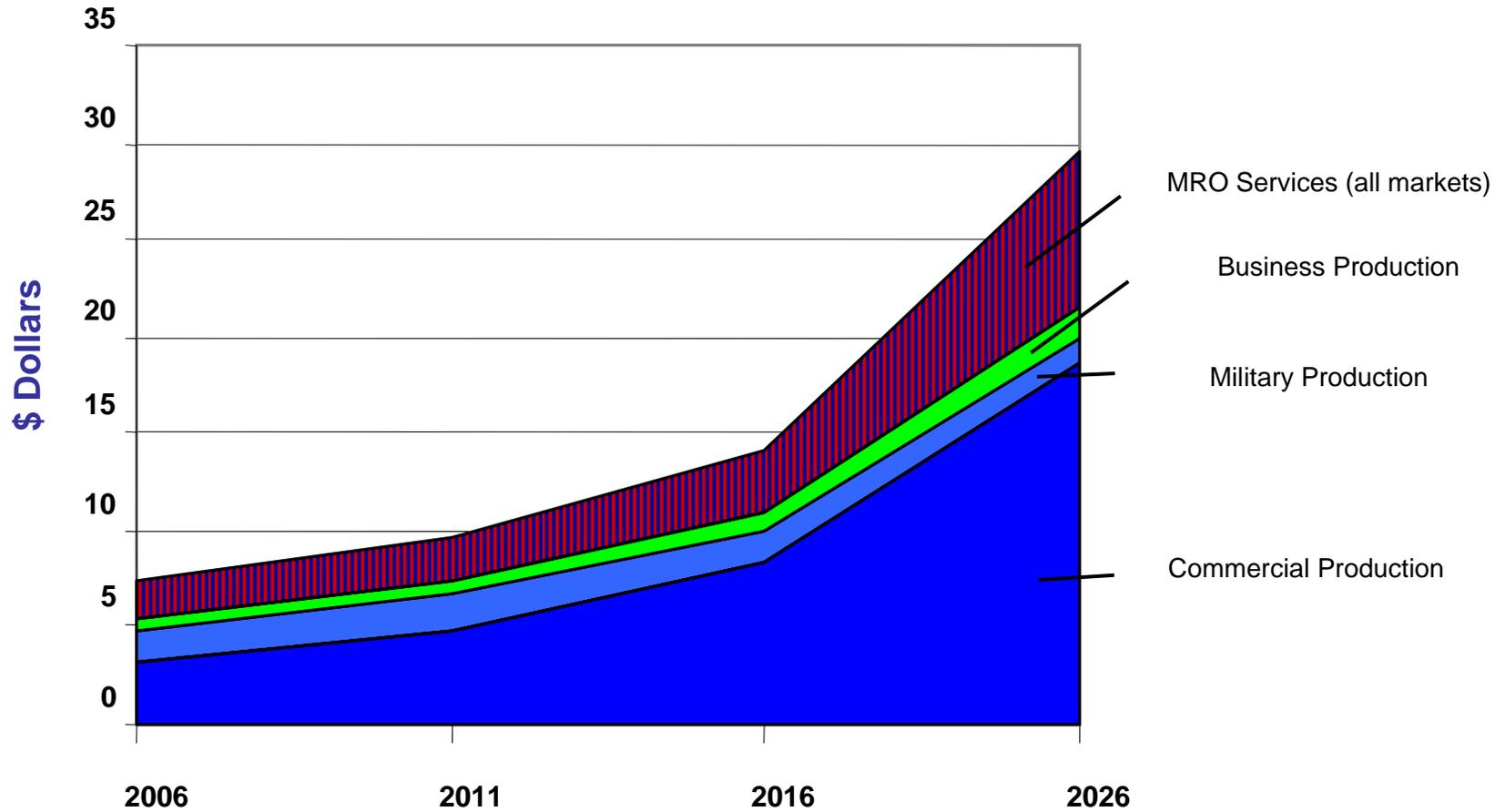
## CF-PMC Aerostructures



**The Fastest Growing Market Segment of CF-PMCs Worldwide**

**2006 Dollars (excludes UAVs)**

# Future Global Expansion of A&D Subsector, Market Segments (CF-PMC Aerostructures)



2006 Dollars (excludes UAVs)

# **U.S. Defense Industrial Base & Its Importance**

# **CF-PMC Defense Industrial Base Importance**

## ***.... Enabling Transformational Defense Capabilities***

- Greater force projection with significant improvement in range, speed and mobility of lighter / faster land, air and sea-based platforms
- Lower life cycle costs with increased manufacturing affordability, reduced maintenance, lower part counts & greater fuel efficiencies
- Enhanced survivability with greater damage tolerance (ballistic armor) as well as increased lethality (higher performance munitions)
- Improved stealth with reduced RF cross section, increased IR signature masking and acoustic dampening
- Expanded “multifunctionality” (embed sensors and actuators for smart, conformable structures and system-of-systems advantages)

***.... Applications are far reaching from  
air and space to naval and land-based uses***

# Air & Space CF-PMC Applications



**B 2 (Northrop)**



**F 35 (LM)**



**UH 60M (Sikorsky)**



**V 22 (Bell)**



**Global Hawk (NG)**



**X-45 (Boeing)**

Military aircraft, rockets and satellites led DOD's development of PMCs historically and today represent DOD's largest applications for PMCs.

PMC uses in manned aircraft and UAVs continue to accelerate with ongoing advancements in affordability, manufacturability and new innovations in materials and application development.

Applications include primary and secondary aerostructures, such as airframes and control surfaces to hatches and enclosures. Additional uses include capability enhancements such as low observables and thermal protection.

Space applications include nose cones, payload fairings, rocket motor casings and nozzles on launch vehicles as well as various structural applications on satellites including solar arrays, antenna masts and optical benches.



**IR (LM)**



**GPS (LM)**



**W (LM)**



**EHF (LM)**



**Titan IV (LM)**



**GBI (OS)**

# Land & Sea

## CF-PMC Applications



HMMWV (AG)



HEMTT (Oshkosh)



FCS (United Defense)



FCS (United Defense)

**Land:** PMC uses in ground vehicles have traditionally been limited because of high costs. However, with improvements in increased affordability, PMC applications are growing in areas such as armor, light weight transportability and components for alternative power systems (A3). Future R&D efforts include the Composites Armored Vehicle (CAV), Joint Light Tactical Vehicle (JLTV), Long Term Armor Strategy (LTAS) and Future Combat System (FCS). A recent study suggests the Army could increase PMC demand by a factor of a hundred in the not too distant future.

**Sea:** PMC naval applications have also been limited historically because of costs and used sparingly in selective applications such as hanger doors (DDG 51), louvers, enclosures, submarine sails (SSN 688), sonar domes and mast enclosures (LPD 17). However, with advancements in affordability and manufacturability of very large scale structures, applications are envisioned for topside uses on DD(X) and CVN 21. Other future uses include hull structures such as those being evaluated on the Composites High Speed Vessel (CHSV) M 80 Stiletto.



DDG 51 (GD)



LPD 17 (NG)



M 80



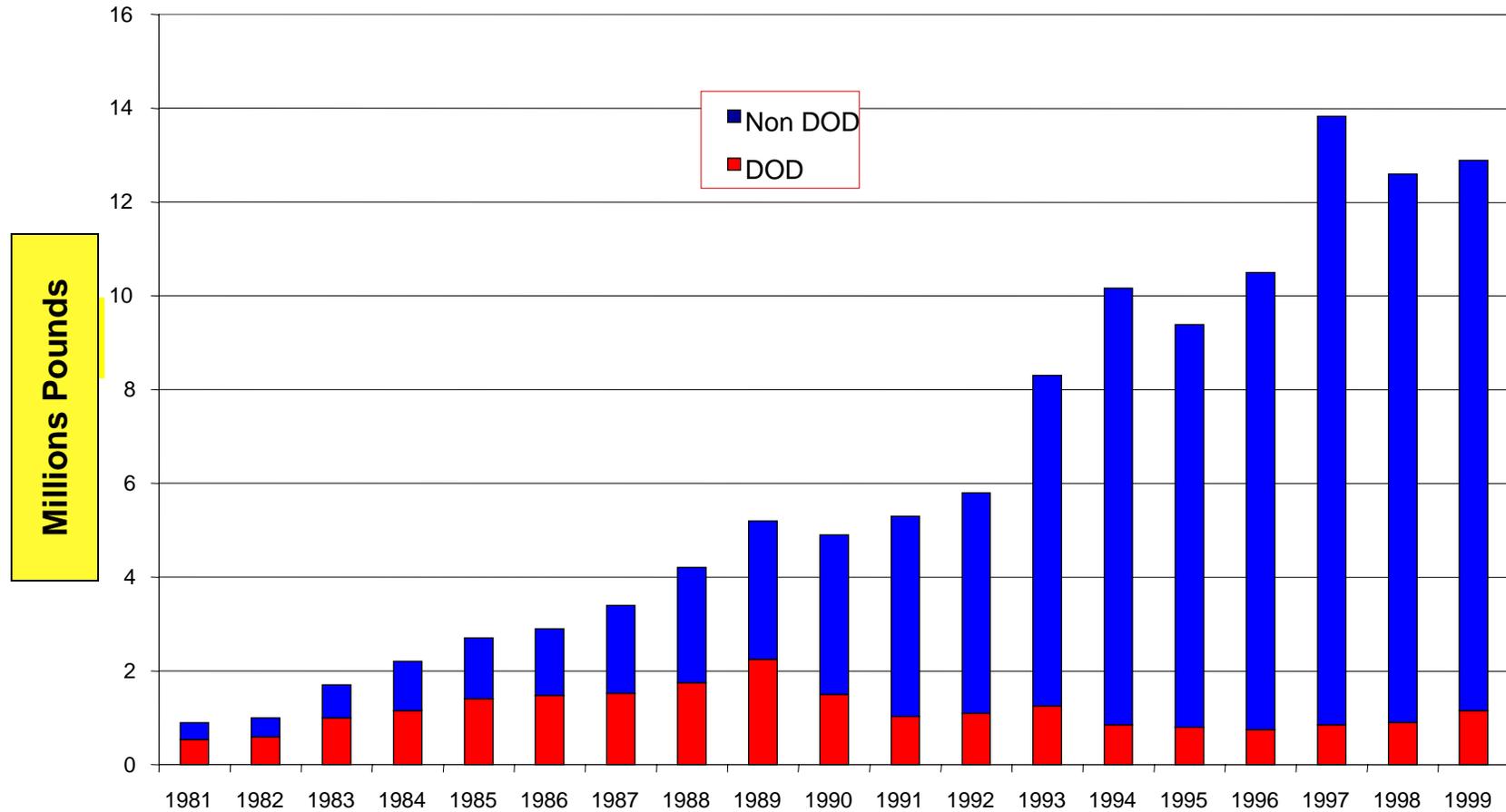
DD(X) (GD)

## Historical Perspectives of a Dual-Use CF-PMC Industrial Base

- Earlier development (60s-70s), wide-scale maturation & transition (80s-90s) was heavily driven by DOD development & acquisition of spacecraft, missiles & aircraft
- CF-PMCs are a success story in dual-use defense industrial policy that stimulated leveraged investment, shared risks, accelerated innovation and an industry-wide expansion (build-out) in manufacturing capacity
- Subsequent surge of commercial demand greatly outpaces DOD usage vs. civilian aviation, industrial and consumer sporting goods market growth (late 80s-present)
- DOD demand falls from 47% to 9% of domestic CF market and 4% globally

**A highly dynamic commercial market affords DOD tremendous industrial base opportunities (productive, agile, innovative, prosperous and expanding industrial base)**

# U.S. Defense Vs. Commercial Domestic Carbon Fiber Demand



**U.S. DOD carbon fiber demand constitutes 9% of total domestic usage and 4% of worldwide usage**

# Status of a Dual-Use CF-PMC Industrial Base

*Overall well-capitalized, and robust industry -- financially healthy with top line & bottom line growth ....*

- Continuing improvements in productivity and affordability
- Strong in-place manufacturing and future surge capacity
- Highly diversified markets to insulate against business cycles and heavy market concentrations (late 80s defense dependencies)
- Robust and dynamic corporate R&D and SME innovation infrastructure
- World class global supply chains and distributed R&D expertise

**Findings consistent with OSD DUIP 2005 CF Industrial Base Study**

***But, will export control impacts create future problems?***

**Section 2.**  
**Global Intensity of Material Suppliers & Value Chain**

## **Global Intensity of Leading U.S. Material Suppliers**

- Export markets pose faster-paced growth opportunities vs. tempered prospects in more mature domestic markets
- Exports and other international business activities account for an average of 50% or more of total business activities
- Most conventional U.S. exports (70-80%) go to established EU markets
- Most other exports (10-20%) are to established Asian markets and mostly concentrated in Japan
- Currently limited exports to emerging markets (China, India)

# Global Intensity of U.S. Material Suppliers in A&D Subsector

- The vast majority of A&D related exports are concentrated in EU markets
- U.S. firms actively participate in supplying foreign A&D commercial aircraft OEMs (Airbus, Embraer) and downstream value chain fabricators
- U.S. suppliers actively participate in EU A&D defense and space sectors:  
*Aster missile; NH 90 & EC 135 helicopters; Typhoon, Gripen & Rafael fighters; Arian & Vega launch vehicles; various space satellites*
- U.S. material suppliers successfully leverage past DOD qualification as key competitive advantage in foreign A&D defense and space markets
- U.S. material suppliers are actively engaged in global A&D supply chains and distributive innovation
- Increased multi-national A&D markets (B787, JSF) are pulling U.S. material suppliers into more complex international supply chains

## Projected Export Markets for U.S. Material Suppliers in A&D Subsector

- Largest, long-term regional market growth for CF-PMC suppliers is anticipated to be in emerging markets within Asia
- Anticipated growth in demand for CF-PMCs in China and India are the largest individual foreign national market opportunities for CF-PMC suppliers (no quantifiable market projections identified)
- China and India are viewed as leading B787 buyers which will require offsets that will likely emphasize CF-PMC fabrication and MRO support services
- Given changes in U.S. - India relations, and India's solicitation for military aircraft, the U.S. could incur additional offsets

# International Business Activities Triggering Export Controls

- External and internal publishing and sharing of technical data (material, product, processing and application) to retain & attract customers
- Providing customers with product samples and material & processing data for evaluation and qualification requirements
- Responding to customer RFQs / RFPs with related technical data on materials and processing to support client bids
- Direct personal interactions with customers (on-site visits, telecom, internet) to exchange technical data (materials, processing, products & applications)
- Multi-level interactions with customers and vendors up and down the supply chain (weavers, prepreggers, Tier I & II fabricators, OEMs & integrators)
- Internal interactions (collaborations) between U.S. workers and non-U.S. employees of the same U.S. firms in domestic plants or at offshore facilities
- Similarly impacted are U.S. company relationships with non-U.S. distributors, interns, JV partners, vendors, customers – examples of deemed exports

**Section 3.**  
**Form and Applications of Export Controls**

# EAR Export Controls on CF-PMC Industry: (Dual Use Goods & Technologies)

- Administered by DOC's BIS under the Export Administration Regulations' (EAR) Commerce Control List (CCL)
- EAR controls (ECCNs) for constituent and intermediate materials include:
  - Most controlled CF-PMC materials fall under Category 1: *Advanced Materials*
  - Category 1 material controls can flow-down to other CCL Categories
- Common Category 1 controlled materials (ECCNs) include:
  - (ECCN 1C010) Fiber: High specific strength and or modulus fibers
  - (ECCN 1C010) Prepreg: Combination of high performance fibers and resins
  - (ECCN 1C008) Resin: High temperature resin systems

# Extended EAR Export Controls on Value Chain: (Dual Use Goods & Technologies)

EAR further controls fabricated composites, automated manufacturing equipment and technology “Know-How” including:

- (ECCN 9A991) Fabricated aerostructures: Controls inspected commercial aircraft composite structures (ECCN 1A002 controls semi-finished parts)
- (ECCN 1B001) Most automated manufacturing equipment: Controlling fiber, weaving, prepregging, fiber placement and non-destructive inspection machines
- (ECCN 1E001) “Technology” (Know-How): Controls on the development or production of processes, products and applications

**Most far reaching control on CF-PMC’s value chain is “Know-How”**

## **General Technology Note (GTN)**

*The export of “technology” that is “required” for the “development”, “production”, or “use” of items on the CCL is controlled according to the provisions in each Category. “Technology” “required” for the “development”, “production”, or “use” of a controlled product remains controlled even when applicable to a product controlled at a lower level.*

(CCL Supplement No. 2 to Part 774 EAR)

# ITAR Export Controls on CF-PMC Industry: (Defense Articles & Defense Services)

Administered by DOS's DDTC under ITAR and Missile Technology Control Regime (MTCR) through the U.S. Munitions List (USML)

- Materials & Fabrications: While ITAR principally controls systems & components vs. technologies & materials -- materials, processing, and related Know-How can be controlled when incorporated in USML military items
- Publications and dissemination of technical papers on innovations -- of which dissemination is essential to collaborative R&D & commercialization
- Technical Assistance Agreements (TAAs) used by industry for technical exchanges of Know-How amongst foreign co-workers in the U.S. or aboard as well as with export customers, vendors, JV partners & R&D collaborators
- Manufacturing Licensing Agreements (MLAs) used to impart Know-How involving controlled items at U.S. foreign plants, between export customers, foreign JV partners & vendors

**Section 4.**  
**The Effects & Impacts of EAR-ITAR Export Controls**

## Current Effects of EAR Controls on **CF-PMC Material Suppliers**

**At present, no significant loss of imminent exports (canceled orders) or anticipated near-term sales (lost bids) since:**

- Most CF-PMC material exports are commercial in nature and not for defense-end uses and thus face little to no control
- Related exports consist mostly of materials not requiring a license since most grades of materials possess performance levels below levels of higher performing materials that are closely controlled
- Most high performance material exports (Category 1 materials) go to established firms in NATO countries that enjoy preferred EAR treatment which facilitates U.S. exports without a license or through license exceptions when a license would otherwise be required
- Virtually all EAR controlled (licensable) material exports to Europe receive approval and with relatively limited adverse impact on U.S. industry (time delay, approval uncertainty, compliance cost, business disruption, etc.)

## **Impacts of EAR Controls on CF-PMC Value Chain**

**Although EAR controls seldom block exports of physical materials to existing major markets in Europe, industry struggles with rising conflicts and new challenges with EAR controls:**

- Barriers to new, long-term, fast growing emerging regional markets
- Obstacles to key international A&D subsector markets
- Restrictions on strategic trade in automated manufacturing equipment
- Degradation of world class, globally distributive manufacturing and R&D enterprises due to constraints on foreign tech transfer (Know-How)

**Left unchecked, these impacts challenge U.S. industry's long-term global leadership in worldwide commercial and defense sectors**

## Effects of EAR Controls on Technology & Know-How

- Significant industry uncertainty & confusion about EAR control of technology & Know-How (process, product & application development)
- A debate underway following DOC expanded interpretation that Know-How is controlled when applied to controlled *and* uncontrolled materials because of the General Technology Note
- Where tech transfer restrictions will be a significant problem lies largely outside of the EU in emerging Asian markets, especially China -- which is said to be the single largest, long-term, future growth market

# Future Impacts of EAR Controls on Technology & Know-How

**Know-How controls impact U.S. value chain with implications to U.S. economic competitiveness *and* national security. Examples include:**

## **Controls Incentivize Proliferation of Technology & Competition:**

- U.S. industry market entry to China, India and Pakistan blocked by licensing
- Third party in Europe alleged to sell controlled material, equipment & Know-How
- U.S. suppliers concerned with lost export potential, and;
- Worries persist controls incentivized offshore proliferation & competition

## **Controls Block U.S. Value Chain Following U.S. OEM Customers Offshore:**

- U.S. A&D OEM business strategy shifting supplier base offshore (B787)
- U.S. controls inhibit U.S. suppliers of materials, fabrication and machines to follow B787 offshore production & MRO realignment to emerging markets
- If U.S. CF-PMC industrial base starved from foreign B787 markets, this will have a significant effect on future U.S. value (supply) chain revenues

# New CF-PMC Industry Working Group Under DOC BIS TAC Pursues EAR Reforms

- Resolve confusion on controls of Know-How
- Raise CF control points to decontrol certain proliferated commercial materials
- Harmonize control point test standard on prepreg:
  - .... DOC BIS's recent standards interpretation decontrolled up to 80% of some U.S. prepreg exports (allegedly below EU control levels).
  - ....however, misperceptions (misuse) of test standards leads some firms to over-control prepreg at levels identified by BIS and DOD MCTL for decontrol
- Lower automated equipment controls of certain proliferated machines
- Assess projected adverse impacts of proposed *China Catch All* rule change
- Consider DOS DDTC implementation fixes to Commodity Jurisdiction (CJ)
- Working Group: Boeing, Airbus, Bell, Sikorsky, Cytec, GE, Cincinnati Machine, Hexcel, Toray, Toho, Vought, AMT, SAMPE .... (partial list)

# **Current Effects of ITAR Control on CF-PMC Material Suppliers**

**At present, no significant loss of imminent exports (canceled orders) or anticipated near-term sales loss (lost bids) since:**

- Most sales of dual-use items for defense uses (regulated under both EAR and ITAR-MTCR) are within NATO countries and fall under EAR control
- Most dual-use exports for EU defense do not require an EAR license and for the limited amount that do, most are approved in a timely and effective manner
- ITAR generally regulates materials developed for specific defense and unique militarily critical technologies (ablatives, stealth, high temperature, satellites)
- When ITAR licenses are required, applications are often approved, but ....

**The ITAR process is plagued with problems centered on implementation processes for licensing materials and excessive ITAR control of “Know-How” all of which seriously hampers U.S. global A&D manufacturing and innovation supply chains and disrupts major U.S. & EU commercial & defense A&D programs**

# ITAR Process Problems

- Rising volume of license applications for both materials and Know-How
- Growing delays in licensing reviews and reduced turnaround time
- Overly restrictive provisos of approved ITAR licenses (*denial through proviso*)
- Licenses *Returned Without Action* (a way of saying “no” without saying *no?*)
- USG intrusion into U.S. business relations with export customers (such as tracking U.S. raw material sales through export customer supply chains)

## **Leading problems are less about controlling material exports & more about controlling the transfer of Know-How:**

- Interactions up & down CF-PMC’s supply chain are intensive, highly interactive, globally expansive, constant (24/7) & run at “internet” speed
- Many interactions trigger ITAR licensing for numerous reasons including data exchanges for production, acquisition, quality control, process development & product R&D reasons -- uses of licenses are expansive

# Impacts of ITAR Controls on Defense Materials & Know-How

## **ITAR licensing strains strategic U.S. - EU business relationships**

- EU is U.S. largest export market with important single & source relationships
- EU A&D industry pushing to incentivize & qualify non-U.S. suppliers (SEP, ACG)
- EU displacement of U.S. ITAR products would hobble U.S. market stance

## **ITAR obstruction of value chain impacts U.S. A&D defense markets**

- DOD legacy and new A&D programs have significant foreign participants
- Global supply chains of U.S. legacy military aircraft (UH-60) built for both allies and DOD (with offsets) are heavily impacted by controls (costs & scheduling)
- Supply chains with foreign allies supporting new DOD military aircraft (F-35) are similarly effected (early supply chain disruptions & innovation impeded)
- ITAR Know-How controls are blocking important U.S. reverse knowledge-sharing (imports) of EU expertise in CF-PMC and related technologies

# Impacts of ITAR Controls of Defense Materials & Know-How (2)

## **ITAR obstruction of value chains impacts U.S. A&D commercial markets**

- U.S. A&D commercial aircraft have significant foreign participants (B787)
- ITAR (and EAR) are impacting B787 supply chains (costs, delivery, collaboration)
- ITAR conflicts with “spin-off / spin-on” premise of a dual-use A&D industrial base
- Examples: C-130J to L-100 (Air Force), B737 to P-8A (Navy), Bell 407 to ACH 70 (Army)
- Related firewalls, requalifying ITAR tainted materials & processes cost millions

## **ITAR turning table on U.S. industry-DOD “innovation” partnerships**

- Industry is “opting-out” of collaborative R&D with DOD to avoid ITAR tainting
- U.S. R&D being off-shored to further distance related developments from ITAR
- Offshoring leaves U.S. R&D infrastructure underutilized (IR&D, vendors, academia)
- R&D partnership disengagement denies industry leverage of USG R&D assets
- U.S. industry-government segregation of R&D widens supplier-customer divide

# Impact of ITAR Controls on Technology Development

**Industry development of new commercial material technologies in collaboration with DOD can “taint” developments as ITAR controlled**

- ITAR “tainting” impedes technology commercialization of important civilian dual-uses by essentially excluding marketability to global commercial markets
- ITAR tainting similarly hurts defense transitioning of new U.S. commercial innovations to DOD uses by diminishing dual-use business strategies

**Former state-of-the-art (decades old) U.S. materials development with limited DOD roles (testing, funding) can similarly be “tainted”**

- Related materials might otherwise be considered inherently commercial
- ITAR tainting retards long-term material maturation & continued R&D evolution
- ITAR tainted legacy technologies (materials, processes, Know-How) pose major business risks if (when) they migrate to commercial uses (see-through)

# **Additional Impacts & Effects of ITAR & EAR Controls on Extended Value Chain**

**EAR's *China Catch All* generating tremendous industry concern for flood of new licensing requirements & increased business uncertainty**

**ITAR Commodity Jurisdiction “tainting” industry-government R&D, impeding dual-use commercialization of DOD funded developments**

**ITAR “see-through” provision tainting inherently commercial products due to origins in legacy defense developments**

**Controls on deemed exports impact both employment of non-U.S. citizens and multi-national business interactions (clients, vendors, etc.)**

# Implications of Export Control Impacts for U.S. Defense Industrial Base

- Inhibits U.S.-foreign R&D partnerships for future defense systems (F-35 JSF)
- Increases manufacturing costs, causes delivery delays and reduces global supply chain responsiveness for legacy defense programs (UH-60)
- Tainting decreases DOD R&D collaboration with U.S. industry, local universities and foreign (public-private) institutions (SBIRs, ManTech & CRADAs)
- TAAs/MLAs weaken U.S. foreign military sales (FMS) by constraining offsets
- Controls accelerate technology proliferation that catalyzes overseas R&D investment and increased foreign competitive challenges to U.S. industry
- Controls disproportionately affect U.S. small businesses and diminishes small firm participation in defense R&D and procurement

**DOD is very dependant on a dynamic and increasingly globalized, dual-use industrial base and export controls impede this relationship**

**Conclusions on Effects & Impacts of EAR Controls  
of Dual-Use Commercial Materials & Know-How**

# Conclusions on Effects & Impacts of EAR Controls on Material Suppliers & Dual-Use Items

**Conclusion 1.1 Material suppliers experience no demonstrable adverse impact (lost sales, excessive burden) in established EU export markets**

- Most exports of CF-PMC feedstock materials (fiber & prepreg) are to established EU markets and seldom require licensing
- Most licensable EU exports are to well-vetted EU customers and required licenses are obtained with relative ease

**Conclusion 1.2 Suppliers face significant export barriers to vital emerging foreign markets with major, long-term growth opportunities**

- Emerging foreign markets require high levels of technical exchanges (Know-How) with U.S. materials suppliers to develop processes, products and applications
- U.S. suppliers have experienced costly “dummied-down” technology licenses and domestic firms have avoided key emerging markets due to “presumption of denial”

# Conclusions on Effects & Impacts of EAR Controls on Extended Value Chain & Dual-Use Items

## Conclusion 1.3 The global competitiveness of international value chains (manufacturing and R&D) is greatly impeded by controls on Know-How

- Expanded USG interpretation of controls on Know-How is more encompassing and presents significant impediments to globally distributive enterprises
- Impacts are most prevalent in emerging markets & reportedly affecting EU markets
- While emerging foreign markets are still in formative stages, licensing restrictions on technology transfers in manufacturing has already cost U.S. millions in losses

## Conclusion 1.4 Automation machine OEMs are effectively barred from competing in certain key high growth emerging foreign markets

- Equipment exports to developing countries are tightly controlled and OEMs face licensing denials, unmanageable delays or unworkable provisos for key markets
- OEMs have tempered sales growth by up to 25% or more and face reduced opportunities to follow their U.S upstream customers (primes) to emerging markets
- Allegations of EU OEMs (Germany, Macedonia, Spain) enjoy unfair competitive advantage with unfettered access to emerging foreign markets (China)

# **Conclusions on Effects & Impacts of ITAR Control of Dual-Use Defense Materials & Know-How**

# Conclusions on Effects & Impacts of ITAR Controls on Material Suppliers & Defense Items

**Conclusion 1.5 While U.S. suppliers haven't lost significant exports in EU markets, ITAR's implementation is hampering U.S. competitive advantage**

- While most ITAR material exports are ultimately approved, the licensing process is fraught with enormous problems (excessive delays, intrusiveness & inefficiencies)
- ITAR implementation flaws straining U.S.-EU industry-government supplier relations (often sole source) resulting in threats to qualify non-U.S. suppliers (SEP, ACG)
- U.S. suppliers face rise of newly formed competitors from abroad and weakened EU market standing on major pan-EU A&D and joint U.S. - EU programs (F-35)

**Conclusion 1.6 Most serious impact of ITAR is disruption to collaborative U.S.-EU defense supply chains due to controls on Know-How**

- ITAR restrictions on Know-How (TAAs, MLAs), have impinged on the robustness of world class level, U.S. supply chain enterprises, resulting in millions in added production costs, serious delivery delays, lower reverse knowledge sharing between the U.S. & EU -- while retarding overall U.S. global industry competitiveness and challenging its leadership positions in worldwide A&D markets

# Conclusions on Effects & Impacts of ITAR Controls on Value Chain & Defense Items

**Conclusion 1.7 ITAR may seriously impede U.S. firms' ability to compete in growing international defense and security markets in emerging countries**

- Impacts anticipated in key markets (such as India with broad military aircraft needs) with sizable manufacturing offsets in CF-PMCs expected
- Questions arise about level-playing field with EU and whether ITAR would permit U.S.- India JVs similar to recent EADS R&D offshoring investment

**Conclusion 1.8 Export controls on Know-How have far reaching effects on international U.S. defense A&D value chain & DOD programs**

- Examples include both legacy programs (Black Hawk) and new initiatives (F-35)
- While anecdotal impacts exceed \$15M, suspect similarly large (or bigger) losses exist with other international A&D programs given popularity of offsets & teaming
- ITAR involvement in joint U.S.-EU military programs involving DOD expected to widen due to growing use of higher performance (more controlled) materials
- ITAR challenges expected to further mount with increase in defense exports to emerging regions, growing use of CF-PMCs and rising application of offsets

# Overarching Conclusions on Effects of ITAR & EAR Export Controls

**Conclusion 1.9 Significant confusion and fundamental contradictions exist about export controls amongst key government and industry stakeholders**

- **The extent of this turmoil includes significant disagreement involving:**
  - what materials and technologies are or are not currently controlled
  - which materials and technologies should or should not be controlled
  - who within the USG is responsible for controlling which technologies (BIS, DDTC)
  - when is technology Know-How controlled or not
  - which foreign countries are or are not granted preferred export (exempt) status
  - what test standards should be used or not to determine control thresholds
- **The depth and breadth of differential interpretation of controls resides:**
  - between competing U.S. as well as amongst foreign material suppliers
  - between material suppliers and leading OEMs and system integrators
  - between industry and the USG
  - between different USG departments and federal agencies (DOD / NASA)

**Section 5.**  
**Interview Contacts & Selected References**

# Composites Manufacturing Value Chain Contacts

Listed below are various manufacturing firms contacted for this study. While most are material producers of CF-PMC related materials, manufacturers of specialty resins and other high performance fiber were contacted along with platform OEMs / system integrators and automation equipment machine builders.

- High Performance Fibers
- Resin Systems & Formulators
- Prepreg Materials
- Woven & Braided Textiles
- Near Net Shape Complex Preforms
- Fabricated Composite Parts & Structures
- Tier I & II Suppliers
- Platform OEMs / System Integrators
- Automation Machine Builders

Company	Fiber	Resin Prepreg	Textiles	Parts	Tier I-II	Prime	Auto	Company	Fiber	Resin Prepreg	Textiles	Parts	Tier I-II	Prime	Auto
AGY	x							Lockheed				x	x	x	
Airbus				x		x		Magellan	x						
American General				x		x		Mitsubishi	x	x					
American Synthetic		x						Northrop				x	x	x	
Boeing				x		x	X	Oshkosh Truck				x		x	
Cincinnati Machine							x	Phoenixx				x			
Cytec	x	x	x	x				Pratt & Whitney					x		
DSM Dyneema	x							Raytheon				x	x	x	
DuPont	x	x	x				x	Rolls Royce					x		
Dynamic							x	Saint Gobain	x	x	x	x			
Entec							x	Sartomer		x					
FiberCote		x						Sikorsky						x	
Flotation Technologies				x				Specialty Malts	x	x	x				
GE Engines					x			Techniweave			x	x			x
GKN Aerospace				x	x			Toho	x	x					
Hexcel	x	x	x	x	x			Toray	x	x					
Hitco		x	x	x	x	x		Trelleborg				x			
Honeywell	x							UltraCore				x			
JPS Composites			x					Vought				x	x		

# Key Institutional Contacts

## Government, Trade & Professional Organizations:

- DOD PMC Technical Subject Matter Experts (Air Force, Army)
- DOD MCTL M&P Technology Working Group (MPTWG)
- DOD MIL-17 Composites Materials Handbook (PMC Group)
- DOD Defense S&T Reliance Program (M&P Panel)
- DOC BIS TAC, Composites Technology Working Group (CTWG)
- Institute for Defense Analyses (IDA)
- NRC, Materials Advisory Board (2005 PMC Committee)
- Aerospace Industry Association (AIA)
- American Composites Manufacturers Association (ACMA)
- Association for Manufacturing Technology (AMT)
- Society for the Advancement of Material & Process Engineering (SAMPE)

# Subject Matter Expert Contacts

## Industry Journalist & Private Expert Consultants:

- *High Performance Composites Magazine*, J. Hazen, Editor
- *Composites News*, Editor, S. Loud
- *Composites Manufacturing Magazine*, Contributing Editor, J. Busel
- *Composite Market Reports*, Managing Editor, C. Red
- SAMPE Journal, Technical Editor, S. Beckwith
- InterTech *High Performance Fiber Conference*, Chair, S. Stephenson
- Industry & Government Consultants:

S. Beckwith

DJ DeLong

J. Persh

C. Segal

M. Benante

J. Hendrix

B. Rasmussen

B. Wilcox

T. Bohn

T. Lynch

W. Root

J. DeVault

K. Michaels

W. Roy

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**APPENDIX E**

**THE WASSENAAR ARRANGEMENT  
AND ITS IMPLEMENTATION IN EUROPE**

**Noah J. Richmond**



## **INTRODUCTION**

Export controls changed dramatically after the Cold War. Previously the Coordinating Committee for Multilateral Export Controls (COCOM) controlled technology transfer across the East-West divide. The objective was simple and compelling: Limit the transfer of materially useful military technology to the Warsaw Pact that NATO would face in a prospective World War III. American and European interests were aligned, and compliance was strong. But COCOM could not survive the transition to a post-Soviet era. The dividing line between East and West is now the center of the European Union (EU), a collection of twenty five European States that includes the majority of NATO and a much of the former Warsaw pact. The EU is the largest market in the world, with a common currency (the euro), its own World Trade Organization (WTO) representative, and unified export and import policy. Understanding how the EU regulates exports is essential to understanding the world wide trade in technology.

In addition to the realignment of Europe, Asia has emerged as both a supplier and buyer of military technology. Asian economies such as Japan, Taiwan, and Hong Kong have become critical exporters of technology. The return of Hong Kong has created a new pathway for technology into China. Increased Taiwanese trade and direct investment has also provided both the know-how and capital necessary to build sensitive dual use technologies. While this last trend is perhaps surprising given Taiwan's security dilemma with China, this fact of life indicates how economic and security objectives can compete.

This chapter considers how international export control agreements for dual use technologies have evolved following COCOM. It begins with the history, structure, content and limitations of the Wassenaar Arrangement, the functional successor to COCOM. Signatories to the Wassenaar Arrangement include the US, Canada, and all the major technology exporting countries in Europe and Asia. Wassenaar has served as a foundational international agreement upon which regional and national export controls more are being built, particularly in Europe. The study then delves into EC 1334/2000, a European export control regulation that guides implementation of Wassenaar at the state level. Case studies of the UK, France, Germany, and Ireland illustrate similarities and differences in implementation. Finally, Europe's economic relationship to China is discussed, with a view toward discerning underlying policy priorities regarding the flow of technology to and from China. The dialogue in Europe on the prospective lifting of the Tiananmen Square arms embargo reveals a fundamental difference in policy preferences

between the US and Europe which help explain disparities in implementation of Wassenaar.

## **THE WASSENAAR ARRANGEMENT**

### **Overview**

*The Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies* is the foundational political agreement for the control of conventional and dual use technology through international cooperation. Following a series of plenary meetings, The Wassenaar Arrangement Initial Elements were adopted on July 12, 1996 by 33 signatory countries.<sup>1</sup> The agreement inherits as its basis the control lists from COCOM, thus maintaining continuity in the arrangement's focus on conventional arms and dual use technology. COCOM regulated the spread of militarily significant technology from the West to the East during the Cold War. The collapse of the Soviet Union in 1992, disintegration of the Warsaw Pact, and re-integration of Western and Eastern Europe erased the dividing line COCOM was designed to enforce. On 16 November, 1993, the 17 COCOM member states agreed in principal to terminate COCOM and establish a new international arrangement that would reflect this new political landscape. Following a high level meeting in Wassenaar, Netherlands, COCOM was officially terminated effective March 31, 1994.<sup>2</sup>

The Wassenaar arrangement addresses essentially the same dilemma as COCOM. Member countries share a common interest in controlling the spread of military technology, so as to ensure international security and to maintain national advantage in military arts and sciences. These same countries also compete vigorously to sell both military and dual use goods. Consequently, while all benefit from the increased security resulting from an embargo denying military goods to potential adversaries, there is likewise a strong incentive to break with the embargo. Each nation fears being undercut; if another party sells the technology both the security gain from refusal to sell and the

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<sup>1</sup> The original 33 signatories were Argentina, Australia, Austria, Belgium, Bulgaria, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, South Korea, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Slovak Republic, Spain, Sweden, Switzerland, Turkey, Ukraine, UK, and the United States.

<sup>2</sup> *The Wassenaar Arrangement on Export Controls for Conventional and Dual-Use Goods & Technologies: Basic Documents*. Compiled by the Wassenaar Arrangement Secretariat, January 2006.

economic benefit of agreement to sell are lost.<sup>3</sup> Like COCOM, Wassenaar seeks to solve this dilemma by creating a common export policy among member states. By building equally restrictive export control regimes, member states can prevent a “race to the bottom” in export control restrictions, while simultaneously allowing free competition on an equal footing. Each operates with the assurance that others will not provide those goods that it denies to restricted nations. Consequently, the threat of losing the economic benefit of trade without the commensurate gain in security from preventing proliferation is mitigated, allowing solidarity in enforcement.

The Wassenaar Arrangement contains nine sections that define the commitments of the agreement. The first three sections provide the “substance” of the agreement. Section I gives the purpose of the agreement, Section II defines the scope, and Section III states the control lists. The next three sections give procedures for information exchange, including the (IV) General Information Exchange, (V) Exchange of Information on Dual-Use Goods and Technology, and (VI) Exchange of Information on Arms. The last three sections concern administration of the agreement, and include (VII) Meetings and Administration, (VIII) Participation, and (IX) Confidentiality. From the standpoint of understanding the agreement’s approach to arms control, and its subsequent impact on the shape of European and Asian arms export policy, it is Sections I, II, and III that are most important and which are the focus of this analysis.

The purpose of the Wassenaar Arrangement was first articulated in the Wassenaar Arrangement Initial Elements. (In addition to the four original Initial Elements, a new “5<sup>th</sup> element,” a reference to anti-terrorism, is now part of the Initial Elements.) These five purposive elements are contained in Section I of the agreement. A detailed examination of the Initial Elements reveals four key perspectives reflected in the agreement. These perspectives illustrate important philosophical changes from COCOM, and also show differences between international and American beliefs and approaches to arms control. In summary:

1. The primary objective of Wassenaar is to secure international stability rather than national security.
2. Wassenaar reflects a general agreement that the control of dual-use technologies must be extended to prevent the flow of sensitive technology to non-state entities

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<sup>3</sup> Arguably there is some benefit because had the purchasing party sought out and been denied the first choice for source of supply, the remaining sources would be inferior in quality, cost more, or possibly both. Nevertheless, the marginal gain is insufficient to offset the essential dilemma.

and terrorist organizations in particular. However, the majority of signatories view terrorism as a “fight,” not a “war,” and *fighting* terrorism is one of several coequal objectives.

3. The Wassenaar Arrangement emphasizes national sovereignty, including the right to self defense and the arms transfers necessary for self defense.
4. The Wassenaar Arrangement reveals a *trade off* of economic gains and security benefits, with greater emphasis on the former than the United States might prefer.

We consider these four perspectives in turn. The first of the four original elements provides that,

“The *Wassenaar Arrangement* has been established in order to contribute to regional and international security and stability, by promoting transparency and greater responsibility in transfers of conventional arms and dual-use goods and technologies, thus preventing destabilising accumulations. Participating States will seek, through their national policies, to ensure that transfers of these items do not contribute to the development or enhancement of military capabilities which undermine these goals, and are not diverted to support such capabilities.”

The language of the arrangement contains two important subtleties that reflect the philosophy of the signatory nations. As noted in the first element, Wassenaar contributes to “regional and international security and stability.” The objective thus focuses on the international system, and the detrimental impact of “destabilizing accumulations” and enhanced “military capabilities” on stability. The theory is that arms transfers lead to military capabilities that undermine international stability, and consequently regional and international security is protected by preventing these “accumulations” from occurring. The second element confirms this exact perspective. It provides that that the primary means to accomplish this end is the prevention of arms transfers, “by focusing on the threats to *international and regional peace and security* which may arise from transfers of armaments and sensitive dual-use goods and technologies where the risks are judged greatest.” Conspicuously absent from the first or second element is the term “national security.” The *third* element makes only an oblique reference to national security as a legitimate interests to be protected, stating that the Wassenaar Arrangement will “enhance co-operation to prevent the acquisition of armaments and sensitive dual-use items for military end-uses, if the situation in a region or the behaviour of a state is, or becomes, a cause for serious concern to the Participating States.” In summary, the ordering and language of the objectives indicates a perspective focused on international stability rather than the national security of a particular state.

Following the terrorist attack on the World Trade Center in September 2001, the plenary session of December 2001 added a fifth purposive element explicitly extending coverage of the arrangement to terrorism,

“In line with the paragraphs above, Participating States will continue to prevent the acquisition of conventional arms and dual-use goods and technologies by terrorist groups and organisations, as well as by individual terrorists. Such efforts are an integral part of the global fight against terrorism.”

The addition of the fifth element creates a significant shift in the scope of the Wassenaar Arrangement. In addition to recognizing the suppression of terrorism as a joint strategic objective, the language specifies “groups,” “organizations,” and “individual[s]” as falling within the scope of the arrangement. Both the inclusion of terrorism and the specification of its application to NGOs reflect a shift in thinking in *why* Wassenaar is important. The impact of terrorism could have been subsumed under regional and international security. The explicit identification of terrorism suggests a realignment in thinking about the relative importance of terrorism, and perhaps will shape the ultimate implementation of the Wassenaar Arrangement because the policies that would be undertaken to prevent shipments to non-state actors is different than the policies that would be undertaken to prevent shipments to nations and their recognized governments. The language stops short, however, of alignment with US strategic objectives. Note that the term, “fight” is used rather than “war” in the conclusion, “Such efforts are an integral part of the global *fight* against terrorism.” European strategy documents tend to adopt “fight,” while American strategy documents emphasize “war.” The choice of language indicates that, while mitigating terrorism is a strategic objective, the degree of importance assigned to this objective more closely parallels the European rather than the American perspective.<sup>4</sup>

As concerns national sovereignty, it is important to note that Wassenaar is an “Arrangement,” and not an, “Agreement.” The Arrangement has no binding force whatsoever. Compliance is voluntary. No nation has ratified Wassenaar, and by itself the arrangement has no legal effect. Moreover, the degree of commitment within the arrangement is tepid. The prevention of destabilizing accumulations is to be furthered through the means of, “greater responsibility in transfers of conventional arms and dual-

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<sup>4</sup> See e.g. *EU Focus: The EU, the U.S., and the Fight Against Global Terrorism*. European Union Delegation of the European Commission to the USA, May 2005. See also *A secure Europe in a better world: European Security Strategy*. The European Institute for Security Studies, 2003.

use goods and technologies,” but is restricted to a coordination of, “*national policies,*” that will improve, “transparency and responsibility.” This is significant as concerns economics. The fourth element notes that “bona fide civil transactions” will not be interrupted, nor will the agreement, “interfere with the rights of states to acquire legitimate means with which to defend themselves pursuant to Article 51 of the Charter of the United Nations.” This language suggests that economic interests can trump security interests, and the arrangement does not provide specific criteria for determining what constitutes a “bona fide civil transaction.” Likewise, there is no method for determining when legitimate self defense under Article 41 of the United Nations Charter would apply. Consequently, deciding when a transaction is cause for concern is left to the discretion of the exporting state, or at best, to international norms.

Section II defines the scope of the arrangement, and consists of seven responsibilities that member states undertake. These include: (1) Agreement to meet on a regular basis, (2) voluntary exchange of information to enhance transparency and discussion of how to co-ordinate national control policies to reduce the risk of the transfer of dual-use goods and technologies, (3) acknowledgement that the decision to transfer or deny transfer of any item remains at the discretion of the individual state, (4) agreement to notify transfers and denials to other members, and in particular to notify participating states that deny a transfer of an approval for an essentially identical transaction, (5) continued review of the scope of conventional arms to be covered, and also the ongoing development of guidelines and procedures in light of experience gained, (6) regular assessments of the functioning of the arrangement, and (7) agreement to a set of guidelines set forth in six joint statements issued from 1998 through 2003.

Section III specifies that participating states will control all items set forth in the lists of Dual-Use Goods and Technologies and the Munitions List, with, “the objective of preventing unauthorised transfers or re-transfers of those items.” In addition to the basic lists, an annex of “sensitive items,” and “very sensitive items,” is provided. Member states agree to regularly review and update the lists to reflect technological developments and experience gained. Currently, there are eleven categories plus a note on general technology and software. Within each category, there are sub-lists including “Systems, Equipment, and Components,” “Test, Inspection, and Production Equipment,” “Materials,” “Software,” and “Technology.” The eleven categories are as follows:

1. Advanced Materials
2. Materials Processing

3. Electronics
4. Computers
5. Part One: Telecommunications  
Part Two: Information Security
6. Sensors and Lasers
7. Navigation and Avionics
8. Marine Technology
9. Propulsion
10. Sensitive List
11. Very Sensitive List

The lists have served as the basis for EC 1334/2000, the principal European Union legislation controlling the export of conventional and dual-use technologies. Because of the strong influence of COCOM on Wassenaar, and subsequently Wassenaar on EC 1334/2000, the control lists of COCOM effectively continue as the heart of international export controls today. This result is discussed more fully in the next section, where EU law on export controls is considered in greater depth.

### **Analysis**

Arms control, by definition, separates “haves” from “have-nots.” While the “haves” of Wassenaar are easy to identify—they are the signatories to the arrangement—the “have-nots” are more challenging to name. Just as COCOM sought to exclude the Warsaw Pact from important military technologies, the Wassenaar Arrangement seeks to prevent the flow of technology from the thirty three member states, but, unlike COCOM, there is no explicit list of prohibited nations. Further, the arrangement recognizes the right to self defense and legitimizes shipments in support of this right. Thus there are circumstances in which shipments to states that would normally be prohibited may be allowed. Finally, the addition of the 5<sup>th</sup> purposive element extends the qualitative reach of Wassenaar to non-state actors and perhaps even individual persons.

A key point of strategic divergence is the United States and the European Union’s differing perspectives and approaches to China. While the United States views China as a regional competitor and is deeply concerned with stemming the flow of dual use technology there, the European Union has been a ready and willing source of cryptography, semiconductor, and machine tools equipment to China. Indeed, the European Union has as recently as 2005 approved shipments to China of radiation

hardened integrated circuits, low-signal cloth (i.e., stealth), towed hydrophone technology, and various nuclear components. These positions reflect both differences in interests as well as philosophy in how best to address China's growing power, its emergence as an economic participant in the world economy, and its role as a potential proliferator of controlled technologies.

Though Wassenaar and COCOM are the foundational international agreements from which later control regimes have been established, both have experienced significant failures. Prior to the repeal of COCOM, the Gulf War revealed that both Germany and the United Kingdom had provided significant supplies (by US standards) of dual use military equipment for Iraq. In 1996, Lord Justice Scott concluded a four year inquiry into the shipment of arms to Iraq. The report followed the collapse of the criminal prosecution of three senior executives of Matrix Churchill, a company charged with deceiving the British Government when applying for export licenses for machine tools.<sup>5</sup> Not only were the executive officers of Matrix Churchill aware that the machine tools were likely to be used to make weaponry, but evidence was given that the government itself knew that the license applications were disingenuous.<sup>6</sup> Though the prosecution collapsed due to evidentiary failures, the subsequent report of Lord Justice Scott revealed that the government had adopted a, "more liberal policy on defence sales to Iraq." Though the report is classified, partial public releases showed that economic incentives can corrupt the political process and lead to significant technology transfers proscribed by the letter and spirit of the law. Perhaps the strongest lesson learned is that transparency is important not only to guarantee foreign governments of cooperation, but also to ensure domestic compliance. The now stinging quote of Ian McDonald, head of the Ministry of Defence's Defence Sales Secretariat, captures the failures of the UK government: "Truth is a difficult concept."<sup>7</sup>

Wassenaar followed closely on the heels of the arms transfers to Iraq; it was hoped the arrangement would improve compliance through harmonization and improved accountability between nations. Initially, these hopes were unrealized. In 2002, the General Accounting Office (GAO) published a report on China's evolving semiconductor

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<sup>5</sup> See BBC News, "Q&A: The Scott Report," Tuesday, April 27, 2004.

<sup>6</sup> *Ibid.*

<sup>7</sup> The United Kingdom was not the sole offender. During the same time period Germany was found to have made extensive shipments of sensitive technologies to Iraq.

industry. While the development of indigenous capability is not a direct proxy for the importation of controlled products, it does illustrate overall access to the dual-use technologies necessary for the manufacture of controlled technologies. In the event a country is able to significantly leapfrog development times, the implication is that some amount of outside help, or at a minimum, reverse engineering, has occurred. The dramatic growth in China's semiconductor industry proved that attempts to control know-how, and semiconductor manufacturing technology totally failed. According to the GAO study,

“The multilateral Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies has not affected China's ability to obtain semiconductor manufacturing equipment because the United States is the only member of this voluntary arrangement that considers China's acquisition of semiconductor manufacturing equipment a cause for concern.”<sup>8</sup>

In spite of the one-sided tone of the GAO's summary judgment, the report indicates that the Netherlands, Belgium, Japan, Hong Kong, *and* the US have all had a significant role to play in semiconductor technology transfer to China by means of co-investment in fabrication plants. Direct exports of military grade semiconductors also took place:

“We found that European, Japanese, and U.S. export control authorities license sales of semiconductor manufacturing equipment to China that is at least two generations more advanced than the threshold stipulated in the Wassenaar and Commerce lists (0.50 micron) and three generations more advanced than what the Defense Department considers military critical (0.70 micron).”

The implication is not that the U.S. is the only country following the guidance of Wassenaar, but rather that *no country* has followed the letter of the arrangement with regard to semiconductor exports. In the case of Britain and Ireland, not only have “ordinary” integrated circuits been exported to China, but radiation hardened IC's have also been delivered to the mainland, Hong Kong, and Taiwan (See case studies).

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<sup>8</sup> GAO, p.2-3. The report continues, stating “The arrangement deems only one type of semiconductor manufacturing equipment to be sufficiently sensitive to warrant greater information sharing among arrangement members—no export information is shared for 97 percent of all electronics-related items covered by the arrangement. Transparency, through exchanging information and sharing views, is the sole means by which the arrangement tries to achieve its goals. Over the past several years, fewer items have been subject to the Wassenaar Arrangement, particularly electronics-related items.”

The GAO report also cites deficiencies in reporting criteria, and the incompleteness of the control lists, as major impediments to effective control. Those communications that do occur are reported to occur too infrequently, with delays significantly undermining the potential for dialogue to forestall questionable deliveries. Furthermore, the absence of a “no undercut rule,” softens the impact of timely reporting. Finally, revisions have “watered down” the lists controlling semiconductor exports.

## **THE EUROPEAN UNION**

### **Overview**

The European Union (EU) is a collection of twenty five states in Europe sharing a common market. The EU is also a supra-national governing structure whose powers include exports regulation. With respect to arms control, the EU is critical because it is the single largest competitor to the United States for conventional and dual use exports. It also provides a central point of negotiation (the EU Commission) and legislation (the EU Council). Through these bodies, the EU governs the internal function of its common market and a common external economic policy including customs, export, and international trade negotiations. The EU is thus an important partner in the regulation of strategic, conventional, and dual use technology and equipment.

The basic bodies of the European Union are the Council, the Commission, and the Parliament. The Council acts akin to the British Parliament. It has both legislative and executive functions. The Council usually meets as a collection of executive ministers from the constituent states, giving it an executive flavor, but also has the exclusive power to initiative legislation. The Council typically votes through a qualified majority vote (QMV), where each state has a number of votes pre-assigned to it on the basis of population, GDP, and political expedience; I.e., Germany and France have the same number of votes in spite of the former being more populous and having a larger GDP. Under the QMV procedure, consensus is necessary for most legislation.

The Commission acts as an executive office and has a significant bureaucracy (COREPER) to support its functions. The Commission has the ability to conduct investigations, negotiations, and analyses and to propose legislation initiatives to the Council for review and implementation in legislation. The Commission is presided over by a rotating head of state, drawn from the member states of the European Union.

The Treaty of Maastricht (1992), which established the EU, divided the competence of the EU into three pillars. The pillars are distinguished by the relative

power of the union as compared to the individual state, and the domain of application. The first pillar, the European Communities, favors the EU over the individual state, and includes economic, social, and environmental policy. The second pillar, the common foreign and security policy (CFSP) strikes a more even balance between community and national sovereignty. The third pillar delegates most control to the individual states, and is comprised of police and judicial cooperation in criminal matters (PJCC). Law and policy relevant to arms control falls under each of these headings. The Customs Union, Single Market, and EU Competition Law fall under the first pillar. The CFSP includes the European Security and Defense Policy and falls under the second pillar. Finally, the PJCC, which is under the third pillar, impacts the criminal law governing illegal arms transfers. The three pillar structure is important for US policy makers to comprehend, because it determines what the EU can offer in bilateral negotiations. Law on export policy with regards to the function of the single market can be negotiated directly with the EU, and is binding on all members. In contrast, agreements with the EU in regard to criminal law on weapons trafficking will be mostly persuasive, and effective agreements must be reached directly with each member nation.

The two most important pieces of EU policy are the European Code of Conduct on Arms Transfers and European Council (EC) regulation 1334/2000. The former provides qualitative criteria to take into consideration when making a decision of whether or not to export a dual-use, or conventional military product. The latter directly regulates the export of dual use and conventional military equipment. It falls under the first pillar of EU law because it regulates the operation of the single market. Consequently, it has binding authority throughout the EU. Analysis at the national level is nonetheless necessary because member states retain discretion on how to implement these controls. The Treaty of the European Union (TEU) generally requires that the measures taken be effective but a wide degree of latitude is enjoyed by the national governments, and the result is a rich and diverse set of approaches implementing the regulation.

### **European Code of Conduct on Arms Transfers**

The European Code of Conduct is an agreement set forth by the Council of the European Union. While it is not a binding regulation such as EC 1334/2000, it is nevertheless highly influential in the actual conduct of the member nations. The agreement consists of three primary sections. The preamble gives the purpose of the agreement, and contextualizes the agreement within EU law. The common criterion set forth guidelines for making an assessment of whether or not to grant an export license.

Finally, operative provisions are provided that dictates the member states obligations to one another in the administration of their export control policies.

The preamble of the EU Code of Conduct on Arms Exports cites two principal objectives. First, the agreements seeks to, “set high common standards which should be regarded as the minimum for the management of, and restraint in, conventional arms transfers by all EU Member States.” Second, the code sets forth to, “strengthen the exchange of relevant information with a view to achieving greater transparency.” These two interlocking objectives signal the beginning of two trends that characterize much of the following 15 years in European arms control legislation—harmonization of national export laws, and trust-building through improved communication practices. Indeed, the preamble explicitly recognizes this approach, noting that the agreement is undertaken, “WISHING within the framework of the CFSP to reinforce their cooperation and to promote their convergence in the field of conventional export controls.”

Because the agreement falls under the Common Foreign Security Policy (CFSP), it sets forth policy in a domain where nations enjoy substantive independence in their decision making. The preamble pays considerable respect to the sovereignty of the member states in this domain, as made clear in the final two articles:

“ACKNOWLEDING the wish of EU Member States to maintain a defence industry as part of their industrial base as well as their defence effort,

RECOGNISING that states have a right to transfer the means of self-defence, consistent with the right of self-defence recognized by the UN Charter, have adopted the following Code of Conduct....”

Constrained by the limitations of community sovereignty in the second pillar, encouraging cooperation is the most forceful application possible. Passing a unified law requiring direct effect under the second pillar is simply not possible in this context.

The eight common criteria emphasize, “Respect for the international commitments of EU member state,” “The respect of human rights in the country of final destination,” “The internal situation in the country of final destination, as a function of the existence of tensions or armed conflicts,” “Preservation of regional peace, security and stability,” “The national security of the member states and of territories whose external relations are the responsibility of a Member State, as well as that of friendly and allied countries,” “The behavior of the buyer country with regard to the international community,” “The existence of a risk that the equipment will be diverted within the

buyer country,” and “The compatibility of the arms exports with the technical and economic capacity of the recipient country, taking into account the desirability that states should achieve their legitimate needs of security and defence with the least diversion for armaments of human and economic resources.”

For each of these eight abstract criteria, an additional list of more concrete requirements is provided. For example, following the fifth criterion, the code directs that Member States will take into account:

“(a) the potential effect of the proposed export on their defence and security interests and those of friends, allies and other member states, while recognizing that this factor cannot affect consideration of the criteria on respect of human rights and on regional peace, security and stability; (b) the risk of use of the goods concerned against their forces or those of friends, allies, or other member states; (c) the risk of reverse engineering or unintended technology transfer.”

The lists reveal both the concrete objectives and concerns of the member states, and provide the primary decision criteria and considerations recommended for integration into the member states’ export control regulations. While the Criteria give the objectives requirements that should guide member states when making export license decisions, the operative provisions dictate the mutual obligations of the member states to one another with an emphasis on improved *communication*. The third provision, in particular, notes that, “EU Member States will circulate through diplomatic channels details of licenses refused in accordance with the Code of Conduct,” and states that those nations providing a license for an, “essentially identical transaction,” are required to notify the Member States that issued a denial and give a detailed explanation of the reasoning for granting the license. The objective of developing a common list of controlled military equipment, “based on similar national and international lists,” is provided in the fifth provision. The eighth provision requires each Member State to circulate an annual report on its defence exports and on its implementation of the Code.

In sum, harmonization and mutual accountability are clearly at the core of the agreement, indicated both by the Criteria and the Operative Provisions. The code is a significant step forward from Wassenaar in that it sets forth operational “requirements” and specific measures designed to prevent nations from undercutting one another through the sale of goods denied by other Member States. The force of the code is mitigated by the recognition of rights and privileges with regards to arms transfers enjoyed by sovereign nations. Also, the code falls under the CFSP which limits its effect.

Nevertheless, the code provided a foundation for EC 1334/2000, which sets forth binding legislation under the first pillar of EU law.

It is important to note that the code pre-dates Wassenaar, and thus it would be incorrect to depict the code as a positive evolution in enforcement from the latter—and later—arrangement. Nevertheless, it does show an increased focus by the EU on issues of national and international security, in contrast to the primarily economic focus in its earlier development. In this sense it may be best characterized as a recognition within the EU that, if nothing else, the emerging economic might of Europe would inevitably have a direct impact on international security, and the need for coherent policy at the Union level could not longer be ignored. A decade later EC 1334/2000 would consummate this realization as export control moved from the second pillar to the first, and EU expansion created an economy approximately equal in size to that of the United States.

### **EC 1334/2000**

European Council regulation 1334 was passed on June 22, 2000. EC 1334/2000 is the EU's primary legislation in dual use controls. Entitled, "Setting up a Community regime for the control of exports of dual-use items and technology," the regulation essentially writes the Wassenaar Arrangement control lists into European Union law. The method of implementation also parallels Wassenaar. The Fifth article of the preamble states that:

Common lists of dual-use items, destinations and guidelines are essential elements for an effective export control system; such lists have been established by Decision 94/942/CFSP and subsequent amendments should be incorporated into this Regulation.

EC 1334/2000 has been updated to maintain the currency of its control lists. Both EC 1334/2000 and the most recent update, EC 394/2006, passed February 27, 2006 note that the control list, in Annex I, includes international dual-use lists:

This list implements internationally agreed dual-use controls including the **Wassenaar Arrangement**, the Missile Technology Control Regime (MTCR), the Nuclear Suppliers' Group (NSG), the Australia Group and the Chemical Weapons Convention (CWC). (Emphasis added)

Thus while Wassenaar served as the *political* foundation for cooperation, EC 1334/2000 is the *legal* foundation for dual-use export law in the European Union. EC 1334/2000 falls under the first pillar of European Union law, and therefore must be implemented by the member states through appropriate national legislation in accordance with TEU Article 133.

The preamble to EC 1334/2000 specifies the purpose and character of the regulation. The first three (of sixteen) elements of the preamble state the reasons for adoption of the regulation:

- (1) Dual-use items (including software and technology) should be subject to effective control when they are exported from the Community.
- (2) An effective common system of export controls on dual-use items is necessary to ensure that the international commitments and responsibilities of the Member States, especially regarding non-proliferation, and of the European Union, are complied with.
- (3) The existence of a common control system and harmonized policies for enforcement and monitoring in all Member States is a prerequisite for establishing the free movement of dual-use items inside the Community.

The preamble captures the essence of the EU approach to arms control. The first point is that there is a clear “insider” versus “outsider” perspective. The regulation is designed to provide, “effective control” when dual use-items, “are exported from the Community,” but is also intended to allow, “the free movement of dual-use items inside the Community.” The second article also stipulates to the importance of international commitments. This approach is consistent with the philosophy of Wassenaar, which emphasizes arms control as an approach to enhancing international security by encouraging stability (as compared to the US pursuit of national security through a capability-based dominance).

EC 1334/2000 requires member states of the EU to establish, through national legislation, effective export controls for a common control list. The list is highly similar to that provided in Wassenaar, and indeed the regulation stipulates the influential role of international law in general and Wassenaar in particular. EC 1334/2000 falls under the first pillar of EU law, and therefore the regulation is binding. However, the method of compliance is subject to considerable national discretion, and consequently a brief survey of the relevant national legislation is helpful in understand how 1334/2000 has actually been implemented. Countries vary dramatically in both dimensions. Some regulate exports principally through defense and foreign affairs, others through commerce and trade, and other still through customs. Likewise, some have centralized authority over export controls and others have several responsible bureaucracies. Criminal codes for illegal transfers are also significantly different. Even where the codes are substantially

similar, the resources devoted to their enforcement may vary dramatically with consequent variability in their effect. (Addendum D provides a list of the primary bureaucratic bodies responsible for administration of the law, and Addendum E provides a listing of the legislation bearing on conventional and dual-use export licenses for each of the twenty five member states.)

## **CASE STUDIES OF THE EUROPEAN UNION**

A review of all twenty five member states is beyond the scope of this study. Four countries have been selected for consideration because of their relevance to dual-use exports. Britain, France, Germany, and Ireland each have significant technical prowess, and demonstrate the significant variability within the EU in terms of legislation, implementation, and performance. Each is therefore considered in some detail so as to paint a picture of the significant variance within EU export control law. Subsequently, more general performance data for export controls of conventional and dual-use data are given for all twenty five current EU Member States. An independent survey commissioned by the Commission is also discussed to provide insight into current attitudes within the EU on the functioning of EC 1334/2000. Finally, a discussion of EU perspectives and relations with China as they pertain to export controls is provided. Together, these pieces form a more complete picture of the modern practice of export controls within the European Union and how they bear on matters of the greatest concern to US policy makers.

### **United Kingdom**

#### **National Law and Governing Administrative Body**

The Export Control Organization (ECO) is responsible for administering the UK's export licensing regime. The Export Control Act 2002 provides the current United Kingdom legislation governing the licensing of military and dual use technologies and equipment.<sup>9</sup> Effective May 1, 2004, the act replaced the last comprehensive export control regime, codified in the Import, Export and Customs Powers (Defence) Act 1939 legislation on strategic export controls. Pursuant to the Export Control Act, the government has issued five Orders:

1. Export of Goods, Transfer of Technology and Provision of Technical Assistance, (Control) Order 2003

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<sup>9</sup> For the text of the Act, see <http://www.opsi.gov.uk/acts/acts2002/20020028.htm>

2. Trade in Controlled Goods to Embargoed Destinations, Order 2004
3. Trade in Goods (Control) Order 2003
4. Final Regulatory Impact Assessment of the Control Orders
5. Radioactive Sources: New Order October 2006: Guidance, Licence application forms, Regulatory Impact Assessment etc

### **License Types**

The UK export control regime offers five main types of licenses:

1. Standard Individual Export Licences (SIELs)
2. Open Individual Export Licences (OIELs)
3. Open General Export Licences (OGELs)
4. Standard Individual Trade Control Licences (SITCLs)
5. Open Individual Trade Control Licences (OITCLs)

The Standard Individual Export Licence (SIEL) allows shipment of a specific item to a specific consumer up to a preset volume or value. The licenses are typically valid for two years, though a variant of license allowing for a temporary shipment for trial or demonstration purposes is valid for one year and requires return of the good. The Open Individual Export Licence (IOEL) is similar to the SIEL, except that it allows multiple shipments and is valid for three years. The Open General Export Licence (OGEL) is the most flexible type of license, and allows Open General Export Licences allows, “the export of specified controlled goods by any exporters, removing the need for them to apply for an individual licence, providing the shipment and destinations are eligible and the conditions are met.”<sup>10</sup>

Britain also has export licenses that apply to goods shipped by British nationals entirely outside the UK. The Standard Individual Trade Control Licence (SITCL) allows a specific trader to ship a particular product from a foreign source to an identified country, up to a specific value or quantity. The SITCL represents a step forward in the licensing of brokering and trading operations of UK nationals, even when goods do not flow through British territory. The Open Individual Trade Control Licence (OITCL) is similar, but allows multiple shipments.

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<sup>10</sup> See <http://www.dti.gov.uk/europeandtrade/strategic-export-control/licensingrating/licences/ogels/index.html>.

## **Performance Data**

The UK publishes performance data in the *United Kingdom Strategic Export Controls 2004 annual report* on the time taken to approve or deny licenses and the number of licenses approved and denied. The report emphasizes not only the importance of preventing the transfer of military technology but also the importance of the economic impact of controls on industry: “We shall administer the licensing system efficiently so that we keep the compliance burden on UK exporters to the minimum.” According to the 2004 report, “In 2004 we achieved our best-ever performance in processing export licence applications, with a decision taken on 79% of Standard Individual Export Licences (SIELs) within the 20 working day target.” In 2004, a total of 9,116 SIEL applications were reviewed; 6,730 SIELs were issued, 3 were revoked and 148 were refused. In addition, 1353 were returned because no trade license was required (NTLR).<sup>11</sup> In addition, 115 SITCL applications were processed, with 65 issues, none revoked, 1 refused, and 35 rated NTLR.<sup>12</sup> The statistics on OIELs indicated that 538 were issued, 11 were refused, and 1 was revoked. With regard to OITCLs, 38 were issued, and none were refused or revoked.

## **Exports to China and Hong Kong**

Of particular interest are licenses to China. In 2004, 180 SIELs were issued, 15 temporary SIELs were issued, and 7 SIELs were refused. The total value of SIELs issued was £ 100.0 million (\$180 million). Assuming that the value of products is independent of the approval/refusal decision, approximately £ 3.9 million (\$ 7.0 million) were refused. The United Kingdom recently began producing quarterly reports that provide significantly more detail on the types of technology exported to China. The July-September 2005 report indicates that £ 20.0 million in exports were approved under SIEL licenses. A total of 66 SIELs were issued in the quarter, of which 8 were on the “Military List,” and 58 were “Other items.” A clear majority are dual-use items, including cryptographic software (9 licenses), extended temperature range integrated circuits (2 licenses), radiation hardened integrated circuits (1 license), semiconductor process equipment (1 license), machine tools (2 licenses), numerical control software (1 license), mass spectrometers (5 licenses), compound for semiconductor precursor chemicals (8 licenses), production equipment for global positioning satellite receivers, and components

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<sup>11</sup> United Kingdom Strategic Export Controls Annual Report (2004), p. 13.

<sup>12</sup> Ibid.

for nuclear reactors.<sup>13</sup> In addition, an SIEL for incorporation of £ 0.5 million was granted for radiation hardened integrated circuits. Finally, open individual export licenses applying to China were issued for components for military improvised explosive device disposal equipment, cryptographic software (2 licenses), and hydrophone technology.

In addition to exports to mainland China, £ 1.0 million in SIELs were issued for exports to the Hong Kong Special Administrative Region. Eleven SIELs were granted, of which four cover items appearing on the “Military List,” and seven on the “Other items” list. Notable dual-use items include computer analogue to digital equipment, cryptographic software (2 licenses), equipment employing cryptography (4 licenses), general naval vessel components, and magnetometers. Eight open individual export licenses allow shipments to Hong Kong, the most critical of which allow, “components for semi-conductor process equipment, accessories for semiconductor process equipment,” “components for military electronic equipment,” “cryptographic software,” and a license covering a variety of ballistic shields and armor.

## **Germany**

### **National Law and Governing Administrative Body**

The Federal Office of Economics and Export Control (BAFA) enforces the Foreign Trade and Economics Regulation, which implements the Foreign Trade and Economics Act. The Federal Ministry of Economics and Labour is responsible for administration of the War Weapons Control Act.<sup>14</sup> It is important to note that the scale and enforcement capabilities of BAFA have changed dramatically over time. In the early 1990s, BAFA used to process around 100,000 applications per year with a staff of about 85 employees. Today, BAFA processes 25,000 applications per year with approximately

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<sup>13</sup> The complete list includes: ballistic test equipment, bomb suits, cloth treated for signature suppression for military use, components for corrosion resistant chemical manufacturing equipment, components for military aero-engines, components for military improvised explosive device disposal equipment, components for nuclear reactors, components for vibration test equipment, compound semiconductor precursor chemicals, corrosion resistant chemical manufacturing equipment, cryptographic software, development equipment for gas turbines, extended temperature range integrated circuits, fibre preppregs, frequency synthesizers, imaging cameras, instrumentation cameras, lubricants, machine tools, mass spectrometers, materials analysis equipment, metal alloy in cylindrical forms, military helmets, military improvised explosive device disposal equipment, non-ferrous alloys, numerical control software, production equipment for global positioning satellite receivers, radiation hardened integrated circuits, semiconductor process equipment, signal generators, sporting gun ammunition, technology for the development of military aircraft head-down displays, technology for the production of pressure transducers, technology for the use of military aircraft head-down displays, triggered spark gaps, and vibration test equipment.

<sup>14</sup> BAFA Export Controls—Brief Outline, Edition 02.05.2005, p.2.

350 employees.<sup>15</sup> If a typical staff member works 200 days, under the first administration approximately 1.5 hours of time was available per application. Under the second, approximately 2.8 days is available per application. It is not, therefore, surprising that many leaks occurred in the early 1990s, but that great compliance can now be achieved given the increase in resources devoted to export control. The pertinent criminal code is enforced by the Customs Criminal Department of Cologne (ZKA).

It is important to understand that, in German law, engaging in commercial trade is treated as a fundamental freedom, and any restriction of this freedom must be justified. Citizens in effect have a basic right to export, though the law carves out exceptions from this right. This philosophy is an important cornerstone to understanding German export control law, because the onus to justify restrictions is placed upon the government, rather than requiring the citizen to proactively secure a privilege that by default is withheld.

National legislation pertaining to the control of military exports includes the Basic Law, the War Weapons Control Act, the Foreign Trade and Payments Act (FTPA), and the Foreign Trade and Payments Ordinance (FTPO).<sup>16</sup> In accordance with German trade philosophy, Section One of the FTPA specifies that, “The trade in goods, services, capital assets, payment transactions and any other types of trade with foreign economic territories, as well as the trade in foreign valuables and gold between German residents (foreign trade and payments) is, in principle, not restricted.” Section Two specifies that, “Restrictions shall be limited in nature and scope to the extent necessary to achieve the objective stated in the authorisation. They shall be framed in such a way that the freedom of economic activity is hampered as little as possible.” Section Seven, however, provides an exception to the general economic liberty of free trade: Legal transactions and acts in foreign trade and payments may be restricted in order to:

1. guarantee the vital security interests of the Federal Republic of Germany,
2. prevent a disturbance of the peaceful coexistence between nations, or
3. prevent a major disruption of the foreign relations of the Federal Republic of Germany.”<sup>17</sup>

It is upon this legal basis that The Foreign Trade and Payments Regulation sets forth specific licensing prohibitions and requirements, including the license types,

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<sup>15</sup> Germany's Export Control Law in the New Millennium, Michael Rietz, April 8, 2002.

<sup>16</sup> Sometimes translated as the, “Foreign Trade and Payments Regulation.”

<sup>17</sup> BAFA Export Controls, op. cit.

application procedures, and decision criterion for approval.<sup>18</sup> Germany recognizes the binding authority of EC 1334/2000, and the persuasive authority of the 1998 European Union Code of Conduct on Arms exports.<sup>19</sup> The policy principles guiding German export policy are outlined in the document, “Political Principles Adopted by the Government of the Federal Republic of Germany for the Export of War Weapons and Other Military Equipment,” set into law on 19 January 2000. Exports are categorized into twenty-two categories, which have been closely harmonized with the EU Military Lists, and in turn the Wassenaar Arrangement.<sup>20</sup> Dual-use lists explicitly contain all corresponding entries in EC 1334/2000, as well as additional dual-use items not listed in EC 1334/2000. German law is, therefore, more restrictive than the European Council regulation requires.

German export law also has an important criminal law component. In a short essay, “Germany’s Export Control Law in the New Millennium”, Michael Rietz has identified a number of shortcomings in the criminal justice system when redressing illegal exports.<sup>21</sup> He notes that the district courts have had difficulty interpreting and applying the penalty law, frequently lack knowledge in trade law, often cannot locate current control lists, and are confronted with trial attorneys well skilled in turning these shortcomings to the defendant’s benefit. The net result is that organizational and procedural limitations significantly reduce the impact of the substantive criminal law. Penalties are light, or trials do not occur. Balancing these shortcomings are an increase in the strictness of the substantive law, which now allows punishments as lengthy as fifteen years. If deterrent effect is a product of outcomes and their likelihoods, the final assessment offers mixed signals. While more extreme punishments are available, they are infrequently realized. While a focused criminal effort may not be deterred by such a system, it may be effective at keeping more people more honest, which may pay a greater

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<sup>18</sup> *Ibid.*

<sup>19</sup> It is not completely clear what legal basis is relied on for recognizing EC 1334/2000. Section Five of the FTFA allows exceptions to the freedom to engage in trade where demanded by international agreements, “Legal transactions and acts in foreign trade and payments may be restricted, and existing restrictions may be repealed, to permit the fulfillment of international agreements approved by the legislative bodies in the form of a federal law.” In theory, Germany could recognize EC 1334/2000 via Section Five. However, Germany in general recognized EU regulations as binding, and so an explicit authorization of EC 1334/2000 is not necessary.

<sup>20</sup> See Report by the Government of the Federal Republic of Germany on Its Policy on Exports of Conventional Military Equipment in 2003 (2003 Military Equipment Export Report).

<sup>21</sup> Michael Rietz, “Germany's Export Control Law in the New Millennium, (Institute for Science and International Security, Washington, DC, April 8, 2002. (Downloaded from <http://www.exportcontrols.org/rietz2002.html>)

dividend in the struggle against illegal exports. Also balancing shortcomings in the judiciary are positive changes in the executive. In 1992, the ZKA was given increased powers to survey postal and electronic communications of exporters suspected of violations.<sup>22</sup> Finally, German law now includes “know-how.” Export controls include technical support, and the transfer of technical knowledge.<sup>23</sup>

### **License Types**

There are three types of licenses in the German export system:

1. Individual License/Maximum Amount License
2. Global Export License
3. General Licenses

Individual Licenses permit the shipment of one or several items to a single receiver as part of a single purchase agreement. The Maximum Amount License is a sub-type of the Individual License, and allows several shipments under a general contract up to an authorized amount. A Global Export License allows the export of a group of items to several consignees. These licenses are granted only to exporters with a demonstrated history of compliance, and a large volume of licenses exports in the previous year. Finally, General Licenses allow the export of specific items to pre-identified countries without prior approval. All exports conducted under the General License must, however, be registered with BAFA. German export authorities recognize Community General Export Authorizations as being one type of General License, and thus exports allowed under EC 1334/2000 are allowed under German export law. As of February 5<sup>th</sup>, 2005 there were seven General Licenses in effect, including one that explicitly implements the Community General Export Authorizations.<sup>24</sup> Finally, it is noteworthy that Germany has instituted a catch-all in their legislation, requiring a license when the exporter has knowledge of actual or intended use for weapons production.<sup>25</sup>

### **Performance Data**

The time taken to process dual-use licenses to non-sensitive countries as specified in EC 1334/2000 Annex II Part III is about two weeks. Countries not listed in the Annex

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<sup>22</sup> Ibid.

<sup>23</sup> Germany's Export Control Law in the New Millennium, By Michael Rietz, April 8, 2002

<sup>24</sup> BAFA Export Controls, *op. cit.*, p.10.

<sup>25</sup> Rietz, *op. cit.*

but that are neither sensitive nor subject to embargo take about four weeks. Those that are either considered sensitive or subject to embargo can take well over a month. Denials of export applications are infrequent. Approximately 0.2% of applications are rejected. Some analysts attribute the low rejection rate to strong communication on license requirements, which prevents filing of an application for a disallowed export.

## France

### National Law and Governing Administrative Body

Compared to other contemporary export control systems, the French system of export controls is both thorough and complex. Thoroughness is achieved by leveraging multiple organizations by competency. Customs and the Ministries of Industry, Economics, Foreign Affairs, and Defense may each play a role in approving a license. Extensive legislation defines the approval process:<sup>26</sup>

1. Règlement (CE) n° 1334/2000 du Conseil du 22 juin 2000 modifié (JO.CE L 159 du 30 juin 2000) modifié par le règlement 2432/2001/CE du Conseil du 20 novembre 2001 (JO. CE L 338 du 20 décembre 2001)

2. Décret n° 2001-1192 du 13 décembre 2001 relatif au contrôle à l'exportation, à l'importation et au transfert de biens et technologies à double usage (JORF du 15 décembre 2001)

3. Arrêté du 13 décembre 2001 relatif au contrôle à l'exportation vers les pays tiers et au transfert vers les Etats membres de la Communauté européenne de biens et technologies à double usage (JORF du 15 décembre 2001)

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<sup>26</sup> France has a long history of export controls. The modern legal system for export controls in France was established in the mid-20<sup>th</sup> century in 1939, and export processes for both conventional and dual-use military goods were significantly shaped by subsequent legislation passed in 1955 reorganizing the CIEEMG, an inter-ministerial review body for regulating exports. Significant legislation was also passed in 1992. The list below provides a short list of historical law of interest to the export scholars.

- Décret-loi du 18 avril 1939 instaurant un régime gouvernant le matériel de guerre, les armes et munitions [Decree of law of 18 April 1939, installing a governmental regime on materials of war, arms, and munitions]
- Décret No. 55-965 du 16 juillet 1955 (abrogeant le Décret 49-770 du 10 juin 1949) réorganisant le CIEEMG [Decree No. 55-965 of 16 July 1955 (replacing the Decree 49-770 of 10 June 1949) reorganizing the CIEEMG]
- Arrête du 2 octobre 1992 relatif à la procédure d'importation et d'export de matériel de guerre, armes et munitions, et matériel assimilé (modifiant inter alia le Décret No 73-364 du 12 mars 1973 et amendements) [Order of 2 October 1992 on the importation and export procedure for materials of war, arms, munitions, and associated materials (modified inter alia by the Decree No 73-364 of 12 March 1973 and amendments)]

4. Arrêté du 13 décembre 2001 relatif à la délivrance d'un certificat international d'importation et d'un certificat de vérification de livraison pour l'importation de biens et technologies à double usage (JORF du 15 décembre 2001)
5. Avis aux importateurs et aux exportateurs de biens et technologies à double usage, JORF du 30 décembre 2001.
6. Imprimé de licence et notice explicative
7. Annexe II du règlement, définissant les conditions d'utilisation de l'autorisation générale communautaire d'exportation n° EU001 (modifiée en dernier lieu par le règlement (CE) n° 1504/2004 du 19 juillet 2004, JO.UE L 281 du 31 août 2004)
8. Formulaire d'autorisation générale communautaire d'exportation n° EU001
9. Arrêté du 18 juillet 2002 relatif à la licence générale " biens industriels " pour l'exportation des biens industriels relevant du contrôle stratégique communautaire (JORF du 30 juillet 2002) modifié par l'arrêté du 21 juin 2004 (JORF du 31 juillet 2004)
10. Arrêté du 18 juillet 2002 relatif à l'exportation des biens à double usage chimiques et à la licence générale " produits chimiques " (JORF du 30 juillet 2002) modifié par l'arrêté du 21 juin 2004 (JORF du 31 juillet 2004)
11. Arrêté du 18 juillet 2002 relatif à la licence générale " graphite " pour l'exportation de graphite de qualité nucléaire (JORF du 30 juillet 2002) modifié par l'arrêté du 21 juin 2004 (JORF du 31 juillet 2004)
12. Tableau des licences générales
13. Arrêté du 24 avril 2002 relatif à l'importation et à l'exportation de produits du tableau 1 et à l'exportation de produits au tableau 3 de la convention du 13 janvier 2003 sur l'interdiction de la mise au point, de la fabrication, du stockage et de l'emploi des armes chimiques et sur leur destruction (JORF du 4 mai 2002)
14. Produits et pays soumis à certificat d'utilisation finale et au titre de la Convention sur l'interdiction de la mise au point, de la fabrication, du stockage et de l'emploi des armes chimiques et sur leur destruction
15. Avis aux exportateurs de certains hélicoptères et de leurs pièces détachées à destination de pays tiers (JORF du 18 mars 1995)
16. Avis aux exportateurs relatif à l'exportation des gaz lacrymogènes et agents anti-émeutes vers les pays tiers (JORF du 28 juin 1995)

17. [Règlement \(CE\) n° 1504/2004 du Conseil du 19 juillet 2004](#) (JO UE L281 du 31 août 2004) : actualisation des listes de biens et technologies à double usage et des annexes du règlement CE n° 1334/2000.

France recognizes the validity of EC 1334/2000, the control lists therein, and the subsequent EU regulations modifying these control lists. It should be noted, however, that the current French export process developed under EU regulation 3381/94 and decision 94/942/CFSP (94/942/PESC in French). Because these regulations were originally under the second pillar of EU law, they did not have the binding effect of EC 1334/2000. It is unclear whether France views the current legislation as satisfying the obligations incurred by EC 1334/2000. Because EC 1334/2000 tightened European control of export legislation, if French laws do change, they are more likely to be strengthened rather than watered down.

The legislation defines a process that works as follows. First, a company wishing to export a dual-use good must submit a request to the SETICE (Service de Titres du Commerce Extérieur) (Foreign Trade Service) within the Direction générale des Douanes (Directorate General of Customs). This organization will ultimately deliver a license or issue a denial, and acts as the principal, but not exclusive, gatekeeper through which industry interfaces with the government.<sup>27</sup> The exporter must also submit to the Secretary of the State for Industry a dossier. This ministry gives a “technical opinion” on the product undergoing review. In the majority of cases (about 5,000 per year), the dossier is sufficient to complete the review process. In a minority of cases (a few hundred per year), closer review is necessary. In these cases, the ministry of Industry will act in consultation with an attaché from the Central Security Service of Information Systems, or Ministry of Agriculture, depending upon the nature of the good. For example, cryptology exports require consultation with the former, and chemical and biological exports call upon the latter.

Depending on the country of destination, the Ministry of Industry may also consult with the Minister of Defense or Minister of Foreign Affairs. In each case, the file will be assigned to a sub-directorate with the appropriate functional competency. Within the Ministry of Defense, the principal reviewing groups are “technical services” and the

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<sup>27</sup> The following discussion borrows and summarizes heavily from RAPPORT D'INFORMATION DÉPOSÉ en application de l'article 145 du Règlement PAR LA COMMISSION DE LA DÉFENSE NATIONALE ET DES FORCES ARMÉES, sur le contrôle des exportations d'armement (April 25, 2000).

Délégation générale pour l'armement (DGA) (Directorate General for Armaments), which is roughly equivalent to a combination of the United States military engineering corps together with the civilian acquisition corps. The DGA, possibly in consultation with other agencies such as the Direction Générale de la Sécurité Extérieure (DGSE) (Directorate General for External Security), an integrated military intelligence service, will make an assessment of the final destination of the proposed export. Here the trustworthiness of the designated receiving country is taken into account. As noted in the commission report:<sup>28</sup>

“l’avis ne sera pas le même si la destination est une usine d’engrais dont on sait qu’elle produit effectivement des engrais, ou une usine à la réputation douteuse dans un pays sulfureux...”

The opinion will not be the same if the destination is a manure factory that is indeed known to be a manure factory, or is a manure factory in a shady (literally, “malodorous”) country ...

In the most sensitive cases, the ministry of Industry consults with the Secrétariat Général de la Défense Nationale (SGDN) (Secretary General of National Defense). It should finally be noted that this process, while not identical, is similar to the Commission Interministérielle pour l’Etude des Exportations de Matériels de Guerre (CIEEMG) (French inter-ministerial commission for the examination of defense-related exports) which is responsible for monitoring conventional weapons exports (non-dual use). Once this process is complete, and each service has rendered an opinion, the file is transmitted to SETICE for delivery of the license or denial to the exporter. In rare cases, if the ministries come to divergent opinions, a meeting referred to as the “CIEEMG monoproduit,” (Single product CIEEMG) is called by the SGDN to hear and resolve disputes.<sup>29</sup>

The French process clearly has the advantage of bringing maximum expertise to bear in the different administrations’ various fields of expertise. The trade-off of a decentralized approval process is increased complexity. Export applications are in the hands of multiple organizations at any given time, and the process therefore has considerable potential for delay.

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<sup>28</sup> Ibid, p. 123.

<sup>29</sup> The name “CIEEMG monoproduit” is a misnomer, because, as noted, the process is distinct from the CIEEMG.

## License Types

There are three types of dual-use export licenses available in the French system:

1. La licence individuelle (The individual license)
2. La licence globale (The global license)
3. La licence générales (The general license)

The individual license is the most common type of license, and is given to an exporter for the export of a particular product to a particular destination. The license is valid for one year. Approximately 5,000 individual licenses are issued each year. The global license, in contrast, is given to an exporter for several destinations or countries of destination, and is neither limited in quantity nor value for the authorized products. The global license is valid for two years. Finally, in accordance with EU law, the general license is given for products and countries specified in Annex II of the Council Decisions. It appears that this license is now provided in accordance with regulation EC 1334/2000 given that the EU's competence to regulate trade has moved from the second to first pillar.<sup>30</sup>

The individual license and global license are primarily devices of French law, while the general license is driven by EU law. The former are thus more illustrative of the French approach to balancing risk and cost. The global license, while giving much great flexibility to exporters, is more restrictive and requires considerable proactive measures on the part of the exporter. First, the exporter must show a general flow of foreign dual use goods; they must have an established business with significant volume to justify needing the license. Second, the license will only be given for "final use" destinations or to distributors that demonstrably apply the control procedures specified by the exporter and are able to discern the distributed final goods' application (i.e., civilian vs. military).<sup>31</sup>

In addition, the exporter must establish internal procedures to verify the nature of materials shipped by destination, procedures to identify companies unlikely to respect dual-use controls, identify those individuals personally responsible with respect to these procedures, and develop an internal audit program for verifying the correct

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<sup>30</sup> The European Court of Justice's ruled that export control of dual-use technology falls under the first rather than second pillar of EU law.

<sup>31</sup> RAPPORT D'INFORMATION DÉPOSÉ en application de l'article 145 du Règlement PAR LA COMMISSION DE LA DÉFENSE NATIONALE ET DES FORCES ARMÉES, sur le contrôle des exportations d'armement (April 25, 2000), page 120.

implementation of the established procedures. Finally, an archive of the operations carried out and a follow up documentary must be made available, on request, to the administration concerning the exports made. Customs enforces the implementation of these systems, and has the power to suspend a global license.<sup>32</sup>

The penalty system in France for non-compliance is among the more severe. Article 414 of the code of customs mixes economic and non-economic penalties to dissuade illegal exports. It allows a penalty of confiscation of the goods, their means of transport, and a fine up to twice the value of the goods. These financial incentives are complemented by imprisonment of responsible persons for up to three years. In the case of particularly dangerous exports, or in the instance of an organized black market (rather than a single, opportunistic export), the financial penalties may be up to five times the value of the goods, and terms of imprisonment can be as long as ten years. For nuclear, biological, and chemical exports, additional sanctions may apply.<sup>33</sup>

### **Performance Data**

Unfortunately, little concrete performance data is available. France is a significant exporter of military goods but does not separate out their dual-use exports from conventional military exports in their reports. Consequently, it is difficult to assess the volume of dual-use exports or their final destinations. Likewise, the time taken to issue dual-use licenses is not published.

## **Ireland**

### **National Law and Governing Administrative Body**

The licensing of dual-use exports is administered by the Department of Enterprise, Trade & Employment (DETE) in consultation with the Department of Foreign Affairs. The regulation of dual-use technology is governed by the Control Exports Act of 1983 and the Control Exports Order of 2000. The relationship between the two is similar to US “Congressional” and “regulatory” law. The former is passed in a formal legislative process and gives a designated administrative body the authority to set regulatory law necessary to implement the Congressional Act. Thus the Order was made under the authority of the 1983 Act and lists the military and paramilitary items subject to export

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<sup>32</sup> Ibid, pp. 120-21.

<sup>33</sup> See [web page]

licensing regulation.<sup>34</sup> The lists directly reference Annex I to Council Decision 94/942/CFSP. However, the European Court of Justice held 94/942/CFSP invalid because it has effectively been replaced by EC 1334/2000. Thus, technically, the Control Exports Order of 2000 does not specifically reference EC 1334/2000. Nevertheless, DETE treats the control lists of EC 1334/2000 as controlling, and, from an administrative perspective, those items controlled by the European Union via EC 1334/2000 have been directly transposed into Irish administrative law. Indeed, the DETE website explicitly refers prospective exporters to these lists as a guide for what technologies require an export license. Irish law also references the EU “highly sensitive list,” and the “Catch-All” provision of 1334/2000. The law makes clear that, “Non-listed Dual-Use items,” are subject to control if DETE advises the exporter that they may be intended for illegal military use, if their final destination is a country subject to an arms embargo, or if the exporter had knowledge that the goods are intended for these purposes.<sup>35</sup> The Irish legislation thus provides an example of an EU nation paying extraordinary deference to EC 1334/2000.

Balancing adherence to the EC 1334/2000 control lists is the relatively weak punitive measures for infractions, an absence of enforcement actions, and a bureaucracy limited in capability by its small size. Economic fines for violations of the Control of Exports Act of 1983 are limited to the greater of €12,700 or three times the value of the goods, and a term of imprisonment not exceeding two years. Lesser punishments are applied for violations of the regulations, though it is not clear how a party violates the Act and not the regulation, or vice versa, and if prosecutions for both are cumulative or mutually exclusive. Part of the ambiguity in the law is the lack of prosecutions. To date, there have been none.<sup>36</sup> The implication is that Irelands export controls may help to keep honest exporters honest but are failing to catch those presently operating below the bar.

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<sup>34</sup> Export Licensing of Military and Dual Use Goods in Ireland, p. 3. See DETE website. <http://www.entemp.ie/publications/trade/2001/exportcontrolguidetoc.htm#relevant>.

<sup>35</sup> The exact regulatory language is: “Non-listed Dual-Use items may be subject to control if the exporter is aware or has been advised by DETE that they may be intended, in their entirety or in part, for use in connection with weapons of mass destruction or the production of missiles capable of delivering such weapons, or, as parts or components of military goods illegally exported. An authorization is also required for the export of non-listed Dual-Use items if the purchasing country or country of final destination is subject to an arms embargo and the goods in question may be intended, in their entirety or part for a military end-use. There is a legal obligation on an exporter to notify the DETE if s/he is aware that the goods are intended, in their entirety or in part, for any of these purposes.”

<sup>36</sup> Export Licensing of Military and Dual Use Goods in Ireland, p. 43.

This may in part be due to the small size of the export control systems staff, which consists of four permanent staff at or above the 50% level, and may utilize additional DETE staff when internal demand is high. More proactive enforcement would necessarily entail a larger office and budget.

### **License Types**

Irish law supports exporting under both “licenses” and “authorizations.” There are two types of licenses: Individual licenses and Global licenses. Individual licenses are for exporting goods to a specific consignee, and allow exports for one year. Global licenses allow the export of dual-use goods for a number of destinations from a specific exporter, but are valid for a half year. In addition, a “National General Authorisation” allows all dual-use exports to specific destinations. The Irish system is therefore a tiered system, and allows a more tailored response by destination. By allowing exports to a pre-determined list of approved countries under a single license, administrative capacity can be focused on controlling exports to countries deemed necessary of more discretionary review. Figure 1 depicts the breakout of different license types and amounts.

With regard to *what* Ireland is exporting, the data indicates a strong focus on Cryptography, including Software (33%), Hardware (18%), and “Technology” (13%). Integrated Circuits also make up nearly a quarter (24%) of export licenses. While the data reflects exports from 2003, they are striking because Cryptography and Integrated Circuits are two of the most hotly protested areas of United States export control. In a sense, the data provides the proverbial “smoking gun”—while the United States prohibited exports of “strong” cryptographic software, other countries were nevertheless able to conduct exports under dual-use controls. And, as will be discussed in further detail later, licenses approving shipments of Cryptographic Software, Hardware, and Technology as well as Integrated Circuits were approved for China, Taiwan, and Hong Kong. Figure 2 summarizes Irish exports.

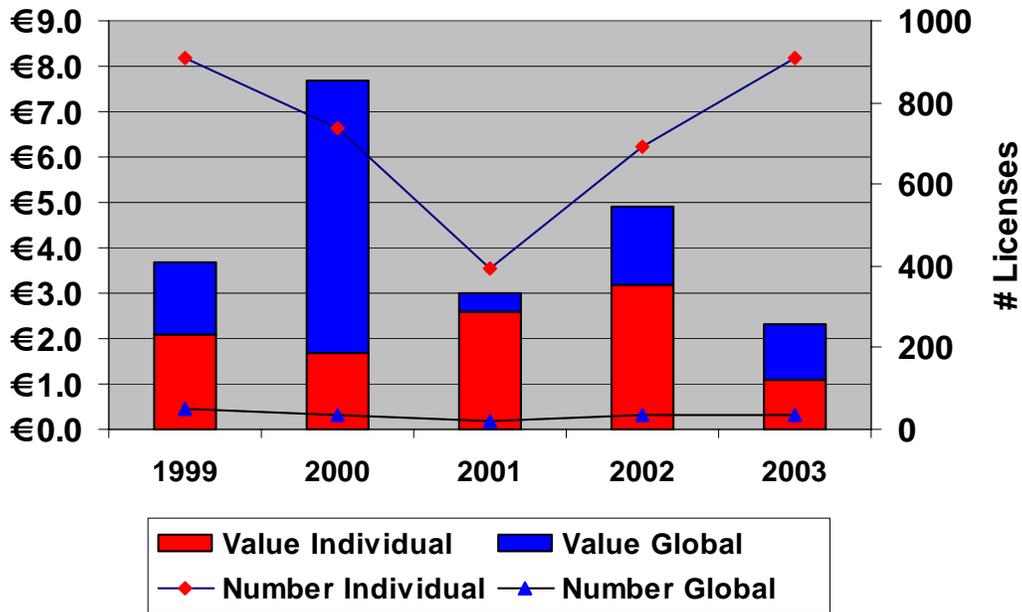


Figure 1: Irish dual use licenses: Individual and Global

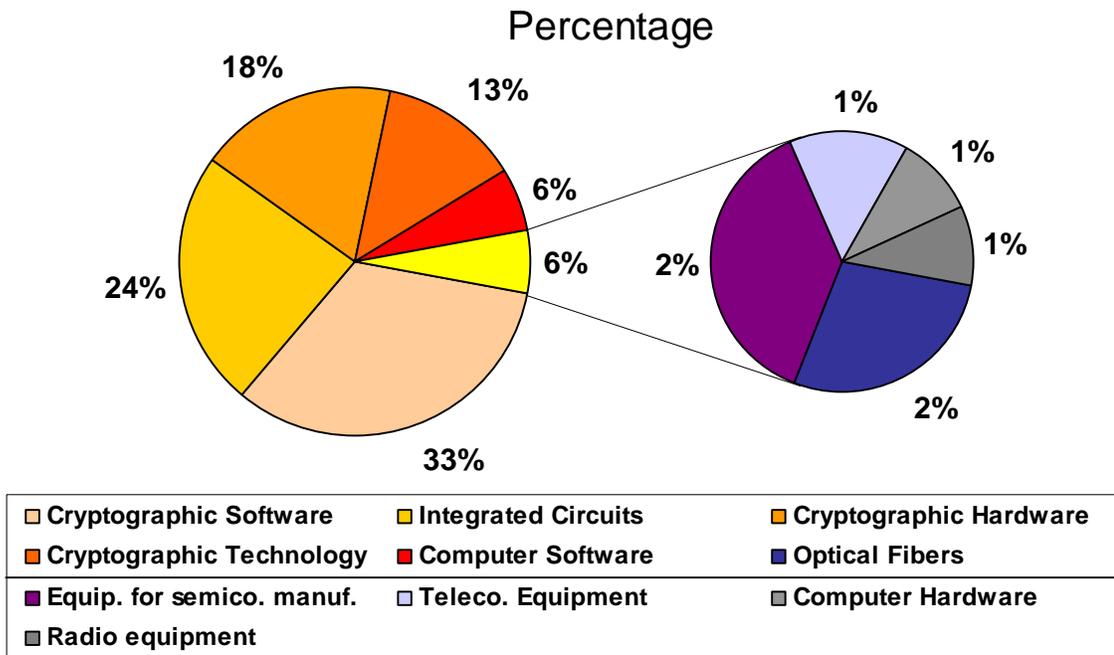


Figure 2: Irish exports by technology type

### Performance Data

In 2003, the Department of Enterprise, Trade and approved 911 individual dual-use licenses and some 37 global dual-use licenses. The total value of the licenses was Euro 1.1 billion and Euro 1.2 billion, respectively. Approvals are generally executed

quickly. The Irish system benefits from centralized authority, which simplifies the application process and focuses dialogue between industry and government. The number of applicants is correspondingly small. According to a report commissioned by the Interdepartmental Group on Export Licensing of Military and Dual-Use Goods in Ireland, the number of companies impacted is small, “About 25 companies apply for dual-use licences. These are generally high-tech companies for whom the products in question are a small proportion of their overall activity in Ireland.”<sup>37</sup> The system has been criticized, however, for a lack of coordination with Customs, a lack of transparency in its decision-making processes, and failure to pro-actively pursue companies that fail to seek export licenses.<sup>38</sup>

### **Exports to China, Hong Kong, and Taiwan**

Because the total value of exports and the number of companies involved is small, it could be argued that the economic impact of export regulation is small. Nevertheless, private industry in Ireland has conveyed concern regarding the possible impact of regulations on the highly competitive International Communications Technology (ICT) sector.

In theory, the Irish regulatory approach also indicates why the Tiananmen Arms Embargo is important. The export of dual-use technologies to countries against which an embargo is in place is strictly prohibited, as is the export of goods with such a country as their final destination. Lifting the embargo would therefore have a real legislative effect. The extent of the practical effect is, however, questionable. As noted, Ireland’s dual-use technology exports to China, Hong Kong, and Taiwan included all Cryptography categories and also Integrated Circuits. China, Taiwan, and Hong Kong ranked first, second, and fifth in total number of individual dual-use licenses granted, collectively accounting for over 37% of all granted.

## **OVERALL EU PERFORMANCE & TRENDS**

### **European Military Exports: Summary of Performance**

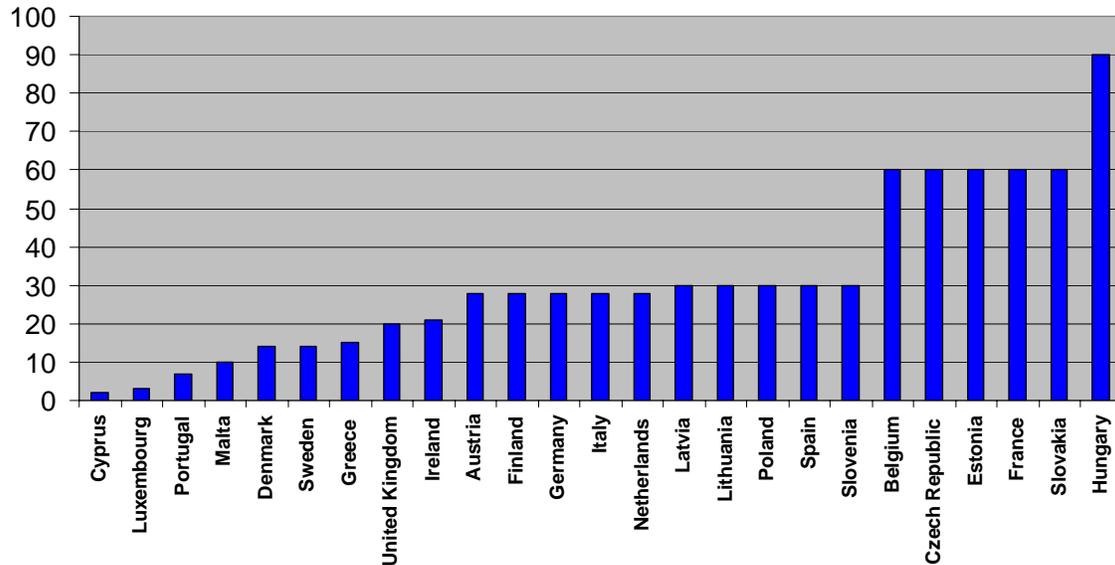
A recent study by the European Commission DG Enterprise provides summary statistics on the performance of EU licensing processes. The study asked each national office to provide the, “Average duration of licensing process.” The results are illustrated

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<sup>37</sup> Export Licensing of Military and Dual-Use Goods in Ireland, p.9.

<sup>38</sup> Export Licensing of Military and Dual-Use Goods in Ireland, p 6.

in the chart.<sup>39</sup> France, United Kingdom, and Czech Republic, have different processing times ranging from 20 to 60 days. Nineteen of the EU-25 have processing times of 30 days or less. Data for all twenty five EU countries appears in Figure 3.



**Figure 3. Average number of days for a military export license across EU countries**

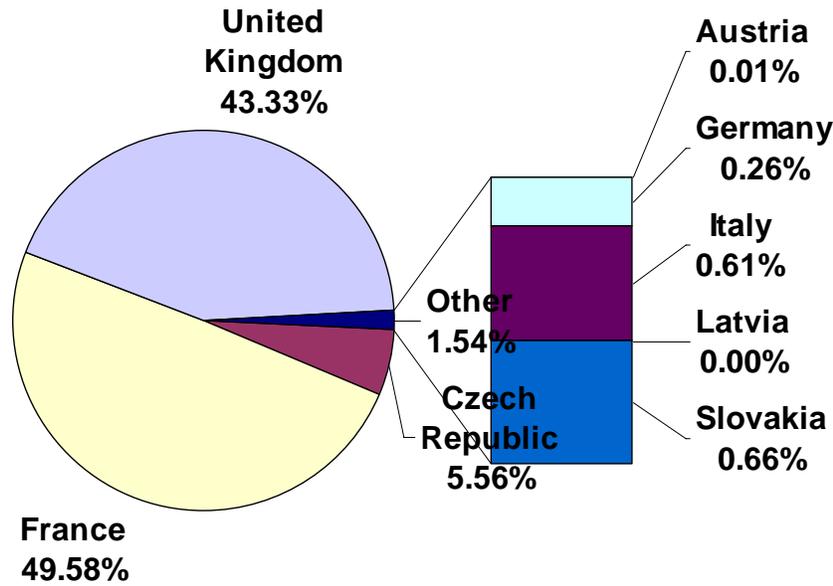
There are inherent limitations in the aggregation of this kind of data. The export of an advanced aircraft and the export of a simple gun are both “exports,” as are exports to friendly nations in NATO and unallied countries such as Pakistan. Nevertheless, United Kingdom and France together make up nearly 90% of military exports, and both provide a diverse array of equipment to both allied and unallied nations. Consequently, their performance statistics “bookend” the competitive landscape of European Exports. If the United States takes significantly longer than 60 days to respond to a license application, US industry is at a clear disadvantage. Similarly, a response of less than three weeks is necessary to provide a competitive advantage. Finally, the “exceptions” to the rule provide a good and surprising target for export controls: While Sweden reports an average of 14 days, it is also reported that when notification and information are provided

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<sup>39</sup> Note that the data provided has several limitations: (1) The data covers all military export licenses, rather than being dual-use specific. Nonetheless, for several countries conventional and dual-use export licenses travel through the same bureaucracy and processes, though the specific criterion evaluated may differ. (2) Some countries gave a “high” and “low” estimate, even though the figure requested was the “average.” Where more than one number was given, the higher of the two was used. (3) Some countries gave different figures for intra-EU and extra-EU licenses. In this case the extra-EU license figures were used.

in advance of the complete application, approvals can be rendered in as little as two hours!

In 2005, the European Union licensed \$341 million Euros (\$428 million) worth of conventional arms for export to China. France, the United Kingdom, and the Czech Republic make up the largest three exporters with 49.6%, 43.3%, and 5.6% of the total, and Austria, Germany, Italy, Latvia, and Slovakia making up the remaining 1.5%. While conventional figures are not determinative of dual use transfers, they do give a good indication of national policy with regards to military transfers in general. It is interesting to note that France and the United Kingdom, two of the stronger proponents for lifting the Tiananmen Embargo both ship approximately \$200 million in conventional arms per year to China, but Germany, which also espouses lifting the ban, ships about \$1 million in conventional arms per year to China.



**Figure 4. EU Conventional Arm Exports to China, by country percentage**

**Assessment of 1334/2000**

The European Commission sponsored an analysis of 1334/2000, and a summary report was released February 20<sup>th</sup> of 2006. This study surveyed both the administrative bodies responsible for the implementation of national legislation established pursuant to EC 1334/2000 and also the private sector companies affected by the legislation. Entitled, “Impact Assessment Study on possible options for the modification of the EU regime on export control of dual-use goods and technologies,” the study assessed six proposed modifications set forth by the Commission:

- A. Identifying the main actors involved in the implementation of Export Controls and collecting feedback from exporters on the implementation of the Regulation
- B. Improving the transparency of the existing National legal and administrative procedures
- C. C.1. Harmonisation of the export authorisation forms used across the EU for individual and Global authorisations  
 C.2. Impact of options to harmonise the conditions of use of the Community General Export Authorisation and National General Licences  
 C.3. The right to apply for a Global export authorisation on adoption by the exporter of an Internal Compliance Programme
- D. Impact of imposing different levels of control on dual-use items entering the EC Custom territory, being in transit or transshipped with a view to being exported
- E. Impact of options for sanctioning illicit brokering of dual-use items
- F. Impact of options to harmonise the implementation of the Catch-All Clause

The results of the study indicate that EU export licenses are not a panacea. According to the study results for task A, “Many exporters said that they had difficulty in understanding and interpreting the dual-use list. They asked for assistance in doing this.” Inconsistencies between nations further complicated the licensing process: “Some Member States are making certain goods licensable under Annex I while other Member States are not.” Multinational corporations also indicated that information exchange within the corporation was unlikely to be affected by 1334/2000, “It was remarked that it is ‘fiction’ to believe authorisations would be applied for in each exchange of technology and that multinational companies should be viewed as one entity, rather than separate companies in the Member States in which they operate.” Inconsistent licensing barriers allowed more sophisticated parties to take advantage of the weakest regulatory regimes, “One company remarked that as they had to apply for authorisations in multiple Member States to export the same products to the same destinations, they sometimes re-routed the goods within the EU to make use of available authorisations in other Member States.”

A critical conclusion is that harmonization is far from complete. Both in terms of what goods are covered, and the relatively difficulty of gaining a license for a listed good, significant differences remain within the membership of the European Union. These variances have significant consequences. Because goods may flow freely within the EU, the advantage of centralized law in 1334/2000 is offset by the need to ensure that the

weakest damns will stem the tide of arms flows. While new member states will be brought into compliance with 1334/2000, thereby improving the regulation of dual use exports, the possible integration of a country with a relatively weak export regime potentially opens a vent for less scrupulous exporters.

Exporters also expressed similar frustrations compared to their US competitors: “Many exporters expressed their concerns and frustrations about the differing procedures and processes Member States employ to approve authorisations, particularly the length of time obtaining an authorisation currently takes. They believed that this impacted on their competitiveness and led to a distortion in trade.” Nevertheless, companies indicated that the system was, “better” than that in the United States, “Overall, companies judged the EU system as comparable to those in Australia, Canada, Japan, and in most areas, better than those in China, Russia and the United States. Many companies who had experience of the US system commented about the complexity of US administrative practises and legislation” Unfortunately, the publicly disclosed report does not delve into greater detail. Nevertheless, the comparison to US export control regimes and indication that the EU systems is “better” than the US system gives some credibility to US industrialists claiming a competitive disadvantage. It is unclear from the report whether multi-national corporations similarly game US and EU export controls in the same way discrepancies within the EU are leveraged to advantage. A real concern should exist given the open acknowledgement of the latter practice, and the number of firms with ownership and operations structures straddling the Atlantic.

### **The Effect of EU Enlargement**

The European Union has been extremely successful at bringing Eastern Europe into compliance with the Wassenaar Arrangement’s framework because joining the EU requires that a prospective member comply with the *acquis communautaire* prior to entry. The *acquis* is the body of law accumulated within the EU so far, and presently consists of 35 chapters including the “Customs Union” (Chapter 29) “External Relations” (Chapter 30), and “Foreign, Security, and Defense Policy” (Chapter 31). The European Code of Conduct on Arms Transfers falls under the *acquis*, and enlargement has included support in helping new members to develop adequate export control regimes so as to satisfy EC 1334/2000. Consequently, one aspect of EU enlargement is the extension of Wassenaar to additional nations, and the transition of those nations from a political agreement in principal to a legal agreement with significant positive incentives. To this end, the United

States should be mindful that EU expansion is perhaps the most effective way to bring the Baltic States into compliance with Wassenaar.

### European Union Perspectives on China

One of the key objectives of the European Union with respect to China is to integrate China into the world economy.<sup>40</sup> The European Union supported China's entry into the WTO, has allocated EUR 250 Million (\$ 300 Million) over five years in EC grants for co-operation initiatives with China from the common External Relations budget, two-way trade surpassed EUR 174 million in 2004, and China is the EU's second largest trading partner after the US while the EU has surpassed the US as China's largest trading partner. The data are summarized in Table 1.

EU25 Merchandise Trade with China	2000	2001	2002	2003	2004	Average growth 2000-2004 (%)
<b>Imports</b>	<b>74.3</b>	<b>81.61</b>	<b>89.60</b>	<b>105.39</b>	<b>126.7</b>	<b>+14.3</b>
	69	9	6	7	37	
<b>Exports</b>	<b>25.7</b>	<b>30.55</b>	<b>34.86</b>	<b>41.169</b>	<b>48.03</b>	<b>+16.9</b>
	58	4	9		9	
	-	-	-	-	-	
<b>Balance</b>	<b>48.61</b>	<b>51.06</b>	<b>54.73</b>	<b>64.228</b>	<b>78.69</b>	
	0	5	7		8	

**Table 1. EU imports and export to China**

The European strategy is one of direct engagement, strongly focused on integration. The fundamental legal basis for these actions is Article 177 of the Treaty of the European Union (TEU) under which the European Community undertakes to foster, "sustainable economic and social development," and, "the smooth and gradual integration of the developing countries into the world economy." Based upon these principles, a dialogue in earnest with the PRC began with the *1985 Trade and Economic Cooperation Agreement*. The agreement provided for regular joint meetings, which eventually matured

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<sup>40</sup> See e.g.: (1) 'Building a comprehensive partnership with China', COM (1998) 181 final of 25.3.1998, (2) 'EU Strategy towards China: Implementation of the 1998 Communication and Future Steps for a more Effective EU Policy', COM (2001) 265 final of 15.5.2001. (3) Commission Working Document, Country Strategy Paper: China (2006)

into the annual summits that now occur each year and show a uniform movement towards increased economic integration and political cooperation.

It is against this background that current EU export policy must play out. Two policy initiatives are telling. The first is the EU movement to lift the Tiananmen arms embargo, and the second is the issuance of a joint EU-China policy statement on arms control, including specifically dual use technologies. These two events bracket a dramatic swing in EU-China relations. They are the bookends to a story that begins with isolation and concludes with integration.

Following the suppression of pro-democracy youth during a demonstration in Tiananmen Square in 1989, the European Union placed an arms embargo on China. Former Chancellor Schröder, breaking with both the Social Democratic Party (SPD) and the foreign minister, Joschka Fischer, recently advocated dropping the embargo. France also supported a lifting of the embargo. French Foreign Minister, Dominique de Villepin argued that, “Our feeling is that the embargo is out of date as relations between Europe and China improve. [Beijing is] a privileged partner and a responsible one.” The United Kingdom and Belgium indicated more reserved support. Finland, Belgium, Portugal and Sweden, however, have voiced opposition, principally citing human rights concerns. The Netherlands and Denmark have “straddled the fence,” appearing concerned but willing to lift the embargo.

Ultimately, the EU did not lift the ban. The United States voiced heavy criticism of the proposed change in position, and some analysts surmise that Britain may have withheld approval, thereby sinking the measure. What is perhaps most significant is to realize that the EU has reached a tipping point on this issue. Vigorous and heavy handed threats by the US Congress, direct protestations by President Bush, and significant admonitions from Secretary of State Condoleeza Rice proved able—but just barely able—to persuade the European Union to defer the issue. The EU statement appears written to allow leaders on both sides to declare victory. It would, however, be a significant error to fail to recognize that while the EU did not lift the ban, the initiative had great support from those countries with the greatest potential for arms exports—both dual use and otherwise.

It is not likely that lifting the embargo will return to the Commissions agenda until 2007, when Germany will hold the presidency for the first half of the year. Even then, Merkel’s ascendancy and renewed diplomatic cooperation between Germany and the United States may further delay a vote. Nevertheless, as Chinese-European economic

integration continues, this contest is likely to eventually be won by China. The only question is when, and the answer is most likely, “not long from now.”

December 9<sup>th</sup>, 2004 marked a significant sea change in EU-China relations with the release of the, “Joint Declaration of the People's Republic of China and the European Union on Nonproliferation and Arms Control.” The agreement consists of ten points plus an Annex, beginning with the recognition of UNSCR 1540. While the declaration focuses on preventing the spread of Weapons of Mass Destruction (WMD) and related technologies, it also makes an explicit reference to conventional arms in the ninth bullet, “Positive and active efforts must also be made to strengthen controls over exports of conventional weapons.” The agreement is noteworthy because it places China on an equal footing with the EU as a “partner” in achieving global stability, “China and the EU, as important forces in the field of international security, bear significant responsibility for the maintenance of international and regional peace, security and stability, and will continue to play a positive role in promoting the international non-proliferation process.” Furthermore, the declaration forecasts a continued intensification of cooperation and partnership, “Strengthening cooperation between China and the EU will be conducive to the multilateral non-proliferation process, as well as to expanding and deepening our comprehensive strategic partnership.”

## **ADDENDUM D: NATIONAL AUTHORITIES**

<b>Nation</b>	<b>Primary Authority</b>
Austria	Ministry of Interior
Belgium	Flemish Region, Walloon Region, Brussels-Capital Region
Switzerland	State Secretariat for Economic Affairs
Cyprus	Ministry of Commerce, Industry and Tourism
Czech Republic	Ministry of Industry and Trade: Licensing Office
Germany	BAFA, Ministry of Economics (Dual-Use) Ministry of Economics and Labor (Conventional)
Denmark	Ministry of Justice
Estonia	Ministry of Foreign Affairs, External Economic Policy Department, Export Control Division
Spain	Ministry of Tourism, Industry and Commerce Ministry of Foreign Affairs (re: “transit” law)
Finland	The Ministry of Defence
France	Ministry of Defence: Strategic Affairs Delegation
Hungary	Dept. of Conventional Arms Trade Control: Hungarian Trade Licensing Office
Ireland	Department of Enterprise, Trade & Employment
Iceland	Ministry of Foreign Affairs
Italy	Ministry of Foreign Affairs UAMA “Unit for Weapons Authorisation”
Liechtenstein	Ministry of Economy
Lithuania	Division of Export Control of Strategic Goods
Luxembourg	Ministry of Foreign Affairs, Licensing Office
Latvia	Ministry of Foreign Affairs Division of Export Control of Strategic Goods
Malta	Trade Services Directorate
Netherlands	Team BKB/CDIU (taxation), Ministry of Financial Affairs
Norway	Ministry of Foreign Affairs
Poland	Ministry of Economy and Labour
Portugal	General Directorate for Armament and Defence Equipments
Sweden	National Inspectorate of Strategic Products
Slovenia	Ministry of Defence
Slovakia	Ministry of Economy
United	DTI Export Control Organization [Check]

Kingdom

## ADDENDUM E: NATIONAL LEGISLATION

<b>Nation</b>	<b>Applicable Legislation</b>
Austria	<ul style="list-style-type: none"><li>• Bundesgesetz vom 18. Oktober 1977 über die Ein-, Aus- und Durchfuhr von Kriegsmaterial Nr. 540/1977 idF Nr. 57/2001 (Federal Law on Imports, Exports and Transit of War Material, BGB1 no. 540/1977</li><li>• Verordnung der Bundesregierung vom 22. November 1922 betreffend Kriegsmaterial Nr. 624/1977 (Federal Government Decree no. 624/1977 ‘on military equipment’ (22 Nov. 1977) )</li><li>• Außenhandelsgesetz, (Foreign Trade Act of 9 March 1995, Legal Gazette 172/1995). (Under authority of the Ministry of Economics)</li></ul>
Belgium	<ul style="list-style-type: none"><li>• Law of 25 March 2003 adapting the Law of 05 August 1991.</li><li>• Special Law of 12 August 2003 adapting the special Law of 08 August 1980 on institutional reforms.</li><li>• Proposition of law of 16 October 2002 to modify the Law of 5 August 1991.</li></ul>
Switzerland	<ul style="list-style-type: none"><li>• Loi fédérale sur le matériel de guerre du 13 décembre 1996</li><li>• Ordonnance sur le matériel de guerre du 25 février 1998</li><li>• Federal law on the control of goods usable for civilian and military purposes and specific military goods of 13 December 1996</li><li>• Ordinance concerning the export, import and transit of dual-use goods and specific military goods of 25 June 1997</li></ul>
Cyprus	<ul style="list-style-type: none"><li>• Ministerial Order 354/2002</li><li>• Ministerial Order 602/2004</li></ul>
Czech Republic	<ul style="list-style-type: none"><li>• Act 38 of 15th of February 1994 to regulate trade in military material with foreign countries and to supplement Act. No. 455/1991 on Small Businesses and Act No. 140/1961 Penal Code. CZ</li></ul>
Germany	<ul style="list-style-type: none"><li>• 89 Decree of the Ministry of Industry and Trade of 12 April 1994</li><li>• Act Implementing Article 26 (2) of the Basic Law (War Weapons Control Act) as amended by the Announcement of 22 November 1990, as amended by Article 3 of the law of 11 October 2002</li><li>• Political Principles Adopted by the Government of the Federal Republic of Germany for the Export of War Weapons and Other Military Equipment, Decision of the Federal Republic of Germany of January 19, 2000</li><li>• Foreign Trade and Payments Act of 28 April 1961 as amended by Article 3 of the Law of 16 August 2002</li><li>• Regulation Implementing the Foreign Trade and Payments Act (Foreign Trade and Payments Regulation – AWW) of 18</li></ul>

	December 1986 as amended by the Announcement of 22 November 1993, as amended by the 61st Regulation Amending the Foreign Trade and Payments Regulation of 26 November 2003
Denmark	The Weapons and Explosives Act No. 67
Estonia	<ul style="list-style-type: none"> <li>• Strategic Goods Act, December 17th 2003, enforced in February 2004</li> <li>• Statutes of Strategic Goods Commission – Regulation No. 26 of the Government of the Republic of January 29th 2004, enforced February 2004</li> <li>• Processing Terms for Individual Import Licenses, Transit Permissions, General Export Authorisation User Certificates for Strategic Goods, Processing Terms and Procedure for State Register of Brokers of Military Goods and List of Documents and Data to be Appended to Requests – Regulation No. 61 of the Government of the Republic of March 9th 2004, enforced March 2004</li> <li>• Establishment of State Register of Brokers of Military Goods and Statutes for Maintenance of Register – Government of the Republic Regulation No. 60 of March 9th 2004, enforced March 2004</li> <li>• EE International Sanctions Act, December 4th 2002, enforced in January 2004</li> </ul>
Greece	<ul style="list-style-type: none"> <li>• The Greek legislation on “Matters related to arms, ammunitions and explosives” exists since September 1993 (N.2168/1993 A-147).</li> <li>• Additional “guidelines” were added in: <ul style="list-style-type: none"> <li>○ September 1995 (N.2334/1995)</li> <li>○ December 1996 (N.2452/1996)</li> <li>○ October 2000 (Ministerial Decision 125 695/E3/5695)</li> <li>○ March 2003 (Ministerial Decision 600/536014).</li> </ul> </li> </ul>
Spain	<ul style="list-style-type: none"> <li>• Real decreto 491/1998, de 27 de marzo, por el que se aprueba el reglamento del comercio exterior de material de defensa y de doble uso</li> <li>• Ley Orgánica 12/1995 de 12 de diciembre, de Represión del Contrabando</li> </ul>
Finland	<ul style="list-style-type: none"> <li>• Decree on the export and transit of defence materiel (108/1997)</li> <li>• Decision of the council of state on the general guidelines for the export and transit of defence materiel (474/1995)</li> <li>• Act on the export and transit of defence materiel (242/1990; amendments up to 900/2002 included)</li> <li>• Firearms Act (1/1998; amendments up to 804/2003 included)</li> </ul>
France	<ul style="list-style-type: none"> <li>• Décret-loi du 18 avril 1939 instaurant un régime gouvernant le materiel de guerre, les armes et munitions</li> <li>• Décret No. 55-965 du 16 juillet 1955 (abrogeant le Décret 49-770 du 10 juin 1949) réorganisant le CIEEMG</li> <li>• Arrête du 2 octobre 1992 relatif à la procédure d’importation et</li> </ul>

	d'export de matériel de guerre, armes et munitions, et matériel assimilé (modifiant inter alia le Décret No 73-364 du 12 mars 1973 et amendements)
Hungary	<ul style="list-style-type: none"> <li>• Loi No. 98-564 du 8 juillet 1998 visant à éliminer les mines Antipersonnel</li> <li>• Décret 95 589 du 6 mai 1995</li> <li>• Government Decree 16/2004 (II. 6.)</li> <li>• Decree 1334/2000 EC (CSFP) HU</li> <li>• 50/2004 Foreign Trade, Dual use goods and technology</li> </ul>
Ireland	<ul style="list-style-type: none"> <li>• Control Exports Act of 1983</li> <li>• Control Exports Order of 2000</li> </ul>
Iceland	<ul style="list-style-type: none"> <li>• Law on export permits of 11 January 1988</li> <li>• Law on weapons of 25 March 1998</li> <li>• Law on air transport of 10 June 1998</li> <li>• Regulation concerning transport of military equipment by air</li> <li>• Regulation on projectile weapons, ammunition</li> </ul>
Italy	<ul style="list-style-type: none"> <li>• Law n. 185, 9 July 1990 on Armaments Export Control, as amended by</li> <li>• Law n. 148, of 17 June 2004 and Decree of the Minister of Defence n. 119, 13 June 2003</li> <li>• Law n. 110, 10 April 1975 on Light Weapons</li> </ul>
Liechtenstein	<ul style="list-style-type: none"> <li>• Loi fédérale sur le matériel de guerre du 13 décembre 1996</li> <li>• Ordonnance sur le matériel de guerre du 25 février 1998</li> <li>• Federal law on the control of goods usable for civilian and military purposes and specific military goods of 13 December 1996</li> <li>• Ordinance concerning the export, import and transit of dual-use goods and specific military goods of 25 June 1997</li> </ul>
Lithuania	<ul style="list-style-type: none"> <li>• Law on the control of strategic goods of 5 April 1995 nr. I-1022 as amended on 29 April 2004 nr. IX-2198.</li> <li>• Government resolution on approval of the licensing rules for strategic goods export, import, transit and intermediation and the rules for control of implementation of strategic goods approved on 22 July 2004 nr. 932.</li> <li>• Government resolution of 2003 which contains the list of strategic goods, both dual-use goods and military equipment. This list is being updated and will be approved soon. The new resolution will only contain and update the list of military equipment.</li> <li>• Several by-laws. Some of these were recently adopted and some are still under preparation.</li> </ul>
Luxembourg	<ul style="list-style-type: none"> <li>• Règlement grand-ducal du 31 octobre 1995 à l'importation, l'export et le transit d'armes, de munitions et de matériel devant servir spécialement à un usage militaire et de la technologie y afférente.</li> </ul>
Latvia	<ul style="list-style-type: none"> <li>• Law on the handling of weapons of 06 June 2002</li> <li>• Law on the circulation of strategic goods April 2004</li> </ul>

- |             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Malta       | <ul style="list-style-type: none"> <li>• Subsidiary Legislation 365.13 Military Equipment (Export Control) Regulations – 1st January, 2002</li> <li>• National Interest (Enabling Powers) Act (CAP. 365) – Amendment to the Manual entitled “List of Military Equipment” in terms of regulation 3 of the Military Equipment (Export Control) Regulations, 2001</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Netherlands | <ul style="list-style-type: none"> <li>• The Import and Export Law (1962)</li> <li>• The Decree on the Export of Strategic Goods (1963) – this decree is not valid anymore, but has been replaced by the Import and Export of Strategic Goods Decree (1997) – the changes include the requirement of an import license of substances related to the Chemical Weapon Convention</li> <li>• The Decree on Financial Transactions of Strategic Goods (1996)</li> <li>• The Decree on Delivery Statement of Strategic Goods – concerns an international import certificate</li> <li>• The Weapons and Munitions Law – overlaps with the Decree on the Export of Strategic Goods</li> </ul>                                                                                                                                                                                                            |
| Norway      | <ul style="list-style-type: none"> <li>• Act of 18 December 1987 relating to Control of the Export of Strategic Goods, Services, Technology, etc.</li> <li>• Regulation of 10 January 1989 laid down by the Ministry of Foreign Affairs relating to the implementation of control of the export of strategic goods, services and technology, as subsequently amended</li> <li>• Guidelines of 28 February 1992 for the Ministry of Foreign Affairs when dealing with applications concerning the export of weapons and military materiel, as well as technology and services for military purposes</li> </ul>                                                                                                                                                                                                                                                                                     |
| Poland      | <ul style="list-style-type: none"> <li>• Control list 1 – Weapons, ammunition and other military materiel</li> <li>• Law of 29 November, 2000</li> <li>• Regulation of the Minister of Economy of 27 February, 2001 on the</li> <li>• Record-Keeping System for Trade in Strategically Relevant Goods</li> <li>• Regulation of the Minister of Economy of 27 February, 2001 on the Procedure of Register-Keeping for the Individual Licenses Issued and the Entrepreneurs Making Use of Global and General Licenses</li> <li>• Regulation of the Minister of Economy of 27 February, 2001 on the List of Certification Units Authorised to Carry on Certification and Inspection of the System of Control and Trade Management</li> <li>• Regulation of the Minister of Economy of 27 February, 2001 on the Specimen of Authorisation to Inspect Trade in Strategically Relevant Goods</li> </ul> |
| Portugal    | <ul style="list-style-type: none"> <li>• Decree-Law 436/91, which establishes the licensing procedures.</li> <li>• Decree 439/94, which contains the list of controlled equipment for both dual use and military goods.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

Sweden

- The Military Equipment Act 1992
- The Military Equipment Ordinance 1992
- List of Military Equipment for combat purposes in accordance with the Military Equipment Act 1992
- Political guidelines on the export of military equipment

- Slovenia
  - Law on defence (RS Official Gazette, Nos. 82/94, 44/97, 87/97, 13/98 - Decree of the RS Constitutional Court, Nos. 33/00, 87/01, 47/02, 67/02, 110/02 and 40/04)
  - Decree on permits and consents for the trade in and production of military weapons and equipment
    - On the basis of Articles 77 and 78 of the Defence Act (Official Gazette, Nos. 82/94, 44/97, 87/97, 13/98 – Constitutional Court Decision, 33/00, 87/01, 47/02, 67/02 and 110/02)
- Slovakia
  - Decree of Ministry of Economics of the Slovak Republic No. 1/2003 from 11. 12. 2002 on execution of some provisions from the Act No. 179/1998 Coll. on trade with military material and on amendment to the Act No. 455/1991 Coll. on small business (Trade License Law) as amended
  - Law No. 179/1998 Coll. on trading with military material and amendment No. 455/1991 Coll. on small business (Trade License Law) as amended
- United Kingdom
  - Export Control Act, 2002.
  - UK Statutory Instrument 2003 No. 2764: Export of Goods, Transfer of Technology and Provision of Technical Assistance (Control) Order 2003

## **ADDENDUM F: EU CODE OF CONDUCT ON ARMS EXPORTS**

The Council of the European Union,

BUILDING on the Common Criteria agreed at the Luxembourg and Lisbon European Councils in 1991 and 1992,

RECOGNISING the special responsibility of arms exporting states,

DETERMINED to set high common standards which should be regarded as the minimum for the management of, and restraint in, conventional arms transfers by all EU Member States, and to strengthen the exchange of relevant information with a view to achieving greater transparency,

DETERMINED to prevent the export of equipment which might be used for internal repression or international aggression, or contribute to regional instability,

WISHING within the framework of the CFSP to reinforce their cooperation and to promote their convergence in the field of conventional arms exports,

NOTING complementary measures taken by the EU against illicit transfers, in the form of the EU Programme for Preventing and Combating Illicit Trafficking in Conventional Arms,

ACKNOWLEDGING the wish of EU Member States to maintain a defence industry as part of their industrial base as well as their defence effort,

RECOGNISING that states have a right to transfer the means of self-defence, consistent with the right of self-defence recognised by the UN Charter,

have adopted the following Code of Conduct and operative provisions:

### **CRITERION ONE**

Respect for the international commitments of EU member states, in particular the sanctions decreed by the UN Security Council and those decreed by the Community, agreements on non-proliferation and other subjects, as well as other international obligations

An export licence should be refused if approval would be inconsistent with, *inter alia*:

a) the international obligations of member states and their commitments to enforce UN, OSCE and EU aenforce UN, OSC

b) the international obligations of member states under the Nuclear Non-Proliferation Treaty, the Biological and Toxin Weapons Convention and the Chemical Weapons Convention;

c) their commitments in the frameworks of the Australia Group, the Missile Technology Control Regime, the Nuclear Suppliers Group and the Wassenaar Arrangement;

d) their commitment not to export any form of anti-personnel landmine.

## CRITERION TWO

The respect of human rights in the country of final destination

Having assessed the recipient country's attitude towards relevant principles established by international human rights instruments, Member States will:

a) not issue an export licence if there is a clear risk that the proposed export might be used for internal repression.

b) exercise special caution and vigilance in issuing licences, on a case-by-case basis and taking account of the nature of the equipment, to countries where serious violations of human rights have been established by the competent bodies of the UN, the Council of Europe or by the EU;

For these purposes, equipment which might be used for internal repression will include, inter alia, equipment where there is evidence of the use of this or similar equipment for internal repression by the proposed end-user, or where there is reason to believe that the equipment will be diverted from its stated end-use or end-user and used for internal repression. In line with operative paragraph 1 of this Code, the nature of the equipment will be considered carefully, particularly if it is intended for internal security purposes.

Internal repression includes, inter alia, torture and other cruel, inhuman and degrading treatment or punishment, summary or arbitrary executions, disappearances, arbitrary detentions and other major violations of human rights and fundamental freedoms as set out in relevant international human rights instruments, including the Universal Declaration on Human Rights and the International Covenant on Civil and Political Rights.

### CRITERION THREE

The internal situation in the country of final destination, as a function of the existence of tensions or armed conflicts

Member States will not allow exports which would provoke or prolong armed conflicts or aggravate existing tensions or conflicts in the country of final destination.

### CRITERION FOUR

Preservation of regional peace, security and stability

Member States will not issue an export licence if there is a clear risk that the intended recipient would use the proposed export aggressively against another country or to assert by force a territorial claim.

When considering these risks, EU Member States will take into account inter alia:

- a) the existence or likelihood of armed conflict between the recipient and another country;
- b) a claim against the territory of a neighbouring country which the recipient has in the past tried or threatened to pursue by means of force;
- c) whether the equipment would be likely to be used other than for the legitimate national security and defence of the recipient;
- d) the need not to affect adversely regional stability in any significant way.

### CRITERION FIVE

The national security of the member states and of territories whose external relations are the responsibility of a Member State, as well as that of friendly and allied countries

Member States will take into account:

- a) the potential effect of the proposed export on their defence and security interests and those of friends, allies and other member states, while recognising that this factor cannot affect consideration of the criteria on respect of human rights and on regional peace, security and stability;
- b) the risk of use of the goods concerned against their forces or those of friends, allies or other member states;
- c) the risk of reverse engineering or unintended technology transfer.

## CRITERION SIX

The behaviour of the buyer country with regard to the international community, as regards in particular to its attitude to terrorism, the nature of its alliances and respect for international law

Member States will take into account inter alia the record of the buyer country with regard to:

- a) its support or encouragement of terrorism and international organised crime;
- b) its compliance with its international commitments, in particular on the non-use of force, including under international humanitarian law applicable to international and non-international conflicts;
- c) its commitment to non-proliferation and other areas of arms control and disarmament, in particular the signature, ratification and implementation of relevant arms control and disarmament conventions referred to in sub-para b) of Criterion One.

## CRITERION SEVEN

The existence of a risk that the equipment will be diverted within the buyer country or re-exported under undesirable conditions

In assessing the impact of the proposed export on the importing country and the risk that exported goods might be diverted to an undesirable end-user, the following will be considered:

- a) the legitimate defence and domestic security interests of the recipient country, including any involvement in UN or other peace-keeping activity;
- b) the technical capability of the recipient country to use the equipment;
- c) the capability of the recipient country to exert effective export controls;
- d) the risk of the arms being re-exported or diverted to terrorist organisations (anti-terrorist equipment would need particularly careful consideration in this context).

## CRITERION EIGHT

The compatibility of the arms exports with the technical and economic capacity of the recipient country, taking into account the desirability that states should achieve their legitimate needs of security and defence with the least diversion for armaments of human and economic resources

Member States will take into account, in the light of information from relevant sources such as UNDP, World Bank, IMF and OECD reports, whether the proposed export would seriously hamper the sustainable development of the recipient country. They will consider in this context the recipient country's relative levels of military and social expenditure, taking into account also any EU or bilateral aid.

#### OPERATIVE PROVISIONS

1. Each EU Member State will assess export licence applications for military equipment made to it on a case-by-case basis against the provisions of the Code of Conduct.

2. This Code will not infringe on the right of Member States to operate more restrictive national policies.

3. EU Member States will circulate through diplomatic channels details of licences refused in accordance with the Code of Conduct for military equipment together with an explanation of why the licence has been refused. The details to be notified are set out in the form of a draft pro-forma at Annex A. Before any Member State grants a licence which has been denied by another Member State or States for an essentially identical transaction within the last three years, it will first consult the Member State or States which issued the denial(s). If following consultations, the Member State nevertheless decides to grant a licence, it will notify the Member State or States issuing the denial(s), giving a detailed explanation of its reasoning.

The decision to transfer or deny the transfer of any item of military equipment will remain at the national discretion of each Member State. A denial of a licence is understood to take place when the member state has refused to authorise the actual sale or physical export of the item of military equipment concerned, where a sale would otherwise have come about, or the conclusion of the relevant contract. For these purposes, a notifiable denial may, in accordance with national procedures, include denial of permission to start negotiations or a negative response to a formal initial enquiry about a specific order.

4. EU Member States will keep such denials and consultations confidential and not to use them for commercial advantage.

5. EU Member States will work for the early adoption of a common list of military equipment covered by the Code, based on similar national and international lists.

Until then, the Code will operate on the basis of national control lists incorporating where appropriate elements from relevant international lists.

6. The criteria in this Code and the consultation procedure provided for by paragraph 3 of the operative provisions will also apply to dual-use goods as specified in Annex 1 of Council Decision 94/942/CFSP as amended, where there are grounds for believing that the end-user of such goods will be the armed forces or internal security forces or similar entities in the recipient country.

7. In order to maximise the efficiency of this Code, EU Member States will work within the framework of the CFSP to reinforce their cooperation and to promote their convergence in the field of conventional arms exports.

8. Each EU Member State will circulate to other EU Partners in confidence an annual report on its defence exports and on its implementation of the Code. These reports will be discussed at an annual meeting held within the framework of the CFSP. The meeting will also review the operation of the Code, identify any improvements which need to be made and submit to the Council a consolidated report, based on contributions from Member States.

9. EU Member States will, as appropriate, assess jointly through the CFSP framework the situation of potential or actual recipients of arms exports from EU Member States, in the light of the principles and criteria of the Code of Conduct.

10. It is recognised that Member States, where appropriate, may also take into account the effect of proposed exports on their economic, social, commercial and industrial interests, but that these factors will not affect the application of the above criteria.

11. EU Member States will use their best endeavours to encourage other arms exporting states to subscribe to the principles of this Code of Conduct.

12. This Code of Conduct and the operative provisions will replace any previous elaboration of the 1991 and 1992 Common Criteria.

**APPENDIX F**

**PROPOSED CHANGES TO CONTROLS  
ON DUAL-USE EXPORTS TO CHINA**

**Bradley Hartfield  
Richard Van Atta**



## SUMMARY

The United States Department of Commerce (DoC) has published a set of proposed rules that expands the regulation and control of exports and re-export of certain goods and technologies to the People's Republic of China<sup>1</sup>. These proposed rules, taken together, comprise a four-part strategy aimed at preventing the export of goods and technologies that could benefit the Chinese military while, at the same time, enhancing purely commercial trade with China. The four provisions are as follows:

- (1) Re-control of exports to China for forty seven categories of items destined for military end-use
- (2) Revisions to the licensing review process for certain items controlled due to proliferation concerns
- (3) New "Validated End-User" certification to allow streamlined export of specified items to approved Chinese companies
- (4) Requirement for end-user certificates for licensed exports to China

The DoC instituted a 120-day review period (July 6 to November 3, 2006) during which they accepted written opinions on the proposed rules.

There is considerable concern among US industry and trade organizations about the potential effects of provisions (1) and (3). The first would require US firms to verify the purely commercial nature of Chinese companies receiving their products or technologies, with a "presumption of denial" for companies that do business with the Chinese military. US industry is concerned about the process by which an exporter can confidently determine the nature of end-use, as well as their potential liability if their products are ultimately put to a military use they did not envision. The third provision, which seeks to facilitate greater trade by "pre-approving" recurring exports to verified commercial trading partners, has been met with a host of questions regarding how available and useful such certification will be.

More generally, there is skepticism about the very nature of the proposed rules. DoC views the new regulations as maintaining US policy in place since the Nixon

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<sup>1</sup> Their formal title, as published in the Federal Register Vol. 71, No. 129, July 6, 2006 is: *Revisions and Clarifications of Export and Reexport Controls for the People's Republic of China (PRC); New Authorization Validated End-User.*

administration of not selling items to the Chinese military,<sup>2</sup> while adding new provisions aimed at increasing commercial trade. DoC also asserts that these new provisions are necessary to bring the United States into compliance with the Wassenaar Arrangement. However, as of this writing, none of the other Wassenaar signatories appears to support these kinds of controls on exports to China (see Appendix E). As a result, US industry expects that these rules, if enacted, would constitute a unilateral constraint on their ability to export to China and confer a competitive advantage on their foreign competitors, without any identifiable, explicit gain in national security. Their concerns include:

- Loss of sales in a key market
- The unilateral nature of the rules, potentially sacrificing business to global competitors without a corresponding gain in security
- Lack of clarity about how, and how well, the co-called Validated End User provisions will work
- New, onerous, yet, undefined, obligations for information gathering about foreign customers
- Open-ended liability for potential actions of independent agents, including customers, shippers, etc.

More broadly, if the proposed regulations inhibit the most advanced and competitive US industries from succeeding in the world's fastest growing economy, it could ultimately diminish their technology advantages. On top of this, the rules could actually be counterproductive for national security if US export restrictions encourage China to develop indigenous capabilities. Would a (possibly) slower moving but more independent China be a greater or lesser risk to United States than a technologically aggressive China with whom our technological, trade, and human relations were broader?

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<sup>2</sup> This would leave unanswered questions such as, if so, why are new controls needed now? Why was an arms embargo necessary after Tiananmen Square in 1989?

## HISTORY

In January, 1996, 28 countries agreed to establish the *Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies*, under which, the export of conventional arms and sensitive dual-use goods and technologies would be made more responsible and secure. Since that time, 12 more countries have signed on. There is an annual plenary meeting of the Wassenaar Arrangement to assess the results of the agreement, consider new issues, and, when necessary, make decisions to better attain the goals of the Arrangement. Meetings are closed and decisions are by consensus.

The meeting of December, 2003 published a *Statement of Understanding* (see Addendum A) which would require the member governments to grant explicit authorization to exporters of dual-use goods to any country against which there is a United Nations Security Council or other regional arms embargo. There are currently embargos of this kind against 15 countries, most of them established by votes of the United Nations Security Council (UNSC). China, however, is subject not to a UNSC embargo—t surprising, as a permanent member of the Security Council—but to two separate arms embargos established independently by the United States and the European Union after the events of Tiananmen Square in 1989. Both the European Union and the United States have maintained their Tiananmen arms embargos on arms to China since.

The 2003 Department of Defense “Annual Report to Congress: Military Power of the People’s Republic of China” expressed new and heightened concern about

**Public Statement from the Wassenaar  
Arrangement plenary meeting,  
December, 2003**

*Concerning end-use oriented controls, Participating States agreed that they should require governmental authorisation for the transfer of non-listed dual-use items to destinations subject to a binding United Nations Security Council (UNSC) arms embargo, any relevant regional arms embargo either binding on Participating States or to which a Participating State has voluntarily adhered, when the items are intended for a military end-user*

*Participating States agreed to support, by all appropriate means, the efforts of the UNSC to prevent illegal arms transfers to terrorist groups and to all governments and groups under UNSC arms embargoes.*

the modernization of the Chinese military.<sup>3</sup> The Chinese military is engaged in a significant and comprehensive modernization program, and it was felt that, in least in part, the Chinese modernization was being supported by their ability to readily import US uncontrolled dual use technology. No observers claim that any viable set of regulations can stop this outright, given the wide foreign availability of equivalent (or superior) products and technologies, but there are some in the US Government who have concluded that a) it can be slowed, and b) the United States does not want its commercial sector to contribute to it.

A series of discussions at the National Security Council (NSC) working group level and an inter-agency process led to a series of drafts (August 2005 and March, 2006) and finally to the development of a set of proposed regulations, which the DoC published in the Federal Register for official review on July 6, 2006. They are formally known as the “Revisions and Clarification of Export and Reexport Controls for the People’s Republic of China (PRC); New Authorization Validated End-User” (71 Federal Register; p. 38,313). Informally, they are often referred to as the “China-catch all.”<sup>4</sup> The DoC has issued these proposed rules as a clarification of that extension to the Wassenaar Arrangement Statement of Understanding. As such, it is considered a multilateral, international obligation which United States companies are required to adhere to, hence on which the DoC is required to develop regulations.

Despite that Statement of Understanding, some observers question how multilateral this will turn out to be. The United States has taken the position that the Statement of Understanding applies first and foremost to China. The other signatories have not. For these regulations to be most effective in restricting PLA access to the products and technologies of concern, all the other Wassenaar Arrangement signatories whose companies sell covered technologies would need to undertake to implement similar restrictions.

As of this writing, there is no indication that other countries have agreed to interpret the Statement of Understand in the way the United States is. It has been suggested that the Department of State has pursued this, but with no public success to

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<sup>3</sup> Specifically cited were precision guidance, Command and Control, advanced materials (carbon fiber, etc.), and avionics.

<sup>4</sup> The Department of Commerce points out that this is a misnomer, in that the items to be newly controlled have been, in their view, reduced to those covered by only forty seven ECCNs. Outside of the US Government, however, “China catch-all” is the near universal phrase to refer to this proposal.

date. DoC has implied that the new German government may be sympathetic and that Germany, and later other Wassenaar countries will come into compliance. However, France and Germany have publicly sought to end the European Union (EU) China embargo, proposing that the human-rights situation which first led to the embargo—the events of 1989, in Tiananmen Square—has significantly improved. The US has made successful efforts at the highest levels to forestall the EU from ending their embargo. A source at an EU embassy reports that despite the apparent majority of EU countries in favor of lifting the embargo, discussions to do so are deadlocked, and that there are no current plans for further discussion.

Based on a reading of the Wassenaar Arrangement documents, it might appear that if the embargo is maintained, the EU would eventually need to implement something analogous to the rules under consideration from the DoC. However, nothing in the Statement of Understanding from December 2003 or the founding documents of the Wassenaar Arrangement indicates a schedule by which member states must come into compliance, and none have yet taken public steps to do so. Furthermore, the EU has argued that this requirement may not even apply in that the original embargo was not authorized under the jurisdiction of the EU.<sup>5</sup>

The DoC has also hinted that Japan will certainly support this effort. According to the head of an industry trade group focusing on export controls, there is some reason to question that outcome. The industry representative reports that two export control experts in the Japanese embassy in Washington recently invited industry representatives in to discuss these proposed rules. He summarizes that discussion by stating that the Japanese appear quite worried about these proposals, in particular the clauses which concern reexporting of goods and technologies. He also reports that the Japanese are not even considering developing new policy in this area.

## **THE PROPOSED REGULATIONS**

The meaning and significance of the regulations which the DoC is proposing is subject to considerable interpretation. In addition, how the rules are to be implemented is not yet clear. Summaries of these proposals, written by various experts experienced in the field of export controls, often contain significant disagreement as to the implications or

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<sup>5</sup> The efficacy of the EU embargo itself is subject to question. Andrew Rettman reports in the EU Observer of October 3, 2006 that “China's new Z-10 attack helicopter ‘would not fly’ without parts from the British-Italian and Franco-German companies, a new report called ‘Arms Without Borders’ by human rights pressure groups, including Amnesty International and Oxfam, says.”

sometimes, even the nature of the rules which BIS has proposed. The remainder of this appendix seeks to characterize the various sides of this discussion, based on analysis of the text of the proposed rules, written commentaries, and meetings with officials at the DoC and with industry representatives.

### **Goals of the Proposal**

At the beginning of their published text, the DoC explains the goals of the proposed rules in the following way:

It is the policy of the United States Government to prevent exports that would make a material contribution to the military capability of the People's Republic of China (PRC), while facilitating U.S. exports to legitimate civil end-users in the PRC. Consistent with this policy, the Bureau of Industry and Security (BIS) proposes to amend the Export Administration Regulations (EAR) by revising and clarifying United States licensing requirements and licensing policy on exports and reexports of goods and technology to the PRC.

In order to meet these goals, BIS has proposed a number of revisions and extensions to EAR. These can be considered as comprising two categories: those which seek to limit or eliminate various kinds of trade, and those which seek to regulate, but expand it. Among those which intend to restrict exports, one provision (identified as ***Provision #1*** in Figure 14) will control items which are currently uncontrolled. Two others (***Provisions #2 and #3***) add or extend controls on items currently already restricted under previous regulations. ***Provisions #4*** is a modification to a current licensing program aimed at streamlining and expanding controlled trade under certain circumstances. The *Expand Exports* column of Figure 14 lists the Validated End-User Program as part of DoC's effort to create regulations that they believe will expand what they consider legitimate trade with China. The diagonal line dividing the expansion of the End-User Certificate Program is intended to indicate that this provision could be viewed as both restricting and expanding trade. In expanding the range of transactions which are covered, Provision 3 restricts trade. However, it would also serve to collect information on Chinese companies that might enable DoC to identify when lengthy investigations are unnecessary. In fact, BIS representatives have said that applicants who first successfully acquire several end-user certificates would likely be in a much stronger position to be approved as a Validated End User.

Restrict Exports		Expand Exports
Newly Controlled Items	Items Already Controlled	
<b>Provision #1</b>  Military End-Use Restriction	<b>Provision #2</b>  New Review Policy for items controlled for National Security reasons	<b>Provision #3</b>  Expansion of End-User Certificate Program
<b>Provision #4</b>  Creation of Validated End-User Program		

**Figure 1. Functional view of Proposed China Catch-all Provisions**

**Provision #1: Military End-Use Restriction**

The most significant change proposed by the DoC concerns the introduction of controls on the export of certain items that are currently uncontrolled. The proposed regulations explain that the basis of such a change lies both in obligations incurred under the Wassenaar Arrangement as well as long-standing US policy.

To strengthen U.S. efforts to prevent U.S. exports to the PRC that would make a material contribution to the PRC’s military capabilities, this rule proposes revisions to the licensing review policy for items controlled on the CCL for reasons of national security (i.e., controlled pursuant to the Wassenaar Arrangement)... Specifically, this rule...reaffirm[s] that the overall policy of the United States for exports to the PRC of these items is to approve exports for civil applications but generally to deny exports that will contribute to the advancement of Chinese military capabilities.

In order to accomplish this, the DoC proposes

... a new control based on knowledge of a military end-use on exports to the PRC of certain CCL items that otherwise do not require a license to the PRC. The items subject to this license requirement will be set forth in a list.

In the text of the rules, the Departments takes pains to show that the list they propose for inclusion is neither arbitrary nor overly expansive nor the criteria unclear.

The additional items that would be subject to this military end-use restriction are based on careful interagency review of items listed on the CCL that currently do not require a license for export to the PRC but have the potential to advance the military capabilities of the PRC. For purposes of serving this revised policy and U.S. commitments as a Participating State in the Wassenaar Arrangement, this rule proposes to define “military end-use” as: incorporation into, or use for the production , design, development, maintenance, operation, installation, or deployment,

repair, overhaul, or refurbishing of items (1) described on the U.S. Munitions List (USML) (22 CFR Part 121, International Traffic in Arms Regulations); (2) described on the Munitions List (IML) (as set out on the Wassenaar Arrangement Web site at <http://www.wassenaar.org>); or (3) listed under Export Control Classification Numbers (ECCNs) ending in “A018” on the CCL in Supplement No. 1 to Part 774 of the EAR.

Finally, they summarize the process which they propose to implement:

Applications to export, reexport, or transfer items controlled pursuant to proposed section 744.21 would be reviewed on a case-by-case basis to determine whether the export, reexport, or transfer would make a material contribution to the military capabilities of the PRC and would result in advancing the country’s military activities contrary to the national security interests of the United States.

**Provision #2: New Review Policy for items controlled for National Security reasons**

The first rule proposes to modify the current licensing policy for items controlled for reasons of national security, chemical and biological proliferation, nuclear nonproliferation and missile technology. These items already require a license for export to China but the revised license standard would apparently be modified to a presumption of denial for items for national security items exported to any party in China. This section is summarized in the Federal Register as follows:

The proposed amendments include a revision to the licensing review policy for items controlled on the Commerce Control List (CCL) for reasons of national security... This rule further proposes to revise the licensing review policy for items controlled for reasons of chemical and biological proliferation, nuclear nonproliferation, and missile technology for export to the PRC, requiring that applications involving such items be reviewed in conjunction with the revised national security licensing policy

**Provision #3: Expansion of End-User Certificate Program**

The United States has required End-User Certificates for a limited number of exports to China in the past. This provision seeks to expand both the range of items covered and the dollar threshold beyond which it comes into force. The DoC summarizes it as follows:

[T]his rule proposes to require exporters to obtain an End-User Certificate, issued by the PRC Ministry of Commerce, for all items that both require a license to the PRC for any reason and exceed a total value of \$5,000. The current PRC End-Use Certificate applies only to items controlled for national security reasons. This rule also proposes to eliminate the current requirement that exporters submit PRC End-User Certificates to BIS with

their license applications but provides that they must retain them for five years.

BIS also suggests that this provision will not just regulate trade, but also increase it, as presented at the end of the ensuing paragraph:

BIS anticipates that this expansion of the End-Use Certificate requirement will facilitate BIS's ability to conduct end-use checks on exports or reexports of controlled goods and technologies to the PRC, consistent with the existing end-use visit understanding with the Government of the PRC. Facilitation of end-use checks should facilitate increased U.S. exports to the PRC.

#### **Provision #4: Creation of Validated End-User Program**

This final provision seeks to create an entirely new authorization which aims to facilitate and expand trade with Chinese customers who are proven to be companies which meet US government criteria as evidenced by examination of their financial and trading records, board members, etc.

To facilitate legitimate exports to civilian end-users, BIS proposes to establish a new authorization for validated end-users. This proposed authorization would allow the export, reexport, and transfer of eligible items to specified end-users in an eligible destination, including the PRC. These validated end-users would be those who meet a number of criteria, including a demonstrated record of engaging only in civil end-use activities and not contributing to the proliferation of weapons of mass destruction or otherwise engaged in activity contrary to U.S. national security or foreign policy interests.

In conjunction with other relevant agencies, BIS proposes to evaluate prospective validated end-users on the basis of a range of specific factors, which include the party's record of exclusive engagement in civil end-use activities; the party's compliance with U.S. export controls; the party's capability to comply with the requirements for VEU; the party's agreement to on-site compliance reviews by representatives of the United States Government; and the party's relationships with U.S and foreign companies. In addition, when evaluating the eligibility of an end-user, agencies would consider the status of export controls in the eligible destination and the support and adherence to multilateral export control regimes of the government of the eligible destination....

The request [for application for VEU status] also should include a description of how each item would be used by the eligible end-user in an eligible destination. Such requests would be accepted from exporters, reexporters and end-users.

BIS proposes to publish on an on-going basis a list of Validated End-Users, the specific items approved for export to those end-users, and eligible destinations.

Finally, the text describes the extensive recordkeeping, reporting and auditing requirements which it envisions.

... prior to the initial export or reexport under authorization VEU, exporters or reexporters would be required to receive and retain certifications from eligible end-users that state that they are informed of and will abide by all VEU end-use restrictions; they have procedures in place to ensure compliance with the terms and conditions of VEU; they will not use items obtained under VEU in any of the prohibited activities ...; and they agree to allow on-site visits by U.S. Government officials to verify their compliance with the conditions of VEU. Validated end-users found to be not in compliance with the requirements of VEU ... will be subject to removal from the list of validated end-users and other action, as appropriate.

In addition, ..., exporters and reexporters who use authorization VEU would be required to submit annual reports to BIS. These reports must include specific information regarding the export or reexport of eligible items to each validated end-user. Exporters, reexporters, and end-users who avail themselves of VEU also would be audited on a routine basis... Upon request by BIS, exporters, reexporters, and validated end-users would be required to allow inspection of records or on-site compliance review.

Provisions 1 and 3 have generated the most concern within industry. We will focus on these two in the discussion below.

**Proposed control based on knowledge of military end-use on exports to China of selected items on the CCL which otherwise do not require a license**

This section has undoubtedly generated the most controversy. Its central provision places new controls on certain CCL items that currently do not require a license for export to the China.

4. Amend §742.4 by revising paragraph (b)(7) to read as follows:

For the People's Republic of China, there is a general policy of approval for license applications to export, reexport, or transfer items to civil end-users. There is a presumption of denial for items that would make a material contribution to the military capabilities of the People's Republic of China. Thus, all license applications for exports, reexports, and transfers to the People's Republic of China will be reviewed on a case-by-case basis to determine whether the export, reexport, or transfer would

make a material contribution to the military capabilities of the People's Republic of China.

The core of this entire regulation is contained in the meaning of the word *material*. Despite the very detailed definition of some of the terms in these proposed changes (e.g., Military end-use), what would constitute a material contribution remains undefined. One plausible meaning is “significant and important, changing in a notable way the capabilities of.” Although this still leaves significant room for interpretation, it does suggest that items put to a relatively mundane military use (e.g., diesel engines) might not be affected.

However, another interpretation is that material here means “of substance, having a physical presence.” Although this would appear to include almost any possible export, it might be seen as thereby allowing the export of “non-material” software and other technologies which are on the list of items explicitly covered. This meaning is therefore unlikely. The point however is that by not clarifying their meaning and intention here, the DoC has made it particularly difficult for companies to know how to respond to this proposal or assess its likely impact. In private discussions, the DoC has made it clear that they intend this to mean virtually *any* military end-use. It appears that their text has not made this clear and it is not always obvious to industry observers.

7. Amend §744.6 by revising paragraph (a)(1)(ii) to read as follows:

No U.S. person, as defined in paragraph (c) of this section, shall, without a license from BIS, knowingly support an export or reexport, or transfer that does not have a license as required by this section or by §744.21. Support means any action, including financing, transportation, and freight forwarding, by which a person facilitates an export, reexport, or transfer without being the actual exporter or reexporter.

This section has also generated significant controversy. It appears to make a great range of direct and indirect players liable for actions not necessarily under their control. Companies have expressed considerable concern about what would constitute due-diligence under this provision. What will be officially required to make sure that a customer is not going to reexport a US product to China? In the Information Technology industry, for example, many products are sold through distributors. In that there are no requirements for third parties (e.g., in Europe, Japan or Malaysia) to adhere to US export controls, how can a company confidently assert they have done due diligence without becoming vulnerable to prosecution at some later date? Industry indicates that they do not feel this is clear. In response to assurance from DoC, industry representatives point out

that regulatory enforcement is completely independent from policy formulation; hence, off-the-record assurances are not found to be fully satisfactory.

This section also implies that licensing is an important part of the new regulation. This appears not to be the case. In our meetings with representatives from the DoC, they made it clear that they expect very few licenses to be issued under this provision, if there is any military end use. They might be issued, for example, for the few items of military end-use that are of clear and singularly humanitarian end-use. Otherwise, items with a likely military end-use, will be turned down. In discussions with the DoC, the view was stated that rather than being turned down, they expect that companies will find it preferable to not apply at all when there is a likelihood of denial. Hence, they envision the need to process relatively few applications.

Continuing on with the main sections of this provision:

§744.21 Restrictions on Certain Military End-uses in the People’s Republic of China (PRC).

(a) *General prohibition.* In addition to the license requirements for items specified on the Commerce Control List (CCL), you may not export, reexport, or transfer any item listed in Supplement No. 2 to Part 744 to the PRC without a license or under a license exception described in paragraph (c) of this section if, at the time of the export, reexport, or transfer, you know, meaning either:

- (1) You have knowledge that the item is intended, entirely or in part, for a “military end-use,” as defined in paragraph (f) of this section, in the PRC; or
- (2) You have been informed by BIS that the item is or may be intended, entirely or in part, for a “military end- use” in the PRC.

This standard of knowledge has generated controversy, at least in part because it is notably different from the version that received unofficial circulation previous to the July 6 publication of the formal proposal. The previous one stipulated that this applied in the case of *direct* knowledge, that is to say, if one knew. The standard currently proposed is if one knows or should have known. Although this change may have profound liability implications for entities all along a supply chain, the actual change is not contained in this version of the text, but rather in a reference to a previously written portion of EAR, the definitional section, §772.1.DEFINITIONS OF TERMS AS USED IN THE EXPORT ADMINISTRATION REGULATIONS (EAR):

Knowledge. Knowledge of a circumstance (the term may be a variant, such as "know," "reason to know," or "reason to believe") includes not only positive knowledge that the circumstance exists or is substantially

certain to occur, but also an awareness of a high probability of its existence or future occurrence. Such awareness is inferred from evidence of the conscious disregard of facts known to a person and is also inferred from a person's willful avoidance of facts. This definition does not apply to part 760 of the EAR (Restrictive Trade Practices or Boycotts).

Unofficially, it appears that this was revised by the Department of Defense during the interagency review which preceded its publication. Although this is clearly a much more exacting standard to meet, DoC notes that all previous export control regulations have this very standard of knowledge.

(b) *Additional prohibition on those informed by BIS.* BIS may inform you either individually by specific notice, through amendment to the EAR published in the Federal Register, or through a separate notice published in the Federal Register, that a license is required for specific exports, reexports, or transfers of any item because there is an unacceptable risk of use in or diversion to military end-use activities in the PRC. Specific notice will be given only by, or at the direction of, the Deputy Assistant Secretary for Export Administration. When such notice is provided orally, it will be followed by written notice within two working days signed by the Deputy Assistant Secretary for Export Administration or the Deputy Assistant Secretary's designee. The absence of BIS notification does not excuse the exporter from compliance with the license requirements of paragraph (a) of this section.

In fact, BIS does propose that rather than seek to determine end-use on their own, companies may apply to BIS for an advisory opinion on the matter. Industry has expressed concern that this process may be quite lengthy, in that the DoC will need to send out such requests to other agencies. There is also some concern that institutional reasons may lead to a frequent response of "we don't know" on the part of the government, leaving industry to resume both the task and the liability.

(c) *License Exception.* The only License Exception that may apply to the prohibitions described in paragraphs (a) and (b) of this section are the provisions of License Exception GOV set forth in §740.11(b)(2)(i) or (ii) of the EAR.

(d) *License application procedure.* When submitting a license application pursuant to this section, you must state in the "additional information" section of the BIS-748P "Multipurpose Application" or its electronic equivalent that "this application is submitted because of the license requirement in §744.21 of the EAR (Restrictions on Certain Military End-uses in the People's Republic of China)." In addition, either in the additional information section of the application or in an attachment to the application, you must include all known information concerning the military end-use of the item(s). If you submit an attachment with your

license application, you must reference the attachment in the additional information section.

This suggests that, if available, applicants must include information which confirms or raises the possibility of military end use. From discussions with DoC, it appears likely that real information on military end-use would lead to the application being denied. It would therefore be preferable to companies in most circumstances to simply not apply.

(e) *License review standards.* (1) Applications to export, reexport, or transfer items described in paragraph (a) of this section will be reviewed on a case-by-case basis to determine whether the export, reexport, or transfer would make a material contribution to the military capabilities of the PRC and would result in advancing the country's military activities contrary to the national security interests of the United States.

(2) Applications may be reviewed under missile technology, nuclear nonproliferation, or chemical and biological weapons review policies if the end-user may be involved in certain proliferation activities.

(3) Applications for items requiring a license for other reasons that are destined to the PRC for a military end- use also will be subject to the review policy stated in paragraph (e) of this section.

(f) In this section, "military end-use" means: incorporation into, or use for the production, design, development, maintenance, operation, installation, or deployment, repair, overhaul, or refurbishing of items:

(1) Described on the U.S. Munitions List (USML) (22 CFR Part 121, International Traffic in Arms Regulations);

(2) Described on the International Munitions List (IML) (as set out on the Wassenaar Arrangement Web site at <http://www.wassenaar.org>); or

(3) Listed under ECCNs ending in "A018" on the Commerce Control List (CCL) in Supplement No. 1 to Part 774 of the EAR.

It is notable that in paragraph (f) "military end-use" is very carefully and precisely defined. Furthermore, most of the words used in that definition are *further* defined in a note clarifying that paragraph:

... "production" means integration, assembling, inspection, or testing; "development" means design, and includes testing and building of prototypes; "maintenance" means performing work to bring an item to its original or designed capacity and efficiency for its intended purpose, and includes testing, measuring, adjusting, inspecting, replacing parts, restoring, calibrating, overhauling; "operation" means to cause to function as intended; "installation" means to make ready for use, and includes connecting, integrating, incorporating, loading software, and

testing; “deployment” means placing in battle formation or appropriate strategic position.

The final issue concerning this provision relates to the actual items to be newly controlled. The proposal includes ten categories (Figure 15), which comprise forty seven ECCN listings. DoC has sought to make it clear that they plan to control what they consider the absolute minimum number of items that would still keep US restricted products and technologies out of Chinese military hands. They say that efforts within the interagency process that led to this list were focused on minimizing the extent of coverage to only those things necessary. In fact, their proposal of July 6 does contain fewer items than the drafts unofficially circulated earlier.

**Supplement No. 2 to Part 744—List of Items Subject to the Military End-Use License Requirement of §744.21**

The following items are subject to the military end-use license requirement in §744.21.

- (1) *Category 1—Materials, Chemicals, Microorganisms, and Toxins*
- (2) *Category 2—Materials Processing*
- (3) *Category 3—Electronics Design, Development and Production*
- (4) *Category 4—Computers*
- (5) *Category 5—(Part 1) Telecommunications*
- (6) *Category 5—(Part 2) Information Security*
- (7) *Category 6—Sensors and Lasers*
- (8) *Category 7—Navigation and Avionics*
- (9) *Category 8—Marine*
- (10) *Category 9—Propulsion Systems, Space Vehicles and Related Equipment*

**Figure 2 Categories of Items Proposed to be Controlled**

It is not clear precisely which items may be restricted and which not until sufficient test cases make clear exactly how the proposed rules will be interpreted. However, the list included in the proposed rules is indicative of the breadth of the proposed revisions.

Examples include:

- Equipment [and related software or technology] specially designed for the production of structural composites, fibers, prepregs and preforms controlled in Category 1, not elsewhere specified.

- Machine tools ... having “positioning accuracies”, with all compensations available, better than 0.010 mm along any linear axis; and... machines tools having the characteristic of one or more contouring “tilting spindles” controlled by 2B991.d.1.a.
- (iii) 2B992 Non-“numerically controlled” machine tools for generating optical quality surfaces

In addition, many competitive products are included under various other categories: electronics, telecommunications hardware and software, information security technologies, and avionics. There has been widespread criticism that the list consists largely or solely of items readily available from sources in Europe or industrialized Asia. If these other countries do not create similar restrictions—and there is no public indication to date that they will—virtually all of the items which US companies would be restricted from exporting would be made up by increased sales from other countries into China or by indigenous development. Although one Department of Defense source has suggested that the cost would be greater to the Chinese or the quality less, their claim appears to be based on a general belief in the superiority of American technology rather than a careful survey of actual worldwide capabilities. Furthermore, some observe that by reducing US industry access to this market, it will encourage countries and companies who may not now be competitive to become so.

If this is true, then it is unlikely that the new rules would provide significantly enhanced security to the United States from a military point-of-view, while risking erosion of security from an economic point-of-view. One may also note that if these kinds of provisions do induce companies outside the United States to become more competitive, this will increase the likelihood that technological advances will occur outside of the US security and economic domains. Among the companies who feel they may be significantly affected by these rules are Cisco, especially regarding their routing and encryption capabilities, and Microsoft, due to the standard encryption in their software and database systems.

DoC states that their goal is to not place controls on items which are readily available elsewhere. Such items may be available in three ways:

1. Indigenous availability, from Chinese-owned companies using native Chinese knowledge, within China
2. Availability within China from companies wholly or partly owned by foreign entities, possibly using technology developed outside China
3. Availability from sources outside of China.

For items among the listed forty seven categories which are available indigenously in China, DoC states that they are very open to considering their removal, before the final rules are published. The mechanism to do so requires a company to submit, during the 120-day review period, documentation which shows that fully equivalent items are available within China. It is their belief that armed with such evidence, it would be difficult for others in the inter-agency review process to not acquiesce.

The second category appears to be more problematic. Final determination here is not straightforward, but would entail considerable judgment and interpretation. For example, depending on interpretation, products and technologies clearly available within China may—or may not—remain on the final list of items which will require a license. These indeterminate goods and technologies include items manufactured in China via partnerships with, or subsidiaries of, companies based in countries outside China. DoC suggests that such situations are too complex to evaluate in the abstract, and can only be determined based on the details of a particular situation.

Most critical to industry is the third category wherein equivalent or near-equivalent goods are available from US competitors around the world. DoC has not indicated that they intend to seek the removal of such items. When these competitors are based in companies based in Wassenaar countries, DoC has suggested that either their representatives or those from the State Department may well talk to the government in question to see if they are willing to exercise some restraint upon the company. With respect to removing such items from the proposed control list, DoC appears to have significantly less confidence that such arguments will prevail, although they say that “if strong foreign availability can be documented, DoC can make a case to remove controls.”

#### **Proposed Creation of a new Validated End User Authorization.**

The overall mandate of the DoC is to enhance trade, and, coupled with their proposal to restrict it, they have added a provision which they suggest would expand “legitimate” trade. BIS summarizes the new regulations in this way:

To facilitate legitimate exports to civilian end-users, BIS proposes to establish a new authorization for validated end-users in section 748.15 of the EAR. This proposed authorization would allow the export, reexport, and transfer of eligible items to specified end-users in an eligible destination, including the PRC. These validated end-users would be those who meet a number of criteria, including a demonstrated record of engaging only in civil end-use activities and not contributing to the

proliferation of weapons of mass destruction or otherwise engaged in activity contrary to U.S. national security or foreign policy interests.

Several industry representatives are encouraged, not surprisingly, by this prospect of streamlining regulations. They like this idea, in theory. In practice, they see potential obstacles. Several of these arise from the actual requirements of the regulations, others concern of how broadly – or narrowly – the DoC will implement this provision. We will take a closer look at the actual text of the covering section, §748.15, and then outline the interpretations and expectations we have heard from representatives of DoC and of Industry.

§748.15 Authorization Validated End-User (VEU).

Authorization Validated End-User (VEU) permits the export, reexport, and transfer to validated end-users of any eligible items that will be used in an eligible destination. Validated end-users are those who have been approved in advance pursuant to the requirements of this section. To be eligible for authorization VEU, exporters, reexporters, and potential validated end-users must adhere to the conditions and restrictions set forth in paragraphs (a) through (f) of this section.

(a) *Eligible end-users.* The only end- users to whom eligible items may be exported, reexported, or transferred under VEU are those validated end-users identified in Supplement No. 7 to Part 748.

DoC commits to publishing and maintaining a list of Validated End Users authorizations, wherein each authorization contains the receiving party, the item(s) so approved and the eligible destination (at this point, the PRC is the only eligible destination).

(1) In evaluating an end-user for eligibility under this authorization, BIS, in consultation with the Departments of State, Energy, and Defense and other agencies, as appropriate, will consider a range of information, including such factors as: The party's record of exclusive engagement in civil end-use activities; the party's compliance with U.S. export controls; the party's capability to comply with the requirements of authorization VEU; the party's agreement to on-site compliance reviews by representatives of the United States Government; and the party's relationships with U.S and foreign companies. In addition, when evaluating the eligibility of an end-user, agencies will consider the status of export controls and the support and adherence to multilateral export control regimes of the government of the eligible destination.

Industry points out that this list of evaluation criteria, although not complete, may cause many Chinese companies which are fully civilian in their business to not apply.

They note that few US companies might accept such site visits and disclosure of internal documents.

There are also questions concerning how many Chinese companies might actually pass such a review; will this be so stringent that only the relatively few Chinese companies with significant American ownership can comply? They point out that if this regulation is primarily for those Chinese entities which maintain a foreign face, and whose boards have a large American or European membership, then its utility may be marginal for most US exporters.

(2) Requests for authorization must be submitted in the form of an advisory opinion request, as described in §748.3(c), and should include a list of items, identified by Export Control Classification Number (ECCN), that exporters or reexporters intend to export, reexport or transfer to an eligible end-user. In addition to the information described in §748.3, the items identified by ECCN should be specified to the extent of the applicable subparagraph of the ECCN entry. The request also should include a description of how each item would be used by the eligible end-user in an eligible destination. Requests for authorization will be accepted from exporters, reexporters and end-users....

The phrasing of this section rules carefully rules out exporting similar but not identical products. Even upgrades to the same product are proscribed – unless approved through a new application. Industry is concerned about the extent to which this may interfere with normal business practices. The need to frequently apply to a potentially lengthy administrative process for what may be minor modifications, is perceived as a competitive disadvantage. No one can say how much that may affect current or future contracts, but in a very competitive marketplace, there is concern that this may reduce US competitiveness in potentially very significant ways.

In discussions with officials at the DoC, it is clear that they take several of these objections seriously. For example, they suggest that if a company has already received licenses, accommodated numerous site visits and is otherwise “behaving well,” the processing of a VEU advisory application will probably take less than 60 days. However, they also note that if a company has not previously applied for any licenses (and hence not received an initial “vetting”), it is probably better to postpone applying for a VEU until several licenses have been received.

DoC also makes it clear, in discussion, that not just upgrades, but also changes in use of an item will require a new VEU application. They suggest that if things are in order, the process will probably be short. However, if the proposed change does not fit

into what DoC views as the importer's technology roadmap, there is likely to be a longer delay in processing and "correspondingly greater chance of denial." This appears to raise the prospect of the US DoC determining which sorts of new product lines or innovations on the part of Chinese industry are appropriate and which are not. One can wonder if this may discourage Chinese companies in fast-moving industries from trying to source from the United States, when viable alternatives may be available.

This also raises questions about the provision of the proposed regulation that, once a VEU is approved, all companies can export that item to that company without any further licensing restriction (pending renewal based upon site visits, audits, etc.). If a slight modification to a product requires a new application, how likely that the products of two companies will be sufficiently identical to preclude the need for each company to independently apply?

VEUs will only be issued after extensive review which confirms that there will be no use or transfer of the goods or technologies which is not in the interests of the United States. For a company that is so approved, one can wonder why that approval is tied so tightly to the specific items listed in the application. The extensive vetting of a company which precedes approval of VEU status will enable the unlimited sale of the approved item to that company, without any sort of license, for all US companies. Despite that, that the concerns about the actions and intentions of the Chinese company will presumably thereby have been addressed, DoC has made it clear that that this will not become a blanket approval for any other products.

DoC also lists several end-use restrictions:

(d) *End-use restrictions.* Items obtained under authorization VEU may not be used for any activities described in part 744. Eligible end-users who obtain items under VEU may only:

- (1) Use such items at the end-user's own facility located in an eligible destination or at a facility located in an eligible destination over which the end- user demonstrates effective control;
- (2) Consume such items during use; or
- (3) Transfer or reexport such items only as authorized by BIS.

This suggests that any change, including a Chinese importer adding a new customer, or a current customer adding a new facility, might void any outstanding VEU approvals, and require a new application. It is not clear who would be responsible and who would be liable for monitoring such on-going changes in China's exploding economy.

This section also includes extensive administrative obligations:

(e) *Certification and recordkeeping.* Prior to the initial export or reexport under authorization VEU, exporters or reexporters must receive and retain end-use certifications from eligible end-users stating that:

(1) They are informed of and will abide by all authorization VEU end-use restrictions;

(2) They have procedures in place to ensure compliance with authorization VEU destination and end-use restrictions;

(3) They will not use items obtained under authorization VEU in any of the prohibited activities described in part 744 of the EAR; and

(4) They agree to allow on-site visits by U.S. Government officials to verify the end-users' compliance with the conditions of authorization VEU.

**Note to paragraph (e) of this section:** These certifications must be retained by exporters or reexporters in accordance with the recordkeeping requirements set forth in part 762 of the EAR.

(f) *Reporting and auditing requirements—(1)(i) Reports.* Exporters and reexporters who use authorization VEU are required to submit annual reports to BIS. These reports must include, for each validated end-user to whom the exporter or reexporter exported or reexported eligible items:

(A) The name and address of any validated end-users to whom the exporters or reexporters exported or reexported eligible items;

(B) The eligible destination to which the items were exported or reexported;

(C) The quantity of such items;

(D) The value of such items; and

(E) The ECCN(s) of such items.

(ii) Reports are due by February 15 of each year, and must cover the period of January 1 through December 31 of the prior year. Packages containing such reports should be marked "Authorization Validated End-User Reports." Reports should be sent to: Office of Export Enforcement, Bureau of Industry and Security, U.S. Department of Commerce, 14th Street and Constitution Avenue, NW., Room H- 4520, Washington, DC 20230.

(2) Audits. Users of authorization VEU will be audited on a routine basis. Upon request by BIS, exporters, reexporters, and validated end-users must allow inspection of records or on-site compliance review....

From summary: In addition, as described in proposed section 748.15(f)(1), exporters and reexporters who use authorization VEU would be required to submit annual reports to BIS. These reports must include specific

information regarding the export or reexport of eligible items to each validated end-user. Exporters, reexporters, and end-users who avail themselves of VEU also would be audited on a routine basis, as described in proposed section 748.15(f)(2) (Audits). Upon request by BIS, exporters, reexporters, and validated end-users would be required to allow inspection of records or on-site compliance review.

The concerns raised here are several:

- The government can intervene, via audit, at any time, to any party in the chain, from supplier to customer. That chain clearly includes exporter, reexporter, importer; some have considered that it will be interpreted to include such other actors as shipping agent, any bank involved in the transaction, and perhaps even more.
- Added costs of oversight and administration<sup>6</sup>
- Added Liability

US industry also points out several other, broader concerns:

- How cooperative will the Chinese Ministry of Commerce be? What are their motivations, if any, for expediting such processing?
- How might current commercial relationships be impaired if this leads to a change in attitude on the part of Chinese customers? For example, if a current or prospective customer feels potentially unwarranted suspicion cast upon them because of the new process, they may be more inclined to look for suppliers who do not put them in such a position. Particularly in the case of lengthy processing or denial, ill-will leading to loss of business is a real possibility.

There are also more general concerns about the extent to which both the US and the Chinese bureaucracies can accommodate these extra tasks. With respect to the United States, industry has expressed concern about a possible backlog in processing and the hope that the DoC will expand their staff to enable it to expeditiously process the additional workload these provisions will entail. At this point, DoC has said that

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<sup>6</sup> Presumably, the BIS assessment of the cost to US industry of these regulations was based on this direct cost. Even with this relatively narrow interpretation, some say that the cost to US industry will exceed \$100 million; hence, BIS should propose these changes as a “major rule,” triggering the attendant requirements for public hearings, etc.

regarding their own capacity to absorb this additional work, there are no current plans to hire new staff, although it is possible that some may be transferred in.

The Chinese bureaucracy is somewhat more opaque. In response to concern about Chinese cooperation, DoC points to the working group established in 2004 between the US Under Secretary of Commerce for Industry and Security and the Vice Minister of Commerce of the PRC. They suggest that these things are currently being worked out between the two countries in that forum.

The first of these meetings, between BIS and the Chinese Ministry of Commerce (Mofcom), was held in Washington, DC in September, 2006. During their time in Washington, the Chinese representatives met with several US companies to privately express their concerns about these proposed regulations. With respect to end-user certificates, Mofcom reports that they have ten people in the entire end-user certificate office and have no plans to expand that number. Furthermore, the visiting Chinese representatives were not sure that their government would be willing to officially certify civilian versus military end uses. At best, this suggests the possibility of significant delays; at worse, a moribund and counter-productive policy.

In fact, there is some reason to believe that this provision may not become problematic. A well-respected industry trade-leader has said from his discussions with many companies, no one in industry believes that the VEU program will be effective. Rather than subject their Chinese customers to a process where they are likely to be rejected, he reports that no one in industry intends to use it. If the DoC would like industry to have more confidence in this provision, these observations suggest they need to define a less open-ended process of examining applicants.

## **POSSIBLE OUTCOMES**

The status of all these changes, as of this writing, is that of a proposal, still subject to modification. The review period for these regulations ended November 3, 2006. Industry will likely submit numerous responses presenting their concerns. DoC will then review those comments. In the case of requests to remove particular items from the list of forty seven ECCNs, due to indigenous availability, DoC has said they will pass well-documented requests to their own engineers to do further research to confirm or disconfirm that availability. Thereafter they will enter into interagency consultations with the Departments of Energy, Defense and State.

It is impossible to know in advance the precise result of those internal negotiations. Important exogenous considerations may arise: PLA support of the upcoming Olympics in China may turn into an unexpected wildcard transforming any reasonable end-use assessment into an impossible challenge. China might seek to negotiate their support of US interests on the UN Security Council in exchange for significant modifications of the proposals. It is even conceivable that the Chinese may attempt to leverage their critical influence with North Korea to press to have these proposals withdrawn.

In the normal course of events, however, we can expect that, at the conclusion of the interagency process, one of four outcomes will prevail:

1. Withdraw the rules.
2. Change the status to “Major Rule” which would entail a different and significantly longer process before final regulations could be promulgated.<sup>7</sup>
3. Modify the rules based on submitted opinions or on developments in the world.
4. Implement the rules in their current form.

It appears safe to say that both the withdrawal of the rules, as well as their taking final form without modification, are unlikely outcomes. Although most observers do not expect this to be recast as a “major rule,” it does appear likely there will be some modifications during the interagency process. We anticipate these will amount to removing certain items from the list of re-controlled items which can be readily sourced elsewhere. However, we expect the regulations will remain substantially intact. If so, it is prudent, despite the uncertainties, to consider the impact such a body of regulations may have.

We concern ourselves primarily with the domains of National Security and Economic Impact with respect to the US industrial base. The four quadrants in Figure 16 lay out a schema in which to consider these issues.

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<sup>7</sup> If the cost to industry of a proposed regulatory change is considered to be over \$100 million per year, the agency proposing it must follow a more elaborate and lengthier process before approval. Some well-positioned observers have estimated that the cost of adherence to these proposed rules would be approximately \$5 million per company, and that the number of companies affected would be well over 20, hence requiring the ‘major rule’ procedures.

	<b>Largely Successful</b>	<b>Unsuccessful</b>
<b>National Security</b>	China's military modernization is significantly slowed	All or nearly all newly controlled technologies turn out to be available to China from other sources or China quickly develops indigenous capability
<b>Economic Impact</b>	<p>The value of products blocked is small, relationships are not impaired, and US and Chinese administrative delays are minimal.</p> <p>VEU approvals lead to increased exports to China, by a larger pool of US exporters.</p>	<p>US and Chinese Government processing of applications is slow and onerous. Customers in China move to US commercial competition to source products from America's overseas competitors.</p> <p>Chinese customers for products not covered massively switch to alternative suppliers, to avoid risk of falling under the regulations, and/or as part of an emotional/political response.</p> <p>Established commercial relationships are ended, new ones not easy to establish.</p> <p>Chinese government makes it clear that although they have formally agreed, they encourage Chinese companies to buy elsewhere, demonstrating that behavior in their own purchases.</p>

**Figure 3. Conceptual Outcomes of the New China Trade Regulations**

The top left quadrant considers the outcome if the national security objectives are largely attained. It describes the possible results of these proposals as significantly impeding the modernization plans of the Chinese military. No one, however, in public or private meetings, has suggested that they expect this outcome.

The top right quadrant summarizes the case where the national security goals are not achieved, suggests that most or perhaps all of the items or technologies covered will be available to China through non-US means in the relatively near future. Most observers see this result as a plausible outcome.

The lower right quadrant points to a set of negative economic, technological and political results which are possible. The Chinese government has made it clear they do not like these proposed policies, and one could argue that they might noticeably strain US-China relations. Economically, these measures could also contribute to a mass shift of sourcing away from the United States and to its competitors—even for innocuous products—if anger or resentment led to a reduction in the attractiveness of buying from America.

Finally, the lower left quadrant envisions relative economic success. The three rules which would restrict trade turn out to be of minor economic impact, while the Validated-End User Program succeeds in expanding exports to China. A DoC

representative has added out that this is part of the attractiveness of the rules to Chinese leaders, as it would give Chinese firms greater access to important materials and technologies, while at the same time reducing foreign pressure to reduce their trade surplus with the United States.

Many are concerned that the risk and severity of the results in the negative column outweigh the likelihood and gain indicated in the positive column. This has led to some questioning about why to institute such rules at all. The DoC, in several open meetings, has sought to focus discussion on the operational requirements which companies would face. Despite repeated concerns expressed by industry to them, they did not try to justify the rules based on expected results<sup>8</sup>. This has created some concern within US industry that the US Government discourages trade by imposing constraints after industry and government had agreed to certain levels of controls, with no identifiable, explicit gain in security. Indeed, the preamble to the rules, as published in the Federal Register, makes no clear claim that these regulations will slow the PLA ability to modernize. Rather, it suggests that in line with past policy, we will take action to not contribute to it. We need to carefully weigh our desire to do that against slow-moving but critical effects which these regulations may have on the US industrial base and the US economy.

One can, in fact, ask what the basis is for assessing or measuring any change in either National Security or the strength of the US industrial base. The answer is not well known. How can one reliably determine, measure and monitor these critical concepts? This is a key issue to address if we are to rationally consider the positive and negative impacts of these regulations, and, more generally, export controls, overall. One should understand as clearly as possible the potential ramifications of the export control policies. The goal would then be to design policies to reduce as much as possible the negative economic effects and uncertainties which industry, perforce, would face, while safeguarding national security in clear and demonstrable ways.<sup>9</sup> For example:

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<sup>8</sup> Confusion regarding the rationale of the regulations that has caused some in industry to speculate that the prime motivation is use the VEU, End-User Certificates and licensing procedures as a way to gather information on Chinese developments that would otherwise be hard to acquire.

<sup>9</sup> Addendum H explores in a preliminary way how one might assess, for example, the proposed VEU program.

- If export controls lead China to have less confidence in the United States as a reliable trade partner, how would that affect US economic well-being, and overall competitiveness in the world?
- China is making unprecedented investment in Science and Technology – how would US economic as well as national security interests be affected if access to new technology was difficult or delayed?
- Might this lead to greater efforts on China’s part to become even more self-sufficient in key technology areas?
- Often it is the most advanced products that lead to the new markets and product categories of tomorrow. Might regulations such as these increase the possibility that US industry may falter in some future technological or consumer revolution?

Competitiveness Theory, developed by Michael Porter and his associates at the Harvard Business School, makes an important and well-argued claim that it is in the intensity of market competition, the serendipitous interaction of individuals and communities through competition and collaboration, and the access to the most advanced markets that truly competitive industries are formed. If deemed export regulations make interaction with the global research community more difficult, visa concerns discourage some of the most talented students in the world from studying in the United States, and these proposed regulations keep some of our most advanced and competitive industries from succeeding in the world’s fastest growing economy of China, how will that affect the US global lead in technology, in industry? Would it ultimately affect our standard of living? National Security concerns are critical, but how can we competently compare such economic and industrial base risks against possible gains in our security? Prudence suggests that neither factor by itself should trump the other, without a careful assessment of likely outcomes.

Beyond the difficulty of assessing the rate of Chinese military modernization *with* versus *without* these regulations, lies another difficulty. If such a rate differential could be confidently determined, how would one translate that into the underlying objective, risk to US National Security interests? Would a slower moving, but alienated—or at least more independent—China be a greater or lesser risk to United States than a technologically aggressive China with whom our technological, trade, and human relations were broader? Ultimately how can we measure and monitor how fungible are the economic activities of others in providing the same or similar capabilities to China? What do we gain and lose if we are not actually able to impair Chinese military

capabilities? Although no one wants US products inside Chinese military equipment, as a society what are we prepared to give up to ensure that that doesn't happen?

**ADDENDUM G: TEXT OF THE WASSENAAR ARRANGEMENT STATEMENT  
OF UNDERSTANDING ON EXPORT CONTROLS TO COUNTRIES  
UNDER EMBARGO**

**Statement of Understanding**

**on**

**Control of Non-Listed Dual-Use Items(1)**

**(Agreed at the 2003 Plenary)**

Participating States will take appropriate measures to ensure that their regulations require authorisation for the transfer of non-listed dual-use items to destinations subject to a binding United Nations Security Council arms embargo, any relevant regional arms embargo either binding on a Participating State or to which a Participating State has voluntarily consented to adhere, when the authorities of the exporting country inform the exporter that the items in question are or may be intended, entirely or in part, for a military end-use.\*

If the exporter is aware that items in question are intended, entirely or in part, for a military end-use,\* the exporter must notify the authorities referred to above, which will decide whether or not it is expedient to make the export concerned subject to authorisation.

For the purpose of such control, each Participating State will determine at domestic level its own definition of the term “military end-use”.\* Participating States are encouraged to share information on these definitions. The definition provided in the footnote will serve as a guide.

Participating States reserve the right to adopt and implement national measures to restrict exports for other reasons of public policy, taking into consideration the principles and objectives of the Wassenaar Arrangement. Participating States may share information on these measures as a regular part of the General Information Exchange.

Participating States decide to exchange information on this type of denials relevant for the purposes of the Wassenaar Arrangement.

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\* Definition of military end-use: In this context the phrase military end-use refers to use in conjunction with an item controlled on the military list of the respective Participating State.



## **ADDENDUM H: MONITORING AND MEASURING THE VALIDATED END-USER PROGRAM**

In order to determine the efficacy of this provision, one might want to monitor such data as:

- Number of VEU requests received
- Number of End-User Certificate or License applications for items which could alternatively be covered under the VEU program
- Average (mean) number of days to process for applications approved
- Average (mean) number of days to process for applications denied
- Percentage of applications approved
- Number of distinct shipments made per VEU (where shipment means event which would have required a new license under the previous regime)
- Number of companies exporting under each VEU
- Average duration of VEU before a company needs to replace it with a modified application.
- Number and trends of foreign and Chinese competitors offering products covered by these regulations
- Sales and profit growth for those competitors versus US companies in those markets

A determination of efficacy could comprise the answers to the following kinds of questions:

- Are US companies growing as fast or faster than their competitors?
- Are Chinese importers approved as Validated End Users fairly quickly?
- Do the items covered allow multiple US exporters to export their goods without further application or delays?
- Is the mean time between the issuance of a VEU and when one must re-apply to gain its successor fairly lengthy?
- If, in fact, a critical aspect of this program is the collection of information, is that information of high quality and material use?
- Do our allies see the success of the program and take steps to implement analogous measures?

**ADDENDUM I: TEXT OF PROPOSED RULES**

**Proposed Revision to the licensing review policy for items controlled on the  
Commerce Control List (CCL) for reasons of national security**

**PART 742 – [AMENDED]**

Amendments and revisions to rules:

2. Amend §742.2 by adding paragraph (b)(4) to read as follows:

**§742.2 Proliferation of Chemical and Biological Weapons.**

\* \* \* \* \*

[38317]

(b) \*\*\*

(4) BIS will review license applications for items described in paragraph (a) of this section in accordance with the licensing policies described in paragraph (b) of this section and the licensing policies in both paragraph (b) of this section and §742.4(b)(7) when those items are destined to the People’s Republic of China.

\* \* \* \* \*

3. Amend §742.3 by adding paragraph (b)(4) to read as follows:

**§742.3 Nuclear nonproliferation.**

\* \* \* \* \*

(b) \*\*\*

(4) BIS will also review license applications for items described in paragraph (a) of this section in accordance with the licensing policies described in paragraph (b) of this section and the licensing policies in both paragraph (b) of this section and §742.4(b)(7) when those items are destined to the People’s Republic of China.

\* \* \* \* \*

4. Amend §742.4 by revising paragraph (b)(7) to read as follows:

**§742.4 National Security.**

\* \* \* \* \*

(b) \*\*\*

(7) For the People’s Republic of China, there is a general policy of approval for license applications to export, reexport, or transfer items to civil end-uses. There is a presumption of denial for items that would make a material contribution to the military capabilities of the People’s Republic of China. ... In addition, license applications may be reviewed under missile technology, nuclear nonproliferation, or chemical and biological weapons review policies, to determine if the end-user may be involved in proliferation activities.

\* \* \* \* \*

5. Amend §742.5 by adding paragraph (b)(4) to read as follows:

**§742.5 Missile Technology.**

\* \* \* \* \*

(b) \*\*\*

(4) BIS will also review license applications for items described in paragraph (a) of this section in accordance with the licensing policies described in paragraph (b) of this section and the licensing policies in both paragraph (b) of this section and section 742.4(b)(7) of the EAR when those items are destined to the People's Republic of China.

\* \* \* \* \*

## **Proposed Control based on knowledge of military end-use on exports to China of selected items on the CCL which otherwise do not require a license**

### **PART 742 – [AMENDED]**

Amendments and revisions to rules:

4. Amend §742.4 by revising paragraph (b)(7) to read as follows:

#### **§742.4 National Security.**

\* \* \* \* \*

(b) \*\*\*

(7) For the People's Republic of China, there is a general policy of approval for license applications to export, reexport, or transfer items to civil end-uses. There is a presumption of denial for items that would make a material contribution to the military capabilities of the People's Republic of China. Thus, all license applications for exports, reexports, and transfers to the People's Republic of China will be reviewed on a case-by-case basis to determine whether the export, reexport, or transfer would make a material contribution to the military capabilities of the People's Republic of China.

\* \* \* \* \*

### **PART 744—[AMENDED]**

7. Amend §744.6 by revising paragraph (a)(1)(ii) to read as follows:

#### **§744.6 Restrictions on certain activities of U.S. persons.**

(a) \*\*\*

(1) \*\*\*

(ii) No U.S. person, as defined in paragraph (c) of this section, shall, without a license from BIS, knowingly support an export or reexport, or transfer that does not have a license as required by this section or by §744.21. Support means any action, including financing, transportation, and freight forwarding, by which a person facilitates an export, reexport, or transfer without being the actual exporter or reexporter.

\* \* \* \* \*

8. Section 744.21 is added to read as follows:

#### **§744.21 Restrictions on Certain Military End-uses in the People's Republic of China (PRC).**

(a) *General prohibition.* In addition to the license requirements for items specified on the Commerce Control List (CCL), you may not export, reexport, or transfer any item listed in Supplement No. 2 to Part 744 to the PRC without a license or under a license exception described in paragraph (c) of this section if, at the time of the export, reexport, or transfer, you know, meaning either:

(1) You have knowledge that the item is intended, entirely or in part, for a "military end-use," as defined in paragraph (f) of this section, in the PRC; or

(2) You have been informed by BIS that the item is or may be intended, entirely or in part, for a “military end- use” in the PRC.

(b) *Additional prohibition on those informed by BIS.* BIS may inform you either individually by specific notice, through amendment to the EAR published in the **Federal Register**, or through a separate notice published in the **Federal Register**, that a license is required for specific exports, reexports, or transfers of any item because there is an unacceptable risk of use in or diversion to military end-use activities in the PRC. Specific notice will be given only by, or at the direction of, the Deputy Assistant Secretary for Export Administration. When such notice is provided orally, it will be followed by written notice within two working days signed by the Deputy Assistant Secretary for Export Administration or the Deputy Assistant Secretary’s designee. The absence of BIS notification does not excuse the exporter from compliance with the license requirements of paragraph (a) of this section.

(c) *License Exception.* The only License Exception that may apply to the prohibitions described in paragraphs (a) and (b) of this section are the provisions of License Exception GOV set forth in §740.11(b)(2)(i) or (ii) of the EAR.

(d) *License application procedure.* When submitting a license application pursuant to this section, you must state in the “additional information” section of the BIS–748P “Multipurpose Application” or its electronic equivalent that “this application is submitted because of the license requirement in §744.21 of the EAR (Restrictions on Certain Military End-uses in the People’s Republic of China).” In addition, either in the additional information section of the application or in an attachment to the application, you must include all known information concerning the military end-use of the item(s). If you submit an attachment with your license application, you must reference the attachment in the additional information section.

(e) *License review standards.* (1) Applications to export, reexport, or transfer items described in paragraph (a) of this section will be reviewed on a case-by-case basis to determine whether the export, reexport, or transfer would make a material contribution to the military capabilities of the PRC and would result in advancing the country’s military activities contrary to the national security interests of the United States.

(2) Applications may be reviewed under missile technology, nuclear [38318] nonproliferation, or chemical and biological weapons review policies if the end-user may be involved in certain proliferation activities.

(3) Applications for items requiring a license for other reasons that are destined to the PRC for a military end- use also will be subject to the review policy stated in paragraph (e) of this section.

(f) In this section, “military end-use” means: incorporation into, or use for the production, design, development, maintenance, operation, installation, or deployment, repair, overhaul, or refurbishing of items:

(1) Described on the U.S. Munitions List (USML) (22 CFR Part 121, International Traffic in Arms Regulations);

(2) Described on the International Munitions List (IML) (as set out on the Wassenaar Arrangement Web site at <http://www.wassenaar.org>); or

(3) Listed under ECCNs ending in “A018” on the Commerce Control List (CCL) in Supplement No. 1 to Part 774 of the EAR.

**Note to paragraph (f) of this section:** For purposes of this section: “production” means integration, assembling, inspection, or testing; “development” means design, and includes testing and building of prototypes; “maintenance” means performing work to bring an item to its original or designed capacity and efficiency for its intended purpose, and includes testing, measuring, adjusting, inspecting, replacing parts, restoring, calibrating, overhauling; “operation” means to cause to function as intended; “installation” means to make ready for use, and includes connecting, integrating, incorporating, loading software, and testing; “deployment” means placing in battle formation or appropriate strategic position.

9. Supplement No. 2 to Part 744 is added to read as follows:

## Full text of Items Subject to the Military End-Use License Requirement (proposed)

### Supplement No. 2 to Part 744—List of Items Subject to the Military End-Use License Requirement of §744.21

The following items are subject to the military end-use license requirement in §744.21.

#### (1) Category 1—Materials, Chemicals, Microorganisms, and Toxins

(i) 1A290 Depleted uranium (any uranium containing less than 0.711% of the isotope U-235) in shipments of more than 1,000 kilograms in the form of shielding contained in X-ray units, radiographic exposure or teletherapy devices, radioactive thermoelectric generators, or packaging for the transportation of radioactive materials.

(ii) 1B999 Equipment controlled by 1B999.e specially designed for the production of structural composites, fibers, prepregs and preforms controlled in Category 1, n.e.s.

(iii) 1C990 Fibrous and filamentary materials, not controlled by 1C010 or 1C210, for use in “composite” structures and with a specific modulus of  $3.18 \times 10^6$ m or greater and a specific tensile strength of  $7.62 \times 10^4$ m or greater.

(iv) 1C995 Mixtures not controlled by 1C350, 1C355 or 1C395 that contain chemicals controlled by 1C350 or 1C355 and medical, analytical, diagnostic, and food testing kits not controlled by 1C350 or 1C395 that contain chemicals controlled by 1C350.d, as follows (see List of Items Controlled), except 1C995.c “Medical, analytical, diagnostic, and food testing kits.” (v) 1C996 Hydraulic fluids containing synthetic hydrocarbon oils, having all the following characteristics (see List of Items Controlled).

(vi) 1D999 Specific software controlled by 1D999.b for equipment controlled by 1B999.e specially designed for the production of structural composites, fibers, prepregs and preforms controlled in Category 1, n.e.s.

(vii) 1D993 “Software” specifically designed for the “development”, “production”, or “use” of equipment or materials controlled by 1C210.b, or 1C990.

(viii) 1E994 “Technology” for the “development”, “production”, or “use” of fibrous and filamentary materials controlled by 1C990.

#### (2) Category 2—Materials Processing

(i) 2A991 Bearings and bearing systems not controlled by 2A001.

(ii) 2B991 Limited to machine tools controlled under 2B991 having “positioning accuracies”, with all compensations available, better than 0.010 mm along any linear axis; and machine tools having the characteristic of one or more contouring “tilting spindles” controlled by 2B991.d.1.a. (iii) 2B992 Non-“numerically controlled” machine tools for generating optical quality surfaces, and specially designed components therefor.

(iv) 2B993 Limited to gear making and/or finishing machinery not controlled by 2B003 capable of producing gears to a quality level of better than AGMA 12.

(v) 2B996 Dimensional inspection or measuring systems or equipment not controlled by 2B006.

#### (3) Category 3—Electronics Design, Development and Production

(i) 3A292 Oscilloscopes and transient recorders other than those controlled by 3A002.a.5, and specially designed components therefor.

(ii) 3A999 Limited to items controlled by 3A999.c.

(iii) 3B991 Equipment not controlled by 3B001 for the manufacture of electronic components and materials, and specially designed components and accessories therefor.

(iv) 3B992 Equipment not controlled by 3B002 for the inspection or testing of electronic components and materials, and specially designed components and accessories therefor.

(v) 3D991 “Software” specially designed for the “development”, “production”, or “use” of electronic devices or

components controlled by 3A991, general purpose electronic equipment controlled by 3A992, or manufacturing and test equipment controlled by 3B991 and 3B992.

(vi) 3E292 “Technology” according to the General Technology Note for the “development”, “production”, or “use” of equipment controlled by 3A292.

(vii) 3E991 “Technology” for the “development”, “production”, or “use” of electronic devices or components controlled by 3A991, general purpose electronic equipment controlled by 3A992, or manufacturing and test equipment controlled by 3B991 or 3B992.

*(4) Category 4—Computers*

(i) 4A994 Limited to computers not controlled by 4A003, with an Adjusted Peak Performance (“APP”) exceeding 0.1 Weighted TeraFLOPS (WT).

(ii) 4D993 “Program” proof and validation “software”, “software” allowing the automatic generation of “source codes”, and operating system “software” not controlled by 4D003 that are specially designed for real time processing equipment.

(iii) 4D994 “Software” specially designed or modified for the “development”, “production” or “use” of equipment controlled by 4A101, 4A994 with an Adjusted Peak Performance (“APP”) exceeding 0.1 Weighted TeraFLOPS (WT), 4B994 and materials controlled by 4C994.

(iv) 4E992 “Technology” for the “development”, “production”, or “use” of equipment controlled by 4A994, as described in this Supplement No. 2 to Part 744, and 4B994, materials controlled by 4C994, or “software” controlled by 4D993 or 4D994.

*(5) Category 5—(Part 1) Telecommunications*

(i) 5A991 Limited to items controlled by 5A991.a., 5A991.b.5., 5A991.b.7. and 5A991.f.

(ii) 5B991 Telecommunications test equipment, n.e.s.

(iii) 5C991 Preforms of glass or of any other material optimized for the manufacture of optical fibers controlled by 5A991.

(iv) 5D991 “Software” specially designed or modified for the “development”, “production”, or “use” of equipment controlled by 5A991 and 5B991.

(v) 5E991 “Technology” for the “development”, “production” or “use” of equipment controlled by 5A991 or 5B991, or “software” controlled by 5D991, and other “technologies” as follows (see List of Items Controlled).

*(6) Category 5—(Part 2) Information Security*

(i) 5A992 Equipment not controlled by 5A002, except mass market encryption commodities and software described in §§742.15(b)(1)(i) and 742.15(b)(2); certain “short-range wireless” commodities and software described in §742.15(b)(3)(ii); and commodities and software with limited cryptographic functionality described in §742.15(b)(3)(iii).

(ii) 5D992 “Information Security” “software” not controlled by 5D002, except mass market encryption commodities and [38319] software described in §§742.15(b)(1)(i) and 742.15(b)(2); certain “short-range wireless” commodities and software described in §742.15(b)(3)(ii); and commodities and software with limited cryptographic functionality described in §742.15(b)(3)(iii).

(iii) 5E992 “Information Security” “technology”, not controlled by 5E002.

*(7) Category 6—Sensors and Lasers*

(i) 6A995 “Lasers”, not controlled by 6A005 or 6A205.

(ii) 6C992 Optical sensing fibers not controlled by 6A002.d.3 which are modified structurally to have a “beat length” of less than 500 mm (high birefringence) or optical sensor materials not described in 6C002.b and having a zinc content

of equal to or more than 6% by mole fraction.

*(8) Category 7—Navigation and Avionics*

(i) 7A994 Other navigation direction finding equipment, airborne communication equipment, all aircraft inertial navigation systems not controlled under 7A003 or 7A103, and other avionic equipment, including parts and components, n.e.s.

(ii) 7B994 Other equipment for the test, inspection, or “production” of navigation and avionics equipment.

(iii) 7D994 “Software”, n.e.s., for the “development”, “production”, or “use” of navigation, airborne communication and other avionics.

(iv) 7E994 “Technology”, n.e.s., for the “development”, “production”, or “use” of navigation, airborne communication, and other avionics equipment.

*(9) Category 8—Marine*

(i) 8A992 Underwater systems or equipment, not controlled by 8A002, and specially designed parts therefor.

(ii) 8D992 “Software” specially designed or modified for the “development”, “production” or “use” of equipment controlled by 8A992.

(iii) 8E992 “Technology” for the “development”, “production” or “use” of equipment controlled by 8A992.

*(10) Category 9—Propulsion Systems, Space Vehicles and Related Equipment*

(i) 9A991 “Aircraft”, n.e.s., and gas turbine engines not controlled by 9A001 or 9A101 and parts and components, n.e.s.

(ii) 9B990 Vibration test equipment and specially designed parts and components, n.e.s.

(iii) 9D990 “Software”, n.e.s., for the “development” or “production” of equipment controlled by 9A990 or 9B990.

(iv) 9D991 “Software”, for the “development” or “production” of equipment controlled by 9A991 or 9B991.

(v) 9E990 “Technology”, n.e.s., for the “development” or “production” or “use” of equipment controlled by 9A990 or 9B990.

(vi) 9E991 “Technology”, for the “development”, “production” or “use” of equipment controlled by 9A991 or 9B991.

## **Proposal to Expand the Use of End-User Certificates**

### **PART 748—[AMENDED]**

11. Section 748.9 is amended:

- a. By revising paragraph (b)(1) introductory text;
- b. By revising paragraph (b)(2) introductory text before the list of countries;
- c. By revising paragraphs (b)(2)(i) and (b)(2)(ii); and
- d. By revising paragraph (c)(1).

The revisions read as follows:

**§748.9 Support Documents for License Applications.**

\* \* \* \* \*

(b) \*\*\*

(1) Does your transaction involve items controlled for national security reasons?

Does your transaction involve items destined for the People's Republic of China (PRC)?

\* \* \* \* \*

(2) Does your transaction involve items controlled for national security reasons destined for one of the following countries? (This applies only to those overseas destinations specifically listed.) If your item is destined for the PRC, does your transaction involve items that require a license to the PRC for any reason?

\* \* \* \* \*

(i) If *yes*, your transaction may require an Import or End-User Certificate. If your transaction involves items destined for the PRC that are controlled to the PRC for any reason, your transaction may require a PRC End-User Certificate. Note that if the destination is the PRC, a Statement of Ultimate Consignee and Purchaser may be substituted for a PRC End-User Certificate when the item to be exported (i.e., replacement parts and sub-assemblies) is for servicing previously exported items and is valued at \$75,000 or less.

(ii) If *no*, your transaction may require a Statement by Ultimate Consignee and Purchaser. Read the remainder of this section, then proceed to §748.11 of the EAR.

(c) *License Applications Requiring Support Documents.* \*\*\*

(1) License applications supported by an Import or End-User Certificate. You may submit your license application upon receipt of a facsimile or other legible copy of the Import or End-User Certificate, provided that no shipment is made against any license issued based upon the Import or End-User Certificate prior to receipt and retention of the original statement by the applicant.

\* \* \* \* \*

12. Section 748.10 is amended:

a. By revising the fourth sentence in paragraph (a);

b. By redesignating paragraph (b)(4) as paragraph (b)(5) and by adding a new paragraph (b)(4) and revising newly designated paragraph (b)(5);

c. By revising paragraph (c)(1);

d. By revising paragraph (c) (3) introductory text; and

e. By revising paragraph (g). The additions and revisions read as follows:

**§748.10 Import and End-User Certificates.**

(a) *Scope.* \*\*\* This section describes exceptions and relationships true for both Import and End-User Certificates, and applies only to transactions involving national security controlled items destined for one of the countries identified in §748.9(b)(2) of this part, or, in the case of the PRC, for all items that require a license to the PRC for any reason.

(b) \*\*\*

(4) Your transaction involves an export to the People's Republic of China (PRC) of commodities and software classified in a single entry on the CCL, the total value of which exceeds \$5,000. Note that this \$5,000 threshold does not apply to exports to the PRC of computers, which are subject to the provisions of §748.10(b)(3).

(i) Your license application may list several separate CCL entries. If the total value of entries that require a license to

the PRC for any reason on the CCL on a license application exceeds \$5,000, then a PRC End-User Certificate covering all controlled items on your license application must be obtained;

(ii) You may be specifically requested by BIS to obtain an End-User Certificate for a transaction valued under \$5,000 or for a transaction that requires a license to the PRC for reasons in the EAR other than those listed on the CCL.

(5) Your transaction involves a destination other than the PRC and your license application involves the export of commodities and software classified in a single entry on the CCL, the total value of which exceeds \$5,000.

(i) Your license application may list several separate CCL entries. If any entry controlled for national security reasons exceeds \$5,000, then an Import Certificate must be obtained covering all items controlled for national security reasons on your license application;

(ii) If your license application involves a lesser transaction that is part of a larger order for items controlled for national security reasons in a single ECCN exceeding \$5,000, an Import Certificate must be obtained.

(iii) You may be specifically requested by BIS to obtain an Import Certificate for a transaction valued under \$5,000.

(c) *How to obtain an Import or End- User Certificate.* (1) Applicants must [38320] request that the importer (e.g., ultimate consignee or purchaser) obtain the Import or End-User Certificate, and that it be issued covering only those items that are controlled for national security reasons. Note that in the case of the PRC, applicants must request that the importer obtain an End-User Certificate for all items on a license application that are controlled to the PRC for any reason on the CCL. Importers should not be requested, except in the case of the PRC, to obtain an Import or End-User Certificate for items that are controlled for reasons other than national security. Applicants must obtain original Import or End-User Certificates from importers.

\*\*\*\*\*

(3) If your transaction requires the support of a PRC End-User Certificate, you must ensure that the following information is included on the PRC End-User Certificate signed by an official of the Department of Scientific and Technological Development and Trade in Technology of the PRC Ministry of Commerce (MOFCOM), with MOFCOM's seal affixed to it:

\*\*\*\*\*

(g) *Submission of Import and End- User Certificates.* Certificates must be retained on file by the applicant in accordance with the recordkeeping provisions of part 762 of the EAR, and should not be submitted with the license application. For more information on what Import and End- user Certificate information must be included in license applications, refer to §748.9(c) of the EAR. In addition, as set forth in §748.12(e), to assist in license reviews, BIS will require applicants, on a random basis, to submit specific original Import and End-user Certificates.

\*\*\*\*\*

**§748.12 [Amended]**

13. Section 748.12 is amended by removing and reserving paragraph (a).

14. Supplement No. 4 to Part 748, is amended by revising the entry for ‘‘China, People’s Republic of’’, to read as follows:

**Supplement No. 4 to Part 748— Authorities Administering Import Certificate/Delivery Verification (IC/DV) and End-Use Certificate Systems in Foreign Countries**

Country	IC/DV authorities	System administered
China, People’s Republic of...	Export Control Division I Department of S&T No. 2 Dong Chang An Street Beijing Phone: 8610-6519-7366 Fax: 8610-6519-7926	PRC End-User Certificate
	* * * * *	

## Proposed Creation of a new Validated End User Authorization

### §748.15 Authorization Validated End-User (VEU).

Authorization Validated End-User (VEU) permits the export, reexport, and transfer to validated end-users of any eligible items that will be used in an eligible destination. Validated end-users are those who have been approved in advance pursuant to the requirements of this section. To be eligible for authorization VEU, exporters, reexporters, and potential validated end-users must adhere to the conditions and restrictions set forth in paragraphs (a) through (f) of this section.

(a) *Eligible end-users.* The only end- users to whom eligible items may be exported, reexported, or transferred under VEU are those validated end- users identified in Supplement No. 7 to Part 748.

(1) In evaluating an end-user for eligibility under this authorization, BIS, in consultation with the Departments of State, Energy, and Defense and other agencies, as appropriate, will consider a range of information, including such factors as: The party's record of exclusive engagement in civil end-use activities; the party's compliance with U.S. export controls; the party's capability to comply with the requirements of authorization VEU; the party's agreement to on-site compliance reviews by representatives of the United States Government; and the party's relationships with U.S and foreign companies. In addition, when evaluating the eligibility of an end-user, agencies will consider the status of export controls and the support and adherence to multilateral export control regimes of the government of the eligible destination.

(2) Requests for authorization must be submitted in the form of an advisory opinion request, as described in §748.3(c), and should include a list of items, identified by Export Control Classification Number (ECCN), that exporters or reexporters intend to export, reexport or transfer to an eligible end-user. In addition to the information described in §748.3, the items identified by ECCN should be specified to the extent of the applicable subparagraph of the ECCN entry. The request also should include a description of how each item would be used by the eligible end-user in an eligible destination. Requests for authorization will be accepted from exporters, reexporters and end-users. Submit the request to: The Office of Exporter Services, Bureau of Industry and Security, U.S. Department of Commerce, 14th Street and Pennsylvania Avenue, NW., Room 2075, Washington, DC 20230; or to

The Office of Exporter Services, Bureau of Industry and Security, U.S. Department of Commerce, P.O. Box 273, Washington, DC 20044.

Mark the package sent to either address "Request for Authorization Validated End-User".

(3) Exports, reexports, or transfers made under authorization VEU may only be made to an end-user listed in Supplement No. 7 to Part 748 if the items will be consigned to and for use by the validated end-user.

(b) *Eligible destinations.*

Authorization VEU may be used for the following destinations:

(1) The People's Republic of China.

(2) [Reserved].

(c) *Item restrictions.* (1) Items controlled under the EAR for missile technology (MT) and crime control (CC) reasons may not be exported or reexported under this authorization.

(d) *End-use restrictions.* Items obtained under authorization VEU may not be used for any activities described in part 744. Eligible end-users who obtain items under VEU may only:

(1) Use such items at the end-user's own facility located in an eligible destination or at a facility located in an eligible destination over which the end- user demonstrates effective control;

(2) Consume such items during use; or

(3) Transfer or reexport such items only as authorized by BIS.

[38321] (e) *Certification and recordkeeping.* Prior to the initial export or reexport under authorization VEU, exporters or reexporters must receive and retain end- use certifications from eligible end-users stating that:

- (1) They are informed of and will abide by all authorization VEU end-use restrictions;
- (2) They have procedures in place to ensure compliance with authorization VEU destination and end-use restrictions;
- (3) They will not use items obtained under authorization VEU in any of the prohibited activities described in part 744 of the EAR; and
- (4) They agree to allow on-site visits by U.S. Government officials to verify the end-users' compliance with the conditions of authorization VEU.

**Note to paragraph (e) of this section:** These certifications must be retained by exporters or reexporters in accordance with the recordkeeping requirements set forth in part 762 of the EAR.

(f) *Reporting and auditing requirements—(1)(i) Reports.* Exporters and reexporters who use authorization VEU are required to submit annual reports to BIS. These reports must include, for each validated end-user to whom the exporter or reexporter exported or reexported eligible items:

- (A) The name and address of any validated end-users to whom the exporters or reexporters exported or reexported eligible items;
- (B) The eligible destination to which the items were exported or reexported;
- (C) The quantity of such items;
- (D) The value of such items; and
- (E) The ECCN(s) of such items.

(ii) Reports are due by February 15 of each year, and must cover the period of January 1 through December 31 of the prior year. Packages containing such reports should be marked "Authorization Validated End-User Reports." Reports should be sent to: Office of Export Enforcement, Bureau of Industry and Security, U.S. Department of Commerce, 14th Street and Constitution Avenue, NW., Room H- 4520, Washington, DC 20230.

(2) Audits. Users of authorization VEU will be audited on a routine basis. Upon request by BIS, exporters, reexporters, and validated end-users must allow inspection of records or on-site compliance reviews. For audit purposes, records, including information identified in paragraphs (e), (f)(1) and the note to paragraph (c) of this section, should be retained in accordance with the recordkeeping requirements set forth in part 762 of the EAR.

12. Supplement No. 7 to Part 748 is added to read as follows:

**Supplement No. 7 to Part 748— Authorization Validated End-User (VEU): List of Validated End-Users, Respective Eligible Items and Eligible Destinations**

**Validated End-Users, Respective Eligible Items and Eligible Destinations for Exports and Reexports Under Authorization VEU:**

*Certified End-User*

*Eligible Items*

*Eligible Destination*



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