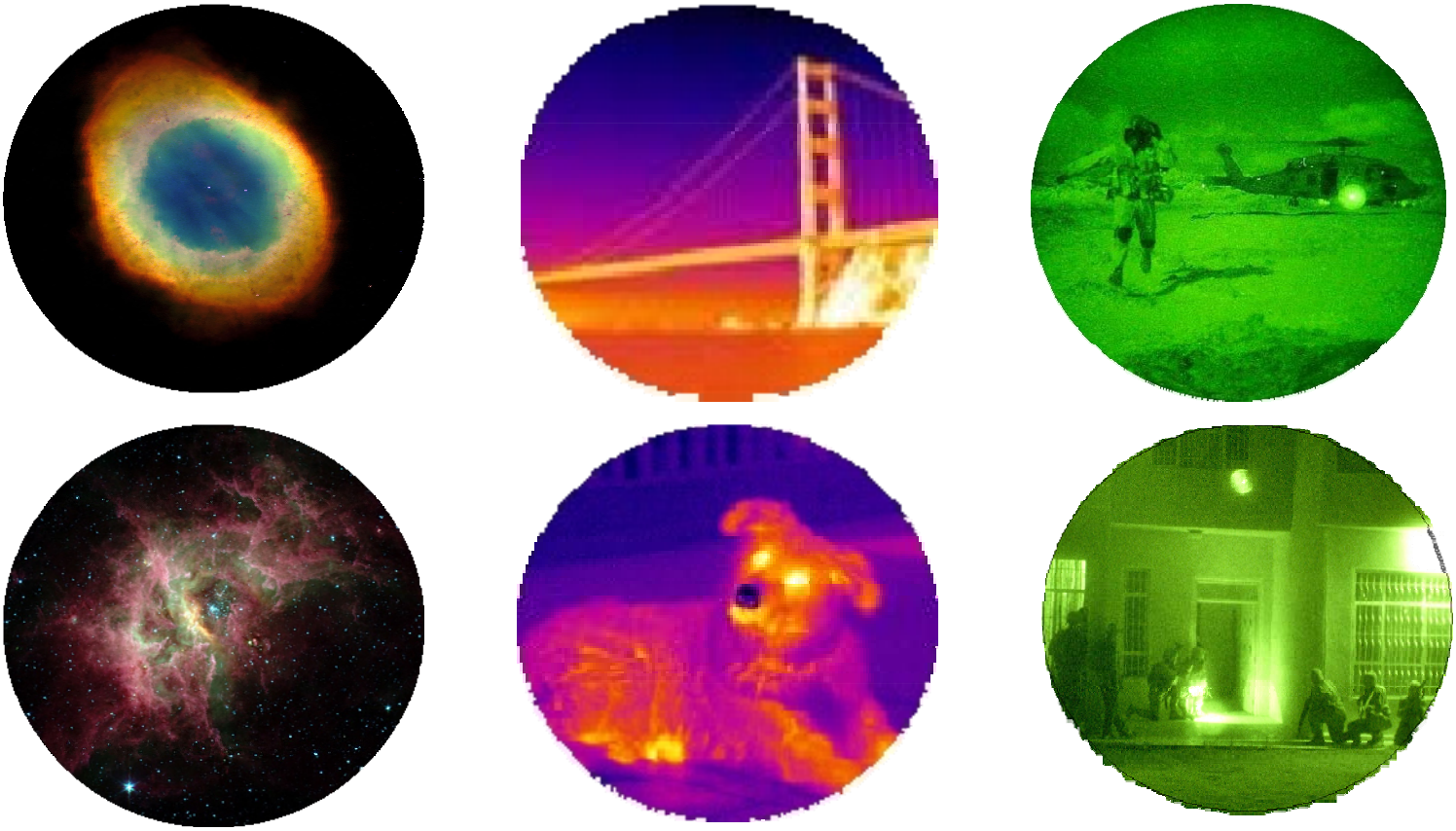
# Defense Industrial Base Assessment:

## U.S. Imaging and Sensors Industry



October 2006

**U.S. Department of Commerce**
**Bureau of Industry and Security**
**Office of Strategic Industries and Economic Security**

# Defense Industrial Base Assessment:

# U.S. Imaging and Sensors Industry

**Prepared By**

**U.S. Department of Commerce**
**Bureau of Industry and Security**
**Office of Strategic Industries and Economic Security**

**For further information about this report, contact**
**Ron DeMarines, Senior Trade and Industry Analyst**
**(202) 482-3755 rdemarin@bis.doc.gov; or**
**Brad Botwin, Supervisory Industrial Specialist**
**(202) 482-4060 bbotwin@bis.doc.gov**

Learn more about our organization at http://www.bis.doc.gov/

# Table of Contents

**I. Executive Summary ..... I-1**

**II. Technology Overview ..... II-1**
A. Imaging and Sensors Technologies ..... II-1
A.1 Image and Sensor Devices ..... II-2
B. Image Enhancement ..... II-3
B.1 Generation 1 ..... II-4
B.2 Generation 2 ..... II-5
B.3 Generation 3 ..... II-5
C. Thermal Imaging ..... II-6
C.1 Uncooled ..... II-7
C.2 Cryogenically cooled ..... II-7
C.3 Generation 1 ..... II-8
C.4 Generation 2 ..... II-9
C.5 Generation 3 ..... II-9

**III. Financial Performance ..... III-1**
A. Sales by Product for Manufacturers, Integrators, and Service Providers ..... III-2
B. Sales Per Employee ..... III-9
C. Capital Investment ..... III-10
D. Industry Financials ..... III-12
D.1 Image and Sensor Operations ..... III-12
D.2 Current Ratio ..... III-13
D.3 Quick Ratio ..... III-13
D.4 Overall Operations ..... III-14
E. Earnings ..... III-16
E.1 Retailers, Distributors, Resellers, and Brokers ..... III-16
E.2 Defense and Non-Defense Earnings ..... III-17
E.3 U.S. and Foreign-Made Product Earnings ..... III-18
E.4 Product Categories ..... III-19

**IV. Domestic and Foreign Business Relationships, Content and Sourcing ..... IV-1**
A. Domestic and Foreign Business Relationships ..... IV-1
A.1 Manufacturers, Integrators, and Service Provider Establishments ..... IV-1
A.2 Research Organizations and Laboratories ..... IV-2
A.3 Distributors, Resellers, Retailers, and Brokers ..... IV-4
B. International and Multinational Ownership and Alliances ..... IV-4
C. Mergers and Acquisitions ..... IV-6
D. Foreign Content ..... IV-8
E. Domestic and Foreign Sourcing ..... IV-9

**V. Research & Development ..... V-1**
A. R&D – Manufacturers and Laboratories ..... V-1
A.1 Manufacturer R&D Trends ..... V-1
A.2 Manufacturer R&D Sources ..... V-2

B. R&D – Research Organizations and Laboratories ..... V-3
B.1 Research Organization and Laboratory R&D Trends ..... V-4

**VI. Employment and Workforce ..... VI-1**
A. Employment by Occupation ..... VI-1
A.1 Manufacturers, System Integrators, and Service Providers ..... VI-1
A.2 R&D Staff Degree Status ..... VI-2
B. Labor Concerns ..... VI-3
B.1 Shortage of Workers ..... VI-3
B.2 Workforce Age ..... VI-4
B.3 Labor Costs ..... VI-5
C. Research Organizations and Laboratories ..... VI-5
C.1 Employment (Federal vs. Private) (Defense vs. Non-Defense) ..... VI-5
D. Occupation – All Research Organizations and Laboratories, U.S. Citizens ..... VI-7
D.1 All Labs ..... VI-7
D.2 Government Labs ..... VI-7
D.3 Private Industry Labs ..... VI-8
D.4 University Labs ..... VI-9
E. Occupation – All Research Organizations and Laboratories, Non-Citizens ..... VI-10
E.1 Private Industry Labs ..... VI-11
E.2 University Labs ..... VI-12
F. Skilled Worker Age Range ..... VI-13
F.1 Government, Private Industry, and University Laboratories ..... VI-13
G. Laboratory Staff Degree Status ..... VI-14
H. Labor Concerns ..... VI-15

**VII. Imaging/Sensors Imports and Exports ..... VII-1**
A. Overview ..... VII-1
B. Imports of Imaging and Sensors Products ..... VII-2
B.1 Import Sources ..... VII-3
C. Exports of Imaging and Sensors Products ..... VII-4
C.1 Export Destinations ..... VII-6
C.2 Exports Reported by Retailers, Distributors, Brokers and Resellers ..... VII-7
D. U.S. Share of the Global Export Market ..... VII-9

**VIII. Export Controls ..... VIII-1**
A. Export Licensing ..... VIII-1
B. DOC Export Licensing History ..... VIII-2
C. ITAR Controls ..... VIII-6
C.1 Comparison of Exports Controlled by the ITAR and the EAR ..... VIII-7
D. Denied Export Licenses ..... VIII-9
D.1 Export Controls and the Uncooled Thermal Imaging Sector ..... VIII-10
D.2 Foreign Competition ..... VIII-12
D.3 U.S. Loss of Foreign Market Share and the Impact of Export Controls .. VIII-13
D.4 Response of Some Manufacturers to U.S. Loss of Foreign Market Share and the Impact of Export Controls ..... VIII-15
E. Export License Approved, but Sale Lost ..... VIII-16
F. Recommendations for Modifications in Export Control Policies ..... VIII-17

**IX. Findings ..... IX-1**

**Appendix A: Letter from U.S. Army, Night Vision & Electronic Sensor Directorate**
**Appendix B: U.S. Imaging and Sensors Industry Survey**
**Appendix C: Selected Major Weapon Programs Utilizing Image/Sensor Technology**
**Appendix D: Selected U.S. Civilian Programs Utilizing Image/Sensor Technology**
**Appendix E: Selected Federal Laboratories and Research Centers Related to Image/Sensor Technology**
**Appendix F: U.S. Department of Defense EO/IR Budgets, FY 2001-2007**
**Appendix G: U.S. Department of Commerce, BIS/SIES Publication List**

# I. Executive Summary

The U.S. imaging and sensors industry is an important and growing part of the U.S. high technology defense and civilian industrial base. The technology and products developed by the U.S. imaging and sensors industry play an important role in maintaining the military advantage the U.S. enjoys today. Imaging and sensors products are used in defense-related applications, such as target imaging, homing, detecting, and tracking. At the same time, the commercial market for such products has grown dramatically over the last five years. Imaging and sensors products have substantial and growing commercial (e.g., surveillance, quality control, process control, and construction and other inspection) and other civil (e.g., astronomy, fire fighting, medical imaging, hunting, and wildlife observation) applications. Imaging and sensors technology and products are continuing to evolve at a rapid rate in both defense and commercial markets.

U.S. firms continue to dominate the defense portion of the industry. However, this is less true for commercial products. Manufacturers in China, France, Germany, Israel, Japan, Russia, and the United Kingdom are increasingly serving the commercial product markets where there is growing global demand.

Increasing global competition, combined with less restrictive export licensing procedures in most overseas markets for both defense and commercial products, has raised some concerns among U.S. industry leaders about their long-term competitive position and ability to maintain technological leadership. To better understand the validity of these issues and their potential implications for current and future U.S. defense production capabilities, the U.S. Army Research, Development and Engineering Command supported the U.S. Department of Commerce, Bureau of Industry and Security's (BIS) concept to initiate an assessment of the U.S. imaging and sensors industry.

This assessment reviews the health and competitiveness of the imaging and sensors industry. The industry, as defined for this assessment, includes manufacturers, integrators, service providers, distributors, retailers, brokers, resellers, and federal and private research laboratories. Industry-specific surveys sent to these groups were used to collect essential employment, financial, product, research and development, and other

data from 2001 through 2005. Survey data was augmented with site visits, attendance at technical conferences, interviews and reviews of other studies of this industry.

BIS's Office of Strategic Industries and Economic Security (SIES) performed this assessment under authority vested in the Department of Commerce through Section 705 of the Defense Production Act (DPA) of 1950, as amended (50 U.S.C. App. Sec. 2155) and related Executive Order 12656. The DPA authority enables SIES to conduct surveys, study defense-related industries and technologies, and monitor economic and trade issues affecting the U.S. defense industrial base. In the past, SIES has performed studies on a broad range of U.S. industrial and technology sectors, including air delivery systems, munitions power sources, biotechnology, ship building and repair, optoelectronics, welding, and the C-17 aircraft program.[1]

**Background**

In the past, highly sophisticated imaging and sensors applications were mainly used for military purposes because of their high per unit cost, while commercial applications utilized more rudimentary technology. In the last ten years, however, the commercial use of imaging and sensors (thermal imaging and image intensification) has grown significantly as have the number of firms producing this equipment. Applications in the medical, automotive, security, firefighting, surveillance, industrial process, and production controls sectors increasingly utilize imaging and sensors technology.

Commercialization of imaging and sensors products has been a slow process because a major portion of the technology has involved expensive hand-crafted components, including subsystems to maintain the devices at cryogenic temperatures. This has changed with development of uncooled detector technologies.

From 2001 through 2005, commercial sales by U.S. firms increased 55.5 percent while defense sales climbed by 51.3 percent. Defense and commercial sales accounted for 70.2 percent and 29.8 percent, respectively, of total U.S. industry sales in 2005.

[1] See the U.S. DOC/BIS/SIES web site for a full listing of published reports: http://www.bis.doc.gov/osies.

## Product and Technology Scope

The BIS assessment covers forty product categories based on two types of imaging and sensors technologies -- Image Enhancement and Thermal Imaging.

**Image Enhancement** products require some type of ambient light source (moonlight, starlight or infrared light). Image intensifiers are currently classified into three product generations, each with its own set of design characteristics.

**Thermal Imaging** products operate by capturing the upper portion of the infrared light spectrum. The two common types of thermal-imaging devices, which are divided in to Generations 1, 2 and 3, are uncooled and cooled. The uncooled is the most common type of thermal-imaging device, and infrared-detector elements contained in these devices operate at room temperature. The cryogenically cooled thermal imaging devices are more expensive and more susceptible to damage and performance failure. While they operate in much the same way as uncooled devices, they provide much higher levels of detection and resolution.

## Financial Performance

The U.S. imaging and sensors manufacturers witnessed robust overall sales growth during the five-year period, rising from $2.55 billion in 2001 to over $3.8 billion in 2005, with defense sales accounting for nearly two-thirds of all sales. Over the same period, earnings from sales as reported by retailers, distributors, resellers, and brokers also grew at a positive rate.

## Domestic and Foreign Business Relationships, Content and Sourcing

Imaging and sensors-related firms develop highly specialized products and services to differentiate themselves from competitors. As a result, these firms depend on business relationships, and more specifically on vertical business relationships, to ensure the exclusive specifications of their imaging and sensors products.

Manufacturer and wholly owned subsidiary relationships were identified most often in U.S. firms' relationships with foreign entities. Reviewing both domestic and foreign business relationships, 48.4 percent of relationships involved a supplier relationship with at least one other manufacturing firm. Service provider and product integrator business relationships accounted for 13.7 percent and 13.2 percent, respectively.

Approximately 66 percent of the 141 respondent manufacturing firms procure products or services from at least one foreign firm. Leading foreign sole-sourced items (based on the number of cases reported) were raw materials with 17.7 percent, image intensifier devices with 13.9 percent, and electronics/electrical controls at 10.1 percent.

The top three reasons mentioned for foreign sourcing were: (1) foreign products and services were less expensive than domestic sources; (2) the products and services the firms required were not available from domestic sources; and (3) the foreign sources were of better quality.

**Research & Development**

The rapid advances in product capabilities and applications among global suppliers are an indication of the importance of Research and Development (R&D) funding to the imaging and sensors industry. To remain competitive in the global marketplace, U.S. suppliers of imaging and sensors products acknowledged that they must continue to invest aggressively in R&D, especially in commercial applications.

Domestic manufacturers of imaging and sensor products spent over $1 billion on R&D from 2001 to 2005. Annual research expenditures topped out at $61.4 million in 2005 from $15.4 million in 2001, while development spending reached $187.6 million in 2005 from a low of $129.5 million in 2001. Total R&D expenditures for manufacturers increased from $146 million in 2001 to $249 million in 2005. This increase in R&D expenditures represented a compound annual growth of 11.2 percent over the period. Expenditures for R&D by laboratories and research organizations rose from $200.9 million to $327.1 million in the period, or by 62.8 percent.

## Employment and Workforce

The U.S. workforce in the imaging and sensors industry reported steady annual job growth during the 2001-2005 period. Based on responses to the BIS survey, the industry has created more than 3,000 new jobs since 2001, with employment climbing to 10,918 in 2005 from 7,721 in 2001.

Despite the increase in industry employment, U.S. companies of all sizes raised concerns about shortages of qualified personnel, including research and design engineers, skilled technicians, and production line workers.

## Imaging/Sensor Imports and Exports

The United States has historically been a net importer of imaging and sensors products, however, this trend has been declining as the value of exports has outpaced that of imports during 2001-2005. As a result, the trade deficit in these products has substantially decreased from $376 million in 2001 to $272 million in 2005.

Since 2002, U.S. imports have increased from $587 million to $734 million in 2005. Although the value of U.S. imports continues to increase, the level of import penetration in the U.S. marketplace has declined. For 2001-2005, the majority of imaging and sensors equipment imports included electrical instruments that use optical radiations (almost $2 billion) and electrical spectrophotometers using optical radiations ($976 million).

U.S. exports of imaging and sensors products have steadily increased from 2001 to 2005, reflecting increasing demand for both commercial- and defense-related applications. The export figures, as reported by 91 firms, highlight that imaging and sensors product exports grew from $280 million in 2001 to $462 million in 2005. Exports in two product categories, night vision system devices/components and infrared (thermal) imaging system devices/components (cooled), dominated the value of U.S. exports. Combined, these two categories captured almost 43 percent ($930.1 million) of the value of total exports ($1.96 billion) during 2001-2005.

The majority of these imaging and sensors products were exported to Western Europe and Asia – especially Japan and South Korea. The European Union (EU), during 2001-2005, was the largest consumer of U.S. imaging and sensor products, representing 72 percent of cumulative exports over the five years.

The global market for defense and commercial imaging and sensor products has grown in recent years. Global exports climbed to $4.3 billion in 2005 from $2.7 billion in 2001, or an annual compound growth rate of 9.8 percent. U.S. exports, as reported by survey respondents, grew at a compound annual rate of over 10.5 percent, the seventh largest growth rate behind Belgium-Luxembourg, China, France, Canada, Germany, and Ireland. Despite double-digit U.S. export growth, the U.S. share of global exports increased by only 0.3 percentage points from 10.5 percent in 2001 to 10.8 percent in 2005.

Although the value of overall exports of industry products increased during 2001-2005, exports of uncooled infrared (thermal) imaging system devices, a significant growing product category, declined by 63.9 percent (from $54.6 million in 2001 to $19.7 million in 2005). This is in contrast to the rest of the U.S. imaging and sensors industry exports and to exports by foreign manufacturers of uncooled thermal imaging products.

U.S. manufacturers noted that restrictive U.S. export controls have severely hampered their ability to supply the increasing global commercial demand for uncooled thermal products. Further, U.S. manufacturers stated that European and Asian suppliers of uncooled thermal products face fewer export restrictions by their licensing authorities and are therefore capturing a growing share of this important market.

Five major U.S. manufacturers of higher-end uncooled thermal products incorporating 640x480 focal plane arrays (FPAs) noted that, because of export controls, they are not currently exporting these products from the United States. However, U.S. manufacturers stated that foreign firms within the European Union (EU) are currently exporting these devices with EU-manufactured 640x480 FPAs.

A total of 33 of 106 survey respondents (31 percent) specifically recommended that current U.S. export control policies be modified as they are an impediment to how firms do business, particularly in allied countries. Fourteen of these respondents had either reported a denied export license, lost sales due to the licensing process, or a combination of the two.

## Conclusion

For the foreseeable future, the financial performance of the overall U.S. imaging and sensors industry will depend on U.S. Department of Defense acquisitions and, to a lesser extent, on commercial demand. However, the future health of the uncooled thermal device subsector will depend on the ability of U.S. manufacturers to compete on a level playing field with European and Asian competitors.

# II. Technology Overview

## A. Imaging and Sensors Technologies

Imaging and sensors devices were originally developed for the military in the 1950s for detecting the enemy in near total darkness. Initial versions of this equipment were cumbersome and marginally effective. As the technology evolved from the early designs, so have the applications of these devices. Today, these devices are used in a wide variety of situations, both military and commercial, ranging from less sophisticated image intensifiers for recreational activity (hunting and wildlife observation) to the most technologically advanced thermal imagers for the military (homing and targeting for missiles) (see Table 2-1). The two types of technology (image enhancement and thermal imaging) are discussed in greater detail later in this section.

**Table 2-1: Imaging and Sensors Applications**

| Defense/Security | Commercial/Recreational | Other |
|---|---|---|
| Imaging (Night Vision) | Home/Business Surveillance | Astronomy |
| Homing | Quality Control | Fire Fighting |
| Targeting | Process Control | Medical |
| Tracking | Construction Inspection | |
| Concealed Weapon Detection | Hunting | |
| Mine Detection | Wildlife Observation | |
| See Through Walls | Semiconductor Scans | |
| Law Enforcement | | |
| Port Security | | |
| Security and Border Control | | |

Source: DOC/BIS I&S Survey 2005

A significant factor in improving sensitivity of these devices has been the addition of cryogenic cooling to reduce extraneous thermal background "noise" which, if not kept in check, distorts the image of the object being viewed. The addition of a cooling mechanism adds significant cost and additional maintenance requirements for the image devices covered by this report. As the applications of imaging and sensors technology expand, a significant portion of the research funding by corporations and governments is being directed toward developing systems requiring little or no artificial cooling to reduce unit costs and required maintenance while maximizing image sensitivities.

Although the state-of-the-art in imaging and sensors technology has advanced to "uncooled" devices, the image sensitivity still lags that of the "cooled" devices.

However, for many applications, especially in the commercial marketplace, current uncooled devices provide acceptable performance when the cost benefits are considered. Cost and performance considerations are also driving military-directed development as the expenditures for equipping U.S. forces in Iraq and Afghanistan escalate.

Defense needs accounted for about 70 percent of the value of total imaging and sensors sales during 2001-2005, with goggles, optical sensors in guided missiles and smart bombs, rifle sights, sensor-equipped unmanned aerial vehicles, and unmanned remote sensor devices accounting for the bulk of military procurement.

Non-defense sales, accounting for the remaining 30 percent of sales during the five-year period, were most concentrated in the following four product categories: infrared (thermal) imaging system devices and components (uncooled), infrared (thermal) imaging system devices and components (cooled), infrared cameras, and night vision goggles. Non-defense products were used for applications including fire fighting (see-through walls), medical imaging, building and energy audits, process control, and law enforcement.

### *A.1 Imaging and Sensors Devices*

There are two basic types of imaging and sensor technologies covered within the scope of this report -- image enhancement and thermal imaging -- each with unique operational characteristics.

## B. Image Enhancement[2]

Imaging enhancement requires an ambient light source (moonlight, starlight or infrared light) to illuminate the viewed object in the near- or mid-infrared spectrum. The light reflected off the viewed object is collected and amplified through a special tube called an image-intensifier tube.

Image Enhancement, or Image Intensifier ($I^2$), devices operate primarily in the near- or mid-infrared range. Near infrared is the closest to visible light, with wavelengths that range from 0.7 to 1.3 micrometers (microns or μm). Mid-infrared has wavelengths ranging from 1.3 to 3 microns.

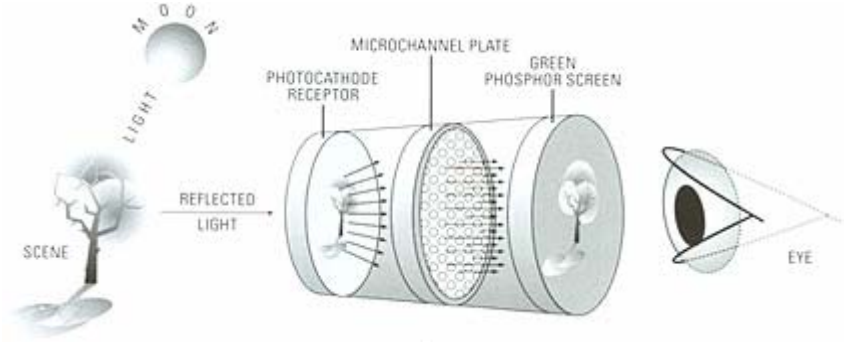
The light reflected off the viewed image - ultraviolet, visible light, near- or mid-infrared - is projected onto the transparent window of the latest generation of image-intensifier vacuum tube as shown in Figure 2-1. The tube has a layer called the photocathode. Light radiation causes the emission of electrons from the photocathode into the vacuum that are then accelerated and multiplied by an applied DC voltage through the microchannel plate towards a luminescent screen (phosphor screen) situated opposite the photocathode. The screen's phosphor in turn converts high-energy electrons back to light (photons), which corresponds to the distribution of the input image radiation but amplified many times.

There are several different generations of image enhancement devices starting from the first crude devices developed near the end of the Second World War. The earliest versions required an active infrared source to "illuminate" the object being viewed. These earlier devices were not practical for combat situations because of the external infrared source required and their bulkiness. It was not until the Vietnam conflict of the 1960s to the 1970s that imaging intensifying devices were developed for combat

[2] Various sources, including: "Image Intensification," Sierra Pacific, http://ww.x20.org/nightvisionTHEORY.htm;
"How Night Vision Works," American Technologies Network Corporation, http://atncorp.com/HowNightVisionWorks;
"Frequently Asked Night Vision Questions," Moro Vision Corporation, http://www.morovision.com/faqs.htm;
"What is an intensified image device?," ITT Corporation, http://www.nightvision.com/camera_systems/faq.html.

situations. Image intensifiers are currently classified into three generations, each with its own set of design characteristics.

**Figure 2-1**




Source: http://www.korry.com/products/nightshield/NVIS_technology.stm

*B.1 Generation 1*

Generation 1 (GEN 1) devices utilized the first true passive image intensification technology and are now the type most commonly used in civilian applications such as rifle scopes. These devices require the equivalent of about one-half the light of a full moon to operate efficiently; their sensitivity can be enhanced in low light situations if assisted by an infrared light source.

With the exception of certain rifle scopes, GEN 1 products do not require export licenses. Rifle scopes equipped with image intensification capabilities are restricted from being exported to certain countries designated as terrorist countries. These products require an export license and are controlled by the U.S. Department of Commerce, Bureau of Industry and Security, in accordance with the Export Administration Regulations (EAR). The export control classification number (ECCN) for optical sightseeing devices for firearms is 0A987.

*B.2 Generation 2*

Through the application of a more sensitive photocathode, a micro-channel plate and more enhanced electronics, GEN 2 devices are more efficient then GEN 1 versions. This increased sensitivity provides more clarity under darker conditions than the earlier generation. Generation 2 devices have improved image distortion along with automatic brightness control. Applications for GEN 2 equipment include civilian, scientific, and military applications where higher performance is required in lower light environments.

Most GEN 2 products destined for export also require an export license; most are licensed for export by the Department of Commerce, Bureau of Industry and Security, and are controlled on the Commerce Control List (CCL) under ECCNs 6A002 (Optical Sensors) and 6A003 (Cameras). A portion are subject to the International Traffic in Arms Regulations (ITAR) and therefore licensed for export by the Department of State.[3]

*B.3 Generation 3*

Mainly used for military applications, Generation 3 (GEN 3) devices are similar in structure to GEN 2 image intensifiers, but they use a different chemical compound (typically gallium arsenide) to coat the photocathode for a more efficient conversion of light to electrical energy at extremely low levels of light and longer tube life. Generation 3 equipment can be used in much darker environments than GEN 2 devices.

GEN 3 products sold internationally require an export license from the U.S. Department of State or the Department of Commerce, depending on the commodity being exported.

[3] 22 CFR Parts 120-130

## C. Thermal Imaging [4]

This technology operates by capturing the upper portion of the infrared light spectrum, which is emitted as heat by objects instead of simply reflected as light. Hotter objects, such as warm bodies, emit more of this light than cooler objects like trees or buildings.

Thermal imaging devices operate primarily in the thermal-infrared spectrum, which occupies the largest part of the infrared spectrum, ranging from 3 μm to over 30 μm.

Thermal imagers employ a special lens that focuses the infrared light emitted by all of the objects in view. The focused light from several thousand points in the field of view is scanned by a phased array of infrared-detector elements. The detector elements create a very detailed temperature pattern called a thermogram.

The thermogram created by the detector elements is translated into electric impulses which are sent to a signal-processing unit, a circuit board with a dedicated chip that translates the information from the detector elements into data for the display. This data appears as a color, the shade determined by the intensity of the infrared emission. The combination of all the impulses from all of the detector elements creates the image.

Most thermal-imaging devices scan at a rate of 30 times per second. They can sense temperatures ranging from -4 degrees Fahrenheit (-20 degrees Celsius) to 3,600 F (2,000 C), and can normally detect changes in temperature of about 0.4 F (0.2 C). There are two common types of thermal-imaging devices: uncooled and cooled.

---

[4] Various sources, including: "Understanding Focal Plane Arrays," Sierra Pacific Infrared Resources, http://www.x26.com/infrared/fpa.htm;
"What is Infrared Technology?," L-3 Communications, http://thermal-eye.com/learnmore/whatis.html;
"How Thermal IR Imagers Work," http://x20.org/library/thermal/how.htm;
"Thermal Weapon FLIR Sights and Scopes," Sierra Pacific Infrared Resources, http://www.x26.com/film.htm;
"How Thermal Vision Works," Moro Vision Corporation, http://www.morovision.com/how_thermal_imaging_works.htm;
Tribolet, Vuillermet and Des Tefanis, "Generation IR Detector Approach In France," http://www.sofradir.com/_pdf/third_generation_cooled_IR_detector_approach_in_France.pdf.

*C.1 Uncooled*

This is the most common type of thermal-imaging device. The infrared-detector elements are contained in a unit that operates at room temperature. This type of system is completely quiet, activates immediately, and has a built-in battery.

*C.2 Cryogenically Cooled*

In comparison to uncooled devices, cooled thermal imaging devices are more expensive and more susceptible to damage from rugged use. They operate in much the same way as uncooled devices, but provide much higher resolution. The semiconductor material used in the detector is typically mercury cadmium telluride (HgCdTe) or indium antimonide (InSb). These systems have the elements sealed inside a container that cools them to below 32 F (0 C). The advantage of such a system is the resolution and sensitivity that result from cooling the elements. Cryogenically cooled systems can recognize a difference as small as 0.2 F (0.1 C) from more than 1,000 ft (300 m) away, which is enough to tell if a person is holding a gun at that distance.

Forward looking infrared (FLIR) technology, originally developed by the United States Navy to assist in the identification and targeting of opposition forces, has many military, law enforcement, fire fighting, and commercial applications. Forward looking infrared systems have the capability to display a visible analog image of infrared emission at night or through cloud/fog cover in real time. They offer vision enhancement superior to that available through conventional night vision systems. For example, Army Apache helicopters have FLIR units that can give the pilot a concise view of what lies miles ahead of the aircraft**.**

Both thermal imaging and image intensification have operational characteristics that define their optimal use. The environment surrounding the target object primarily determines which of the two types of technology is best suited for creating an image. A summary of the operational characteristics is shown in Table 2-2.

**Table 2-2: Thermal Imaging vs. Image Intensification**[5]

| *$I^2$ Device - Image Intensifier* | *Thermal Imager* |
|---|---|
| • Sees visible light that is amplified by a photo cathode tube.<br>• Requires a visual contrast to generate a clear image, i.e., similarly colored or camouflaged objects are difficult to distinguish one from another.<br>• Is negatively affected by point light sources and shadows. Can bloom or shut down in direct light.<br>• Cannot easily detect camouflaged, still objects, or those in foliage due to low visible contrast.<br>• Provides positive facial recognition under good conditions.<br>• Cannot see through smoke and haze.<br>• Costs less and is more compact.<br>• Sees through visible glass. | • Sees long-wave infrared energy or radiant heat emitted by objects.<br>• Requires a thermal contrast to generate a clear image; two objects of the same temperature and surface finish are difficult to distinguish one from another.<br>• Does not require or see visible light, and is not affected by shadows or changing light conditions.<br>• Can see people or objects in dark areas regardless of color, clothing, or shadows. Highlights animate objects in a scene or in foliage.<br>• Does not provide positive facial recognition.<br>• Sees through smoke and haze.<br>• Costs more and is less compact.<br>• Cannot see through visible glass. |

All thermal imaging products destined for export require an export license and are controlled either by the U.S. Department of Commerce or by the U.S. Department of State.

### *C.3 Generation 1*

The first generation[6] of thermal devices required various degrees of cryogenic cooling and contained relatively small linear arrays (typically fewer than 200 elements) of infrared detectors. These detectors, when equipped in an image device, used a two-dimensional scanning system to generate a viewable output. Although still used in

[5] "What is Thermal Imaging," EMX Incorporated, http://www.emx-inc.com/WhatisThermalImaging.html
[6] Tribolet, Vuillermet and Des Tefanis, "Generation IR Detector Approach In France," http://www.sofradir.com/_pdf/third_generation_cooled_IR_detector_approach_in_France.pdf.

various defense and non-defense applications, first-generation devices have been widely supplanted by second-generation infrared detectors.

### *C.4 Generation 2*

Second-generation[7] detectors utilize two-dimensional (rather than linear) arrays coupled with readout circuit arrays for signal processing. The two-dimensional array allows for a greater number of infrared sensitive elements that increase input sensitivity. Because the signal processing circuits are directly coupled with the detectors, the scanning signal is transmitted to the image device by signal multiplexing. This generation of detectors still requires a cryogenic cooling system to allow adequate thermal sensitivity. The material principally used in the arrays was mercury cadmium telluride (HgCdTe). Generation 2 detectors significantly improved the signal-to-noise ratio or image resolution over Generation 1.

Sometimes referred to as Generation 2.5, improvements were incorporated into Generation 2 detectors that reduced the size of the elements in the arrays as well as the pixel pitch (the distance from the center of one element to the center of adjacent elements).

### *C.5 Generation 3*

Generation 3[8] infrared detectors offer a significant improvement over Generation 2 detectors in terms of sensitivity, optional multi-color detection (dual bands), fewer operating constraints, higher operating temperatures, and lower prices. In Generation 3 detectors, the pixel pitch (and therefore array element size) has been reduced to accomplish smaller array dimensions. The multi-color capabilities are achieved by stacking two detector levels separated by a common electrode, each sensitive to a different infrared spectrum. Generation 3 detectors include those that operate with reduced cooling requirements, some approaching room temperature.

---

[7] "What is Thermal Imaging," EMX Incorporated, http://www.emx-inc.com/WhatisThermalImaging.html
[8] "What is Thermal Imaging," EMX Incorporated, http://www.emx-inc.com/WhatisThermalImaging.html

# III. Financial Performance

For the purpose of this study, the imaging and sensors industry was divided into three segments: 1) manufacturers, integrators, service providers; 2) retailers, distributors, brokers, and resellers; and 3) federal and private research laboratories. Manufacturers, integrators, and service providers reported their sales and financial performance for their imaging and sensors operations and their overall corporate operations. Retailers, distributors, brokers, and resellers reported earnings related only to imaging and sensors sales. Federal and private laboratories provided investment and R&D spending figures, but were not required to report financial or sales data as the majority of these organizations were not sales organizations or profit centers. Note that this report includes sales and profit data derived from wholly-owned foreign operations of several U.S. firms.

Generally, the U.S. imaging and sensors industry (manufacturers, integrators, and service providers) witnessed robust sales and export growth during 2001-2005. Manufacturing productivity, measured by sales per employee, grew as did operating income and operating profits. Earnings from sales as reported by retailers, distributors, resellers, and brokers also grew at an impressive rate over the same five-year period. The only areas in which U.S. exports declined significantly in the five-year period were infrared (thermal) imaging system devices and components (uncooled) and optics components and lenses.

The future financial performance for the imaging and sensors industry will depend primarily on U.S. Department of Defense appropriations and the needs of U.S. forces in Iraq and Afghanistan. With respect to non-defense markets, expanding imaging and sensors applications in the commercial sectors will likely boost future demand. The extent to which U.S. companies invest in product development for commercial applications, along with other factors, will play a key role in U.S. competitiveness in non-defense markets, given the high level of foreign competition.

## A. Sales by Product for Manufacturers, Integrators, and Service Providers

The total sales for the imaging and sensors manufacturing industry, represented by the 141 manufacturing firms responding to the BIS survey, climbed to approximately $3.9 billion in 2005 from about $2.5 billion in 2001, as noted in Table 3-1. U.S. defense spending increased by more than 40 percent since 2001,[9] which helped promote defense sales during the five-year period.

**Table 3-1: Industry Sales, 2001-2005 (in $thousands)**

| | 2001 | 2002 | 2003 | 2004 | 2005* | 2001-2005 Sales Totals | Average Annual Sales |
|---|---|---|---|---|---|---|---|
| **Total Sales Per Year** | 2,545,198 | 2,575,680 | 2,885,769 | 3,517,978 | 3,882,669 | 15,407,293 | 3,081,459 |
| **Defense Sales Per Year** | 1,800,635 | 1,758,673 | 1,988,902 | 2,426,576 | 2,724,735 | 10,699,520 | 2,139,904 |
| **Non-Defense Sales Per Year** | 744,563 | 817,008 | 896,867 | 1,091,401 | 1,157,934 | 4,707,774 | 941,555 |

Source: DOC/BIS I&S Survey 2005
*Blend of actual and projected data

The total sales of the top ten firms represented in the survey are dominated by defense system integrators and manufacturers. They accounted for 82.7 percent of total sales in 2005, down from 85.9 percent in 2001. Defense sales accounted for more than two thirds of total industry sales (see Table 3-2).

**Table 3-2: Defense and Non-Defense Shares of Total Sales, 2001-2005**

| | 2001 | 2002 | 2003 | 2004 | 2005* |
|---|---|---|---|---|---|
| **Defense Sales** | 70.7% | 68.3% | 68.9% | 69.0% | 70.2% |
| **Non-Defense Sales** | 29.3% | 31.7% | 31.1% | 31.0% | 29.8% |

Source: DOC/BIS I&S Survey 2005
*Blend of actual and projected data

Between 2001 and 2005, defense sales and non-defense sales grew by 51.3 percent and 55.5 percent, respectively.

[9] Office of Management and Budget, Executive Office of the President of the United States. FY06 Budget Priorities, "Protecting America."

Sales over this period reflect an 8.8 percent compound annual growth rate (CAGR); the CAGR of defense and non-defense sales reached 8.6 percent and 9.2 percent, respectively, as illustrated in Table 3-3.

**Table 3-3: U.S. Industry Sales Growth, 2001-2005**

| | 2001-2002 | 2002-2003 | 2003-2004 | 2004-2005 | 2001-2005* Sales Growth | CAGR[1] |
|---|---|---|---|---|---|---|
| **Total Sales Growth Per Year** | 1.2% | 12.0% | 21.9% | 10.4% | 52.5% | 8.8% |
| **Defense Sales Growth Per Year** | *-2.3%* | 13.1% | 22.0% | 12.3% | 51.3% | 8.6% |
| **Non-Defense Sales Growth Per Year** | 9.7% | 9.8% | 21.7% | 6.1% | 55.5% | 9.2% |

[1]5-year compound annual growth rate
*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

The period of 2003 to 2004 saw the largest growth in total sales during the timeframe; total sales jumped by 21.9 percent, which included a 22 percent spike in defense sales and a 21.7 percent rise in non-defense sales.

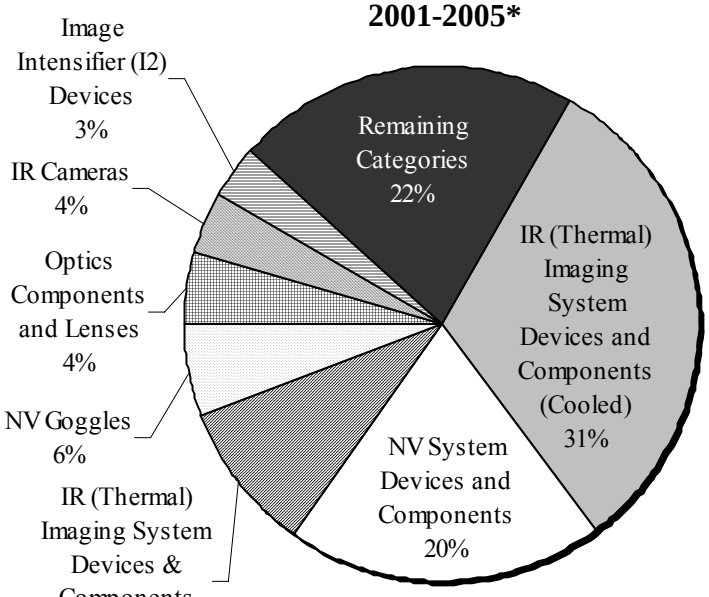
Some companies could not separate defense sales from total sales, as the firms did not know their customers' intended end use for their products. Because these firms primarily operate in non-defense sectors, sales data were included in "non-defense" sales. For this reason, non-defense sales may be somewhat overstated in Table 3-2.

Increased defense sales during 2003-2005 for the Iraq and Afghanistan conflicts can be seen in Table 3-4. Product categories that highlighted major sales increases include night vision goggles and infrared target detection systems (for use in detecting and tracking targets), and image intensifier devices (for use in rifle sights and goggles) (see Table 3-4).

| Table 3-4: U.S. Manufacturers, Integrators & Service Providers: Imaging and Sensors Defense Sales, Select U.S. Manufactured Products (in $thousands), 2001-2005 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **PRODUCT** | **2001** | **2002** | **2003** | **2004** | **2005*** | **5-Year Total** | **CAGR[1]** |
| Infrared (Thermal) Imaging System Devices and Components (Cooled) | 787,872 | 733,358 | 765,004 | 854,069 | 1,004,159 | 4,144,463 | 5% |
| Night Vision System Devices and Components | 502,484 | 456,643 | 497,027 | 740,686 | 817,765 | 3,014,606 | 10% |
| Infrared (Thermal) Imaging System Devices & Components (Uncooled) | 102,421 | 106,727 | 150,449 | 180,358 | 123,402 | 663,357 | 4% |
| Night Vision Goggles | 89,543 | 64,193 | 78,175 | 133,793 | 186,415 | 552,119 | 16% |
| Optics Components and Lenses | 60,045 | 72,107 | 89,477 | 106,006 | 106,375 | 434,011 | 12% |
| Other Components, Modules, Materials, Machinery, S/W & Svs, spectroscopic accessories | 35,775 | 71,593 | 85,901 | 63,102 | 64,559 | 320,929 | 13% |
| Image Intensifier (I2) Devices | 47,316 | 29,906 | 45,206 | 64,465 | 83,428 | 270,321 | 12% |
| Airborne Surveillance Systems | 45,264 | 35,113 | 26,403 | 41,122 | 45,572 | 193,474 | 0% |
| Infrared Target Detection Systems | 14,610 | 12,217 | 12,545 | 16,827 | 54,698 | 110,897 | 30% |
| Other Categories | 115,304 | 176,816 | 238,714 | 226,148 | 238,361 | 995,341 | 16% |
| **Defense Sales TOTAL** | **1,800,635** | **1,758,673** | **1,988,902** | **2,426,576** | **2,724,735** | **10,699,520** | **9%** |
| Year-to-Year Defense Sales Growth | | -2% | 13% | 22% | 12% | | |

[1] 5-year compound annual growth rate
*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

**Figure 3-1: Total Sales by Major Product Categories, 2001-2005***

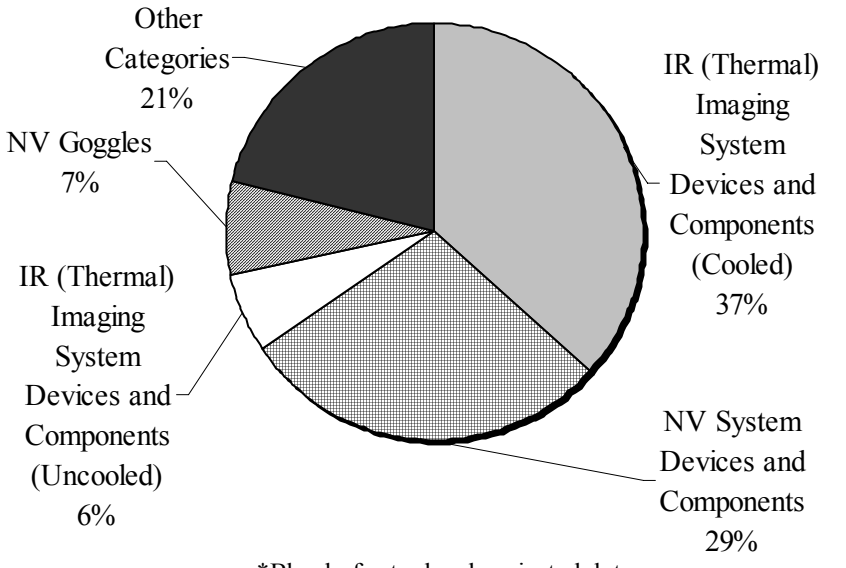



*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

The "Remaining Categories" includes other categories not listed, as well as the "Other Components, Modules, Materials, Machinery, Software and Services" subcategory. This subcategory generated over $233 million revenue per year, or 7.6 percent of the industry total during 2001 to 2005.

With regard to defense sales, infrared (thermal) imaging system devices and components (cooled) and night vision system devices and components accounted for over 66 percent of defense sales for 2001-2005 (see Figure 3-2).

**Figure 3-2: Defense Sales By Major Product Categories, 2001-2005***




*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

Non-defense sales during the five-year period were most concentrated in the following four product categories: other components modules, materials, machinery, software and services; infrared (thermal) imaging system devices and components (uncooled); infrared (thermal) imaging system devices and components (cooled); and infrared cameras (see Table 3-5 for select products and non-defense sales totals). These categories comprised 59 percent of all non-defense sales reported (see Figure 3-3). Other categories include night vision goggles, optics components and lenses, image intensifiers devices, infrared detectors, night vision system devices and components, and 28 other categories each with less than three percent of non-defense sales reported.

**Figure 3-3: Non-Defense Sales By Major Product Categories, 2001-2005***

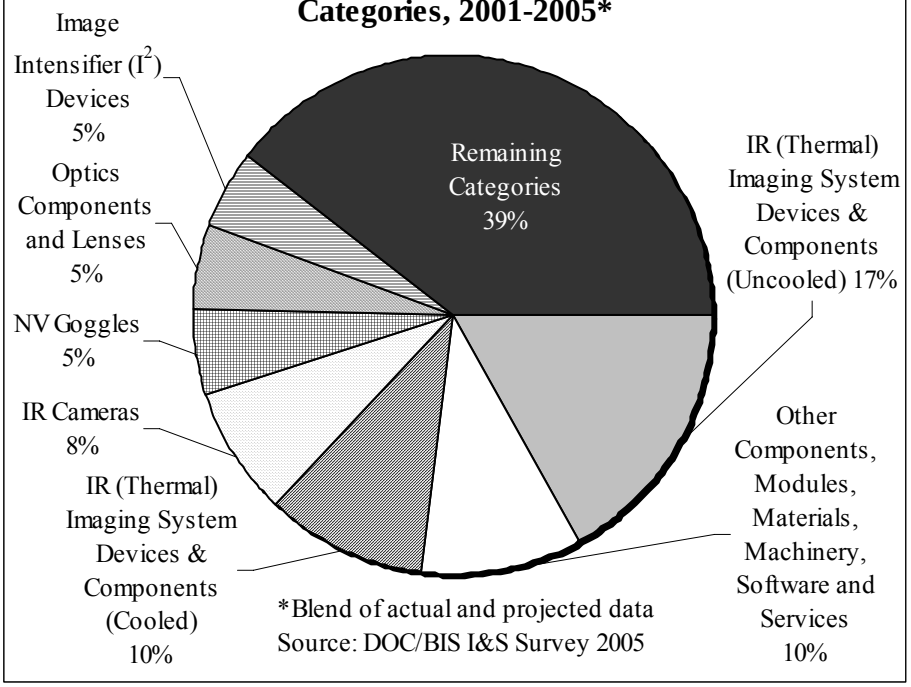



**Table 3-5: U.S. Manufacturers, Integrators & Service Providers: Imaging and Sensors Non-Defense Sales, Select U.S. Manufactured Products (in $thousands), 2001-2005**

| PRODUCT | 2001 | 2002 | 2003 | 2004 | 2005* | 5-Year Total | CAGR[1] |
|---|---|---|---|---|---|---|---|
| Other Components, Modules, Materials, Machinery, S/W & Svs, spectroscopic accessories | 119,138 | 142,576 | 164,821 | 201,393 | 216,858 | 844,787 | 13% |
| Infrared (Thermal) Imaging System Devices & Components (Uncooled) | 100,158 | 116,111 | 140,731 | 202,830 | 220,362 | 780,192 | 17% |
| Infrared (Thermal) Imaging System Devices and Components (Cooled) | 105,502 | 121,771 | 137,710 | 157,429 | 171,313 | 693,725 | 10% |
| Infrared Cameras | 79,117 | 89,331 | 87,784 | 117,363 | 101,074 | 474,668 | 5% |
| Night Vision Goggles | 53,432 | 90,914 | 77,861 | 66,908 | 81,949 | 371,064 | 9% |
| Optics Components and Lenses | 39,153 | 38,664 | 39,190 | 61,843 | 71,677 | 250,527 | 13% |
| Infrared Detectors | 69,272 | 45,261 | 38,306 | 47,452 | 48,769 | 249,061 | -7% |
| Image Intensifier (I2) Devices | 46,464 | 46,268 | 46,002 | 44,319 | 52,540 | 235,594 | 2% |
| Night Vision System Devices and Components | 5,703 | 6,001 | 7,855 | 17,058 | 35,600 | 72,216 | 44% |
| Other Categories* | 126,623 | 120,111 | 156,607 | 174,806 | 157,792 | 735,939 | 4% |
| **Non-Defense Sales TOTAL** | **744,563** | **817,008** | **896,867** | **1,091,401** | **1,157,934** | **4,707,774** | **9%** |
| Year-to-Year Non-Defense Sales Growth | | 10% | 10% | 22% | 6% | | |

[1] 5-year compound annual growth rate
*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

Over the five-year period, total sales (defense + non-defense) were mostly concentrated in eight product categories, each averaging more than $100 million in reported yearly sales for each. Product sales ranked by value were: infrared (thermal) imaging system devices and components (cooled); night vision system devices and components; infrared (thermal) imaging system devices and components (uncooled); other components, modules, materials, machinery; night vision goggles; optics components and lenses; infrared cameras; and image intensifier devices. The top four individual categories constituted approximately 68.4 percent of total industry sales during this timeframe (see Table 3-6).

**Table 3-6: U.S. Manufacturers, Integrators & Service Providers: Imaging and Sensors Total Sales, Select U.S. Manufactured Products (in $thousands), 2001-2005**

| PRODUCT | 2001 | 2002 | 2003 | 2004 | 2005* | 5-Year Total | CAGR[1] |
|---|---|---|---|---|---|---|---|
| Infrared (Thermal) Imaging System Devices and Components (Cooled) | 893,374 | 855,129 | 902,714 | 1,011,498 | 1,175,472 | 4,838,188 | 6% |
| Night Vision System Devices and Components | 508,187 | 462,644 | 504,882 | 757,744 | 853,366 | 3,086,822 | 11% |
| Infrared (Thermal) Imaging System Devices & Components (Uncooled) | 202,579 | 222,838 | 291,180 | 383,188 | 343,764 | 1,443,549 | 11% |
| Other Components, Modules, Materials, Machinery, S/W & Svs, spectroscopic accessories | 154,913 | 214,168 | 250,722 | 264,495 | 281,417 | 1,165,716 | 13% |
| Night Vision Goggles | 142,975 | 155,107 | 156,036 | 200,701 | 268,364 | 923,183 | 13% |
| Optics Components and Lenses | 99,198 | 110,771 | 128,667 | 167,850 | 178,052 | 684,538 | 12% |
| Infrared Cameras | 89,948 | 100,034 | 103,131 | 140,763 | 141,368 | 575,244 | 9% |
| Image Intensifier ($I^2$) Devices | 93,781 | 76,174 | 91,208 | 108,785 | 135,968 | 505,915 | 8% |
| Infrared Detectors | 77,251 | 58,511 | 54,905 | 66,068 | 64,542 | 321,276 | -4% |
| Other Categories* | 282,991 | 320,304 | 402,323 | 416,886 | 440,356 | 1,862,861 | 9% |
| **Sales TOTAL** | **2,545,198** | **2,575,680** | **2,885,769** | **3,517,978** | **3,882,669** | **15,407,293** | **9%** |
| Year-to-Year Sales Growth | | 1% | 12% | 22% | 10% | | |

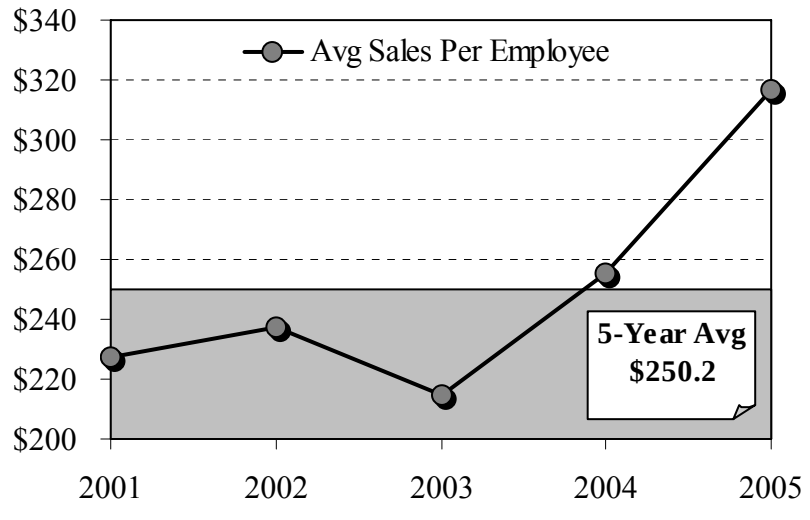
[1] 5-year compound annual growth rate
*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

## B. Sales Per Employee

The sales-per-employee ratio is a measure of productivity and offers an indicator of the overall economic performance of a firm or industry. Based on 2001-2005 data reported to BIS, average industry sales-per-employee totaled $250,229. Year-by-year data is shown in Figure 3-4.

The sales per employee figure calculated from respondent data is higher than the $178,905 average reported in 2002 by the U.S. Census Bureau, which is based on a broader, but related, industrial sector captured by the North American Industry Classification System (NAICS). United States Census Bureau data for 2002 is the latest available. The Census data is based on the Census of Manufacturers survey, which is undertaken every five years.

**Figure 3-4: Average Sales Per Employee 2001-2005* (in $thousands)**




*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

The year-over-year growth rate of sales per employee during the five year period was 39.3 percent, an average annual rate of 7.9 percent (see Table 3-7). The highest year-

over-year growth based on reported data was 24 percent during 2004 to 2005, reflecting a strong U.S. economic growth and increased demand from the Defense Department. The only decline was over 2002 to 2003, when average sales per employee fell by 9.6 percent.

| Table 3-7: Year-to-Year Growth, Sales per Employee, 2001-2005 | | | | | |
|---|---|---|---|---|---|
| | **2001-2002** | **2002-2003** | **2003-2004** | **2004-2005*** | **Average Annual Growth Rate** |
| **Percent Growth** | 4.6% | -9.6% | 18.8% | 24.0% | 7.9% |
| *Blend of actual and projected data<br>Source: DOC/BIS I&S Survey 2005 | | | | | |

## C. Capital Investment

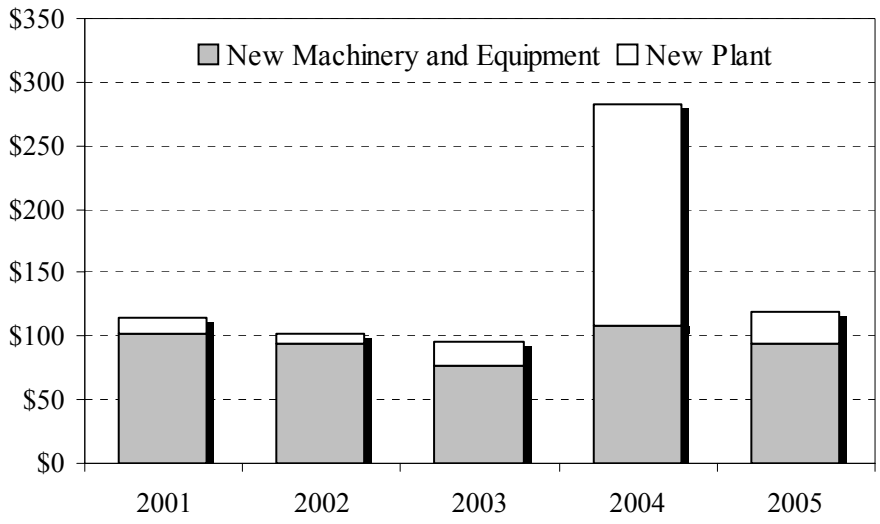
According to the BIS industry survey responses, new investment in plant, machinery and equipment fluctuated up and down during the period of 2001 through 2005, as Table 3-8 illustrates. The spike in investment for 2004 can be treated as a statistical outlier because it captured a large new plant investment by one major company. Leaving 2004 aside, the data reveals that overall investment has grown less than might have been expected, particularly because the industry had solid year-on-year sales growth of 11.3 percent in 2003, 21.4 percent in 2004, and 10.0 percent in 2005.

| Table 3-8: Investment in Plant, Machinery, and Equipment, 2001-2005 (in $millions) | | | | | |
|---|---|---|---|---|---|
| | **2001** | **2002** | **2003** | **2004** | **2005*** |
| New Plant | 13.2 | 8.8 | 18.8 | 174.7 | 25.1 |
| New Machinery and Equipment | 101.4 | 94.0 | 77.1 | 108.3 | 94.0 |
| Total Investment | 114.6 | 102.8 | 95.9 | 283.0 | 119.1 |
| *Blend of actual and projected data<br>Source: DOC/BIS I&S Survey 2005 | | | | | |

Total investment in new plant, machinery and equipment grew 5.24 percent from 2001 to 2005 (see Figure 3-5). Survey data reveals that only the industry's biggest players, particularly major defense contractors, made significant investments. Very few small and medium-sized companies made investments during the five-year period. More specifically, the top ten companies accounted for 86.9 percent of total investment in plant, machinery, and equipment, while the top twenty accounted for 95.3 percent.

The rapidly growing imaging and sensors market and high levels of profitability have not resulted in an industry-wide increase in production capacity beyond the largest players in the imaging and sensors industry. Complaining that U.S. export controls present obstacles for the U.S. industry's ability to compete with European, Japanese, and Chinese manufacturers, some industry leaders indicated that they are more likely to make future investments abroad for high-end uncooled products, particularly in Europe, than to do so in the United States. The BIS survey did not request capital investment data for offshore U.S. operations.

**Figure 3-5. Investment in Plant, Machinery and Equipment, 2001-2005* (in $millions)**




*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

## D. Industry Financials

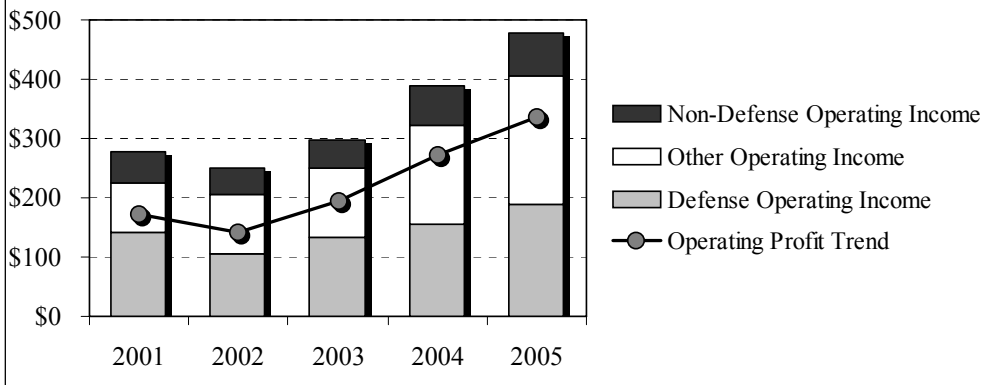
### *D.1 Image and Sensor Operations*

Firms producing sensors, imagers, and components, as well as integrators and service providers, collectively reported an increase in operating profits for their imaging and sensors operations during 2003-2005, after experiencing a decline in 2002 (see Figure 3-6). During 2002 to 2005, aided by a growing commercial market and sharply increased military demand, operating profits climbed 137 percent, an annual average growth of almost 34 percent.

Many firms were unable to provide separate operating income breakouts for defense/non-defense operations. Data from those firms are captured in the "Other" category in Figure 3-6. Nonetheless, the industry trend of rapidly expanding defense income is apparent, based on firms that did report separate defense/non-defense data. Operating income derived from defense sales was more than double that for non-defense sales for firms responding to the BIS survey.

Defense operating income topped $190 million in 2005, climbing 78 percent from a five-year low of $106.7 million in 2002. Non-defense operating income rose 62 percent during the same period, from $45.2 million in 2002 to $73.3 in 2005.

**Figure 3-6: Income Statement for Image and Sensor Operations 2001-2005* (in $millions)**




*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

Profitability of imaging and sensors operations exhibited a steep upward trend during 2001-2005, despite a drop in 2002. Using 2002 as a base year, operating profits jumped to $335.9 million in 2005 from $141.7 million in 2002, or by 137 percent.

*D.2 Current Ratio*

The current ratio (current assets divided by current liabilities) is an indication of a company's ability to meet short-term debt obligations; the higher the ratio, the more liquid the company. The minimum acceptable current ratio is approximately 1.1.

For their imaging and sensors operations, respondent firms collectively reported strong financial health during 2001-2005, with a current ratio well above 1.1 for the period, reaching 3.1 in 2003 before declining slightly over the following two years (see Table 3-9).

**Table 3-9: Current Ratio for Reporting Firms, 2001-2005**

| | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Current Ratio for Image and Sensor Operations | 1.8 | 2.2 | 3.1 | 3.0 | 2.9 |
| Current Ratio for Overall Operations | 1.7 | 1.5 | 1.8 | 1.4 | 1.4 |

Source: DOC/BIS I&S Survey 2005

The current ratio of the imaging and sensors operations of the reporting firms consistently topped that of the firms' overall operations over the 2001-2005 period.

*D.3 Quick Ratio*

The quick ratio, or "acid test" (current ratio excluding inventories), measures very short-term solvency. Quick ratio is viewed as a sign of company's financial strength or weakness (higher number means stronger, lower number means weaker). Results from reporting firms showed the quick ratio for imaging and sensors operations climbing from

a low of 1.13 in 2001 to 2.36 in 2003, before declining to 2.11 and 2.08 in 2004 and 2005, respectively (see Table 3-10).

The 2005 quick ratio of 2.08 means that for every dollar of current liabilities there are 2.08 dollars of easily convertible assets. In general, a quick ratio of 1 or more is considered a base-line for healthy financial performance.

**Table 3-10: Quick Ratio of Image and Sensor Operations, 2001-2005**

| 2001 | 2002 | 2003 | 2004 | 2005* |
|---|---|---|---|---|
| 1.13 | 1.51 | 2.36 | 2.11 | 2.08 |

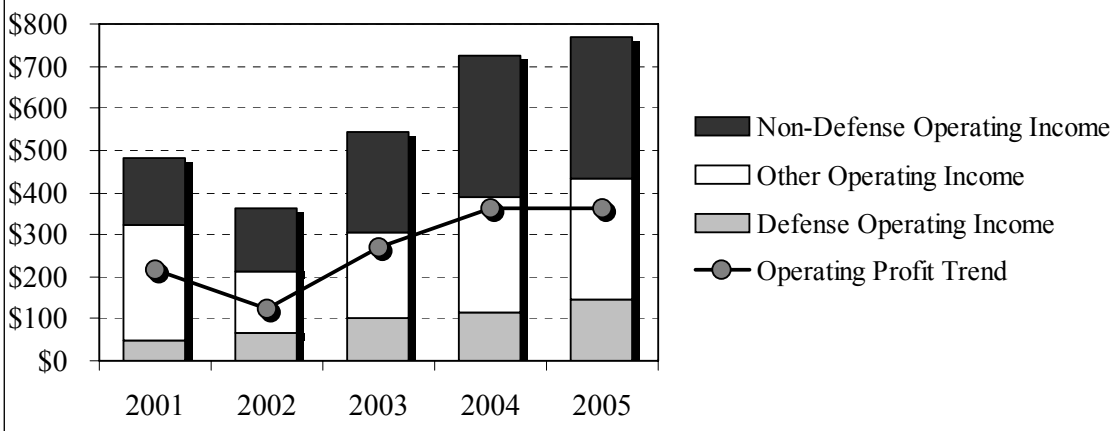
*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

*D.4 Overall Operations*

The operations of a majority of the firms responding to the BIS survey involved a broader scope of defense and non-defense products/services beyond imaging and sensors types. These commercial and other non-defense activities account for a large percentage in the overall sales of the firms included in the BIS survey than do the imaging and sensors operations (defense and commercial).

In another divergence from the data reported exclusively for imaging and sensors operations, the growth in non-defense operating income for overall operations of reporting firms outpaced that in defense operating income (see Figure 3-7).

**Figure 3-7: Income Statement for Overall Operations, 2001-2005* (in $millions)**




*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

As shown in section D.2, the current ratio of the overall industry indicated a diminished ability to meet short-term debt when compared with imaging and sensors operations. Further evidence of the financial health of the overall operations of the respondent firms can be shown in the quick ratio data in Table 3-11.

**Table 3-11: Quick Ratio of Overall Operations, 2001-2005**

| 2001 | 2002 | 2003 | 2004 | 2005* |
|---|---|---|---|---|
| 1.64 | 1.41 | 1.68 | 1.27 | 1.27 |

*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

When compared with that of imaging and sensors operations in 2005 of 2.08, the short-term solvency of the overall firm operations, while still healthy, lags considerably (see Table 3-10).

Another indicator of the financial divergence between the overall operations and imaging and sensors operations is the trend in working capital, which is calculated by subtracting current liabilities from current assets. Working capital represents the amount of liquidity available to a business. As illustrated in Figure 3-8, working capital for the overall

operations of the reporting firms declined for the five-year period, whereas imaging and sensors operations experienced a sharp upward trend.

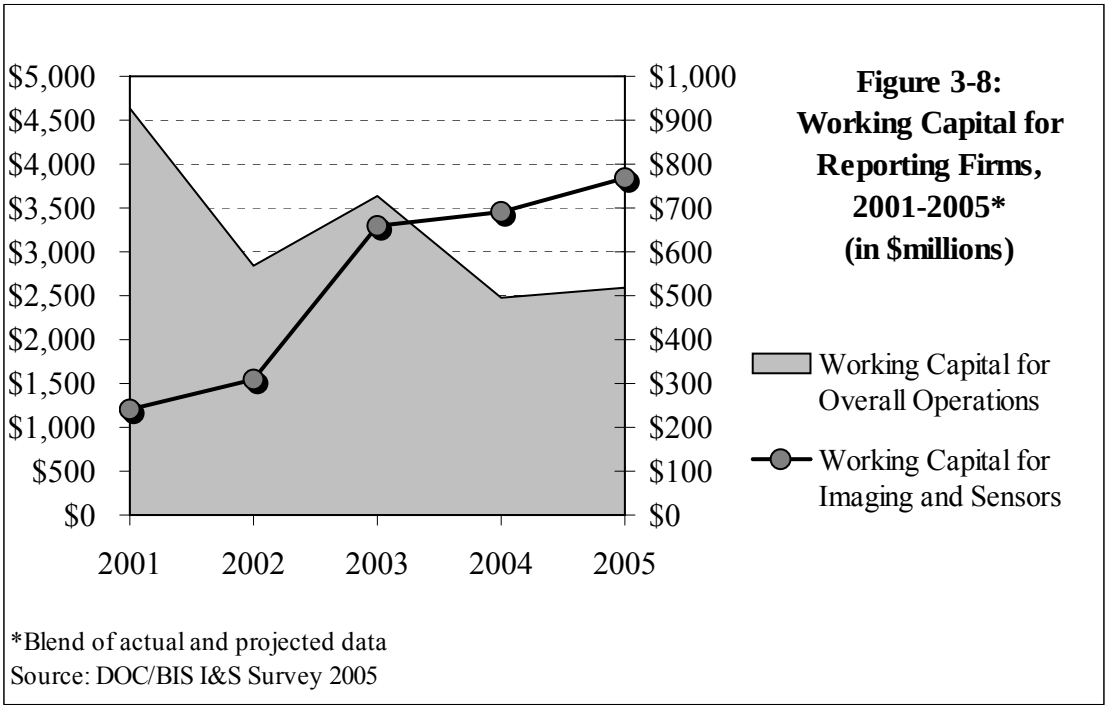



**Figure 3-8: Working Capital for Reporting Firms, 2001-2005* (in $millions)**

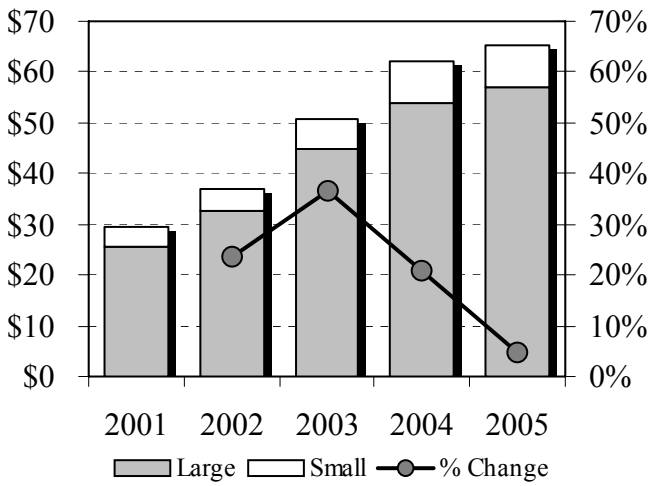
*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

## E. Earnings

### *E.1 Retailers, Distributors, Resellers, and Brokers*

Earnings reported by retailers, distributors, resellers, and brokers of imaging and sensors equipment experienced a compound annual growth rate of 17.1 percent, reaching over $65 million in 2005 from $29.6 million in 2001. Of the $65 million in 2005, 87.3 percent was attributed to larger companies with reported annual earnings over $1 million, and the remainder to small-sized companies with earnings below $1 million. Earnings attributed to the top five companies in 2005 amounted to over $46 million, or 71 percent of the total. Although total earnings for the industry have increased over the five-year period, year-on-year growth has steadily declined since 2003 (see Figure 3-9).

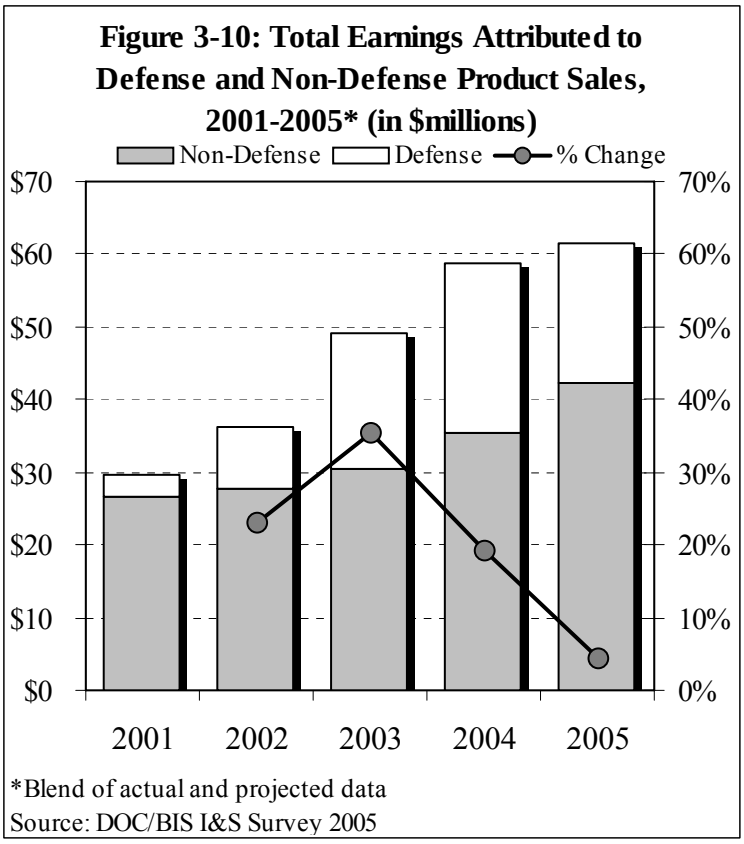
**Figure 3-9: Total Earnings for Large and Small Retailers, Distributors, Resellers and Brokers, 2001-2005* (in $millions)**




*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

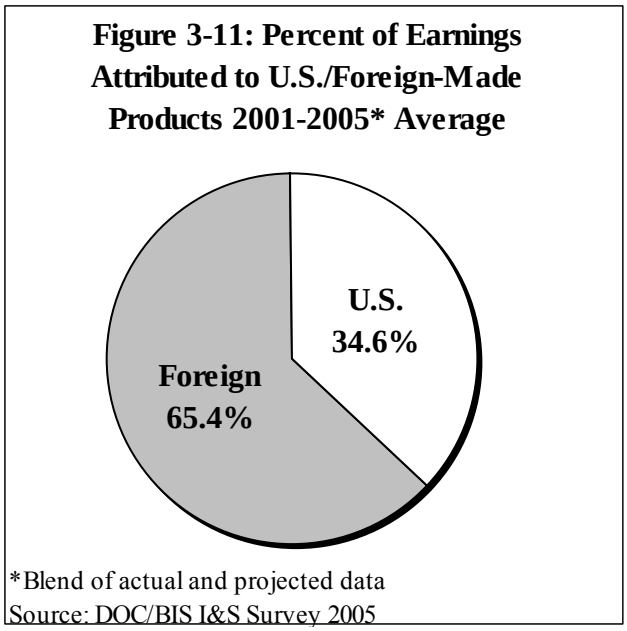
*E.2 Defense and Non-Defense Earnings*

Retailers, distributors, resellers and brokers also reported data on earnings attributed to defense and non-defense-related sales of imaging and sensors products. Non-defense earnings represented the majority of total earnings over the five-year period, increasing to $41.1 million in 2005 from $25.5 million in 2001 (see Figure 3-10). Defense earnings also increased, climbing sharply to $19.2 million in 2005 from approximately $3 million in 2001. This represented a compound annual growth rate of close to 46 percent, surpassing a compound annual growth of 10 percent for earnings attributed to non-defense-related sales. Not surprising for this segment of the industry, non-defense earnings represented an average of more than 67 percent of total industry earnings, whereas defense earnings represented only 27 percent.




*E.3 U.S. and Foreign-Made Product Earnings*

Retailers, distributors, resellers, and brokers also reported earnings attributed to sales of both U.S. and foreign-made imaging and sensors products. From 2001 to 2005, average annual earnings attributed to U.S.-made products amounted to 34.6 percent of total earnings (see Figure 3-11). Earnings from sales of U.S.-made products experienced a compound annual growth rate of nearly 36 percent during the five-year period.




Earnings from foreign-made product sales experienced eight percent growth over the period while overall earnings from foreign-made products represented an average of 65.4 percent of total earnings. As a share of total industry earnings, foreign product earnings have been steadily decreasing since 2001, from 83 percent in 2001 to 60 percent in 2005 (see Table 3-12).

**Table 3-12: U.S. and Foreign-Made Earnings, Retailers, Distributors, Resellers And Brokers, 2001-2005 (in $thousands)**

| | 2001 | 2002 | 2003 | 2004 | 2005* | CAGR |
|---|---|---|---|---|---|---|
| **Total Earnings (US/Foreign)** | 25,995 | 30,044 | 38,716 | 46,275 | 52,707 | 15% |
| **Sub-Total US-Made Earnings** | 4,492 | 7,562 | 16,838 | 21,683 | 21,160 | 36% |
| **Percent Earnings from US-Made** | 17.3% | 25.2% | 43.5% | 46.9% | 40.1% | |
| **Sub-Total Foreign-Made Earnings** | 21,502 | 22,482 | 21,878 | 24,592 | 31,546 | 8% |
| **Percent Earnings from Foreign-Made** | 82.7% | 74.8% | 56.5% | 53.1% | 59.9% | |

*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

*E.4 Product Categories*

Retailer, distributor, reseller, and broker survey respondents were asked to list all product categories for which they recorded earnings for the five-year period. Product categories were aggregated into two groups: complete systems and components, modules, materials,

machinery, software, and services. Virtually all firms reported earnings entirely from complete systems. Earnings reported from sales of components, modules, materials, machinery, software, and services were minimal, representing only three percent of total earnings over five years. The top five categories (all classified as complete systems) based on total earnings over the five-year period were night vision system devices and components, image intensifier ($I^2$) devices, infrared (thermal) imaging system devices and components (uncooled), infrared cameras, and night vision scopes and monocular devices (see Figure 3-12).

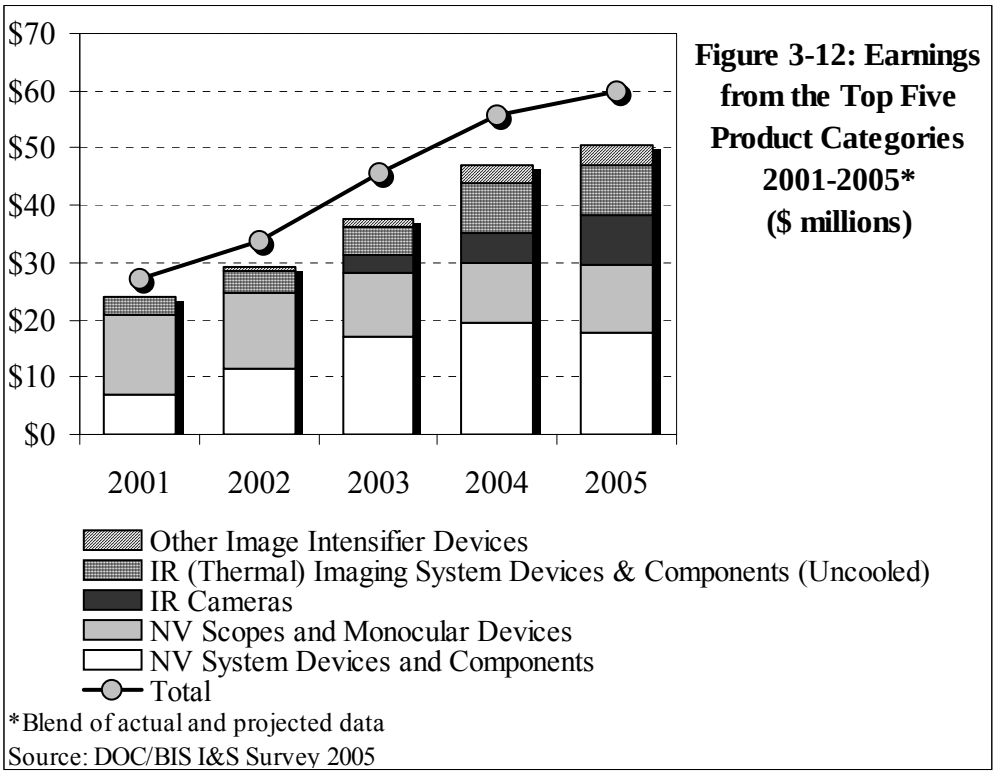



**Figure 3-12: Earnings from the Top Five Product Categories 2001-2005* ($ millions)**

Cumulative earnings for these product categories alone over five years amounted to more than $177 million, or 83 percent of total earnings. Of these five product categories, night vision system devices and components earnings were the largest of the product groups, representing 33.5 percent of total earnings and 40.4 percent of earnings attributed to the top five product categories. Earnings attributed to sales of infrared iameras experienced the largest increase over five years with a compound annual growth rate of more than 66 percent. Nearly all infrared camera sales were classified as non-defense.

# IV. Domestic and Foreign Business Relationships, Content and Sourcing

## A. Domestic and Foreign Business Relationships

### *A.1 Manufacturers, Integrators, and Service Provider Establishments*

Image- and sensor-related firms develop highly specialized products and services to differentiate themselves from competitors. As a result, they depend on business relationships, specifically vertical business relationships, to ensure control over the specifications of their imaging and sensors products. Table 4-1 illustrates the specific types of business relationships indicated by the 172 respondent companies.

**Table 4-1: Types of Business Relationships: Manufacturers/Integrators/Service Providers[+]**

| Relationship with: | % Domestic Relationships | % Foreign Relationships | Total % of Business Relationships |
|---|---|---|---|
| **Manufacturer** | 54.2% | 22.5% | **48.4%** |
| **Service Provider** | 14.0% | 12.5% | **13.7%** |
| **Product Integrator** | 15.1% | 5.0% | **13.2%** |
| **Wholly Owned Subsidiary** | 5.6% | 15.0% | **7.3%** |
| **Licensor** | 4.5% | 12.5% | **5.9%** |
| **Licensee** | 3.4% | 12.5% | **5.0%** |
| **Partially Owned** | 1.6% | 2.5% | **1.8%** |
| **Parent Company** | - | 10.0% | **1.8%** |
| **Co-Production Relationship** | 0.6% | 5.0% | **1.4%** |
| **Service Integrator** | 0.6% | 2.5% | **-** |
| **Joint Venture Partners** | 0.6% | - | **.5%** |
| **Total** | **100.0%** | **100.0%** | **100.0%** |

[+] Firm can have more than one business relationship type
Note: Because of rounding, totals may not add to 100 percent.
Source: DOC/BIS I&S Survey 2005

Business relationships with domestic firms accounted for 81.7 percent of the 219 relationships reported by survey respondents.[10] Domestic business arrangements were more likely to involve manufacturing, integrator, and service provider relationships, as U.S. firms tend to employ specialized services and technologies to enhance product offerings.

[10] The total number of firms responding to this question was 172; however, some firms reported more than one type of business relationship.

Manufacturer and wholly owned subsidiary relationships were most significant in U.S. firms' relationships with foreign entities. In addition, service provider relationships, licensor, and parent relationships are more prominent for U.S. firms with business relationships with foreign entities than with domestic relationships. These five business relationship types comprise 75 percent of all foreign business relationships reported.

Reviewing both domestic and foreign business relationships, 48.4 percent of relationships involved a supplier relationship with at least one other manufacturing firm. Service provider and product integrator business relationships accounted for 13.7 percent and 13.2 percent, respectively. These three categories combined account for 75.3 percent of all business relationships indicated by respondents of the manufacturer/integrator/service provider portion of the BIS survey.

### *A.2 Research Organizations and Laboratories*

Similar to the manufacturers, integrators, and service providers, 64.3 percent of the 28 research organizations and laboratories that responded to the survey reported having a business relationship with other entities. In terms of foreign versus domestic business relationships, research facilities that were only involved in domestic relationships constituted 28.6 percent of the survey respondents; research facilities only involved in foreign relationships represented 7.1 percent of survey respondents. Facilities involved in both foreign and domestic business relationships made up 28.6 percent of the responding firms. These percentages are represented in Figure 4-1.

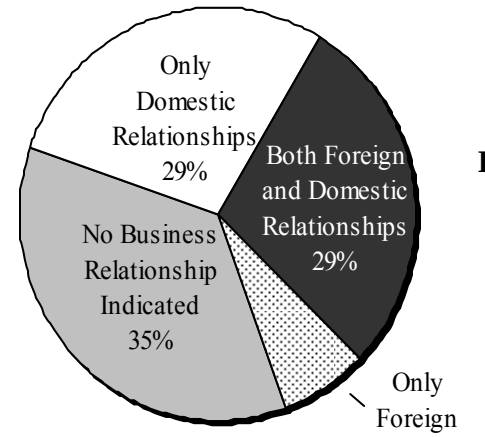



**Figure 4-1: Domestic and Foreign Business Relationships for Research Organizations and Laboratories**

Source: DOC/BIS I&S Survey 2005

The most common relationships included procurement relationships and government affiliations, accounting for 45.8 percent and 12.5 percent, respectively, of total relationships specified. Table 4-2 lists the types of business relationships specified and the percentage of research organizations and laboratories reporting such relationships.

**Table 4-2: Type of Business Relationship of Research Organizations and Laboratories[+]**

| | % Domestic Relationships | % Foreign Relationships | Total % of Business Relationships |
|---|---|---|---|
| **Procurement Relationship** | 50.0% | 37.5% | **45.8%** |
| **Affiliated with the U.S. Government** | 18.8% | - | **12.5%** |
| **Partially Owned** | 12.5% | - | **8.3%** |
| **Broker for Another Organization** | 6.3% | - | **4.2%** |
| **Co-Production Relationship** | 6.3% | - | **4.2%** |
| **Wholly Owned Subsidiary** | 6.3% | - | **4.2%** |
| **Distributor** | - | 12.5% | **4.2%** |
| **Licensor** | - | 12.5% | **4.2%** |
| **Licensee** | - | 12.5% | **4.2%** |
| **Parent Company** | - | 12.5% | **4.2%** |
| **Reseller** | - | 12.5% | **4.2%** |
| **Total** | **100.0%** | **100.0%** | **100.0%** |

[+] Firm can have more than one business relationship type
Note: Because of rounding, totals may not add to 100 percent.
Source: DOC/BIS I&S Survey 2005

*A.3 Distributors, Resellers, Retailers, and Brokers*

Approximately 22 percent of the 63 distributors, resellers, retailers, and brokers specified the type of business relationship shared with other entities.

Retailer relationships were the most commonly specified, representing 33 percent of all business relationships. Distributor relationships and wholesaler relationships followed, making up 27 percent and 20 percent of business relationships, respectively. Table 4-3 lists the types of business relationships indicated by the survey respondents and the percentage of firms reporting such relationships.

**Table 4-3: Type of Business Relationship of Distributors, Resellers, Retailers, and Brokers[+]**

| | % Domestic Relationships | % Foreign Relationships | Total % of Business Relationships |
|---|---|---|---|
| **Retailer** | 41.0% | - | **33.3%** |
| **Distributor** | 24.6% | 35.7% | **26.7%** |
| **Wholesaler** | 24.6% | - | **20.0%** |
| **Wholly Owned Subsidiary** | 6.6% | 50.0% | **14.7%** |
| **Partially Owned Subsidiary** | 1.6% | 7.1% | **2.7%** |
| **Co-Production Relationship** | 1.6% | - | **1.3%** |
| **Broker** | - | 7.1% | **1.3%** |
| **Total** | **100.0%** | **100.0%** | **100.0%** |

[+] Firm can have more than one business relationship type
Note: Because of rounding, totals may not add to 100 percent.
Source: DOC/BIS I&S Survey 2005

## B. International and Multinational Ownership and Alliances

Wholly owned subsidiaries and parent relationships constitute 25 percent of foreign business relationships indicated by the manufacturers, integrators, and service providers. Several major firms operating in the United States have subsidiaries in foreign countries involved in manufacturing, research and development, and marketing. Similarly, foreign-based firms have invested in U.S. and overseas subsidiaries for manufacturing, research and development, and marketing. Table 4-4 displays the types of foreign alliances specified by the survey respondents.

| Table 4-4: Foreign Alliances of Manufacturers/Integrators/Service Providers[+] | |
|---|---|
| | **% of Foreign Alliances** |
| **Manufacturer** | 22.5% |
| **Wholly Owned Subsidiary** | 15.0% |
| **Licensee** | 12.5% |
| **Licensor** | 12.5% |
| **Service Provider** | 12.5% |
| **Parent Company** | 10.0% |
| **Co-Production Relationship** | 5.0% |
| **Partially Owned** | 2.5% |
| **Product Integrator** | 5.0% |
| **Service Integrator** | 2.5% |
| **Total** | **100.0%** |
| [+] Firm can have more than one business relationship type<br>Note: Because of rounding, totals may not add to 100 percent.<br>Source: DOC/BIS I&S Survey 2005 | |

The U.S. firms mentioned below are leaders in the imaging and sensors industry:[11]

- FLIR Systems Inc., headquartered in the United States, manufactures a majority of its products in the United States. However, FLIR's Thermography headquarters is located in Sweden.
- L-3 Communications focuses its business strategy on developing a strong network of supplier relationships worldwide. Within the imaging and sensors industry, L-3 Wescam, based in Ontario, Canada, plays a critical role in L-3 Communications' success in the industry.
- Raytheon, also headquartered in the United States, has its major manufacturing facilities in the United States, with subsidiaries in Australia, Canada, and the United Kingdom.
- Lockheed Martin, another major domestic firm, mainly manufactures in the United States, with major facilities in Argentina and the United Kingdom.
- E.D. Bullard Company mainly operates in the United States with subsidiaries in Germany and Singapore to support its thermal imaging division.

[11] Information regarding the firm's overall operations is based on text highlighted on industry websites

The U.S. subsidiaries of foreign parent companies similarly operate on a global scale:

- BAE Systems Inc., located in the United States, is a subsidiary of BAE Systems PLC, which is based in the United Kingdom.
- ISG Thermal Systems is headquartered in the United Kingdom, and has a U.S. operation that provides manufacturing services for its North American market, in addition to research and development efforts for the whole company.

## C. Mergers and Acquisitions

For the survey period of 2001-2005, there were several significant mergers and acquisitions in the U.S. imaging and sensors industry, involving major defense firms and second-tier suppliers. The overall activity documented during the 2001-2005 period (BIS survey and public sources) indicates that an industry-wide consolidation is underway (see Table 4-5).

**Table 4-5: Acquisition and Divestitures of Imaging and Sensors Assets, 2001-2005 (in $millions)**

| | 2001 | | 2002 | | 2003 | | 2004 | | 2005 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Value | No. | Value | No. | Value | No. | Value | No. | Value |
| Acquisitions | 8 | 250.1 | 11 | 7,959.9 | 3 | 41.0 | 10 | 505.6 | 7 | 195.3 |
| Divestitures | 1 | 0 | 1 | 1.5 | 2 | 0.3 | 4 | 61.0 | 3 | 45.4 |
| Source: DOC/BIS I&S Survey 2005 and public sources | | | | | | | | | | |

In 2005, survey responses highlighted four mergers and acquisitions involving major defense contractors. In 2004, there were eight such deals, two in 2003, five in 2002, and four in 2001. These were large-scale acquisitions, involving major companies acquiring other fairly large firms — Northrop Grumman, L-3 Communications, ITT Industries, FLIR Systems, and DRS Technologies, for example. The bulk of mergers and acquisitions in the imaging and sensors industry involved large defense contractors buying up smaller, specialty manufacturers (see Table 4-6). With these acquisitions, the large defense contractors are filling gaps in their mix of products to position themselves for defense contracts for DOD's next-generation programs.

| Table 4-6: Major Mergers and Acquisitions in the U.S. Imaging and Sensors Industry | | | |
|---|---|---|---|
| **Year** | **Company** | **Acquisition/Products** | **Value (in $million)** |
| 2001 | DRS Technologies | Boeing's Sensors and Electronic Systems<br>electro-optical systems | $67 |
| 2001 | FLIR Systems | Saab Optronics Division<br>thermal imaging subsystems for missiles | $1 |
| 2001 | Northrop Grumman | Litton Electro-Optical Systems<br>electro-optical/infrared products | Not provided* |
| 2001 | II-VI Incorporated | Litton Systems' Silicon Carbide Group<br>crystal silicon carbide substrates | Terms not disclosed |
| 2002 | DRS Technologies | Nytech Integrated Infrared Systems<br>uncooled thermal imaging systems | Terms not disclosed |
| 2002 | ITT Industries | Xybion Electronic Systems<br>image intensification systems and metal-oxide semiconductor cameras | Terms not disclosed |
| 2002 | L-3 Communications | Wescam<br>electro-optic surveillance systems | $118 |
| 2002 | Fluke Corpration | Raytek Corporation<br>non-contact infrared temperature measurement instrumentation | Terms not disclosed |
| 2002 | Mikron Infrared | IMPAC Electronic GmbH<br>infrared temperature measurement instrumentation | Terms not disclosed |
| 2003 | L-3 Communications | Aeromet<br>electro-optic/infrared and airborne instrumentation | $20 |
| 2003 | FLIR Systems | Indigo Systems<br>infrared cameras and detectors | $160 |
| 2004 | ITT Industries | Kodak Remote Sensing Systems<br>high-resolution satellite imaging systems | $725 |
| 2004 | DRS Technologies | Night Vision Equipment Company (NVEC)<br>night vision and thermal imaging technology | $42 |
| 2004 | II-VI Incorporated | Marlow Industries, Inc.<br>thermoelectric cooling solutions | $31 |
| 2004 | L-3 Communications | Brashear LP<br>electro-optical systems | $36 |
| 2004 | L-3 Communications | Raytheon Commercial Infrared<br>uncooled thermal infrared and imaging systems | $42 |
| 2004 | L-3 Communications | Cincinnati Electronics<br>infrared thermal imaging and space electronics | $172 |
| 2004 | L-3 Communications | AVISYS<br>infrared countermeasure (IRCM) | $8 |
| 2004 | Axsys Technologies | Telic Optics<br>infrared optics and optical assemblies | $14 |
| 2005 | Axsys Technologies | Diversified Optical Products, Inc. (DiOP)<br>infrared surveillance camera solutions | $60 |
| 2005 | Goodrich Corp | Sensors Unlimited<br>shortwave-infrared technology | $60 |
| 2005 | L-3 Communications | EOTech<br>holographic weapon sights | $49 |
| 2005 | L-3 Communications | Sonoma Design Group<br>electro-optical and infrared imaging systems | Terms not disclosed |
| * Northrop Grumman acquired Litton Industries for $5.2 billion, but Litton Electro-Optical Systems' value was not disclosed.<br>Source*:* Public sources | | | |

## D. Foreign Content

U.S. manufacturers have been slowly increasing their purchasing of parts and subsystems from foreign vendors, but overall foreign sourcing levels remain quite low. Specialized components and sub-systems are being procured from suppliers based in Japan, Germany, Canada, the United Kingdom, and other competing countries. The total percent of foreign content used in U.S.-made imaging and sensors products was 2.9 percent in 2005, up from 2.6 percent in 2001. The value of foreign content climbed 66.8 percent during 2001-2005, reaching $111.6 million in 2005 (see Table 4-7).

**Table 4-7: Foreign Content in U.S.-Made Imaging and Sensor Products, 2001-2005 (in $thousands)**

| | 2001 | 2002 | 2003 | 2004 | 2005* | % Gain 2001-2005 |
|---|---|---|---|---|---|---|
| **Total Sales Value** | 2,545,198 | 2,575,680 | 2,885,769 | 3,517,978 | 3,882,669 | 52.5% |
| **Value of Foreign Content** | 66,916 | 72,465 | 75,156 | 97,298 | 111,612 | 66.8% |
| **Year-over-Year Growth Rate of % of Foreign Content to Sales** | | 7.0% | -7.4% | 6.2% | 3.9% | |
| **% of Foreign Content** | 2.6% | 2.8% | 2.6% | 2.8% | 2.9% | |

*Blend of actual and projected data
Source: DOC/BIS I&S Survey

Survey results highlighted that levels of foreign content were concentrated in thirteen imaging and sensors product categories (see Table 4-8). The night vision system devices and components product category incorporated $221.1 million worth of foreign content over the five-year period (foreign content equaled 7.2 percent of category total sales). Optics components and lenses used $29.1 million (4.2 percent of category total sales) and infrared cameras used $22.1 million (3.8 percent of category total sales) worth of foreign content. Electronics/electrical controls utilized the highest level of foreign content in manufacturing as a percentage of category total sales at 11.2 percent ($17.5 million in foreign content) during 2001 to 2005, followed by "other", a miscellaneous category of unspecified components, at 9.0 percent ($104.3 million).

| Table 4-8: Foreign Content Use as a Percent of Total Sales, Select U.S. Manufactured Imaging and Sensors Products, 2001-2005 | | | | | | |
|---|---|---|---|---|---|---|
| **PRODUCTS** | **Five Year Avg Foreign Content Use** | **2001 Foreign Content Used** | **2002 Foreign Content Used** | **2003 Foreign Content Used** | **2004 Foreign Content Used** | **2005 Foreign Content Used*** |
| Electronics/Electrical Controls (8 out of 10 companies reporting) | 11.2% | 35.3% | 10.8% | 7.2% | 9.7% | 7.9% |
| Others (20 out of 25 companies reporting) | 9.0% | 7.4% | 9.7% | 9.1% | 9.2% | 8.8% |
| Night Vision System Devices and Components (23 out of 33 companies reporting) | 7.2% | 7.3% | 7.4% | 7.0% | 7.1% | 7.1% |
| Optics Components and Lenses (23 out of 35 companies reporting) | 4.2% | 4.7% | 3.3% | 3.4% | 4.0% | 5.5% |
| Focal Plane Arrays (Cooled and Uncooled) (5 out of 6 companies reporting) | 4.2% | 4.3% | 5.0% | 4.8% | 4.2% | 3.5% |
| Infrared Cameras (2 out of 15 companies reporting) | 3.8% | 4.3% | 4.1% | 5.4% | 2.9% | 3.1% |
| Airborne Surveillance Systems (1 out of 5 companies reporting) | 3.8% | 6.3% | 5.4% | 1.7% | 2.6% | 5.0% |
| *Blend of actual and projected data<br>Source: DOC/BIS I&S Survey 2005 | | | | | | |

Ten countries supplied 85 percent of all U.S. imports of imaging and sensors systems and components during 2001 to 2005, according to U.S. Customs data. Those countries, ranked by their level of imports into the United States, are Japan, Germany, Canada, the United Kingdom, Sweden, Singapore, Switzerland, Ireland, France and Israel. Imports grew from $656 million in 2001 to $734 million in 2005.

## E. Domestic and Foreign Sourcing

The majority of components, materials, production equipment, and other products and services utilized for the imaging and sensors industry were procured from domestic sources.

Almost 57 percent of the 141 respondents that procure from domestic sources indicated that the domestic source was their sole source for one or more products or services. Table 4-9 illustrates the percent of sole sourcing based on the product and service

categories reported. Some firms indicated that they have made it company policy to not use foreign sources, while others used foreign sources only if components and materials were not available domestically.

With regard to U.S. sole sources, raw material sourcing accounted for 10.3 percent of sole sources, while optics components accounted for 8.3 percent. Purchases of machinery and machine tools were 7.7 percent of U.S. sole sources. The end use of the final products manufactured was mixed in terms of defense versus commercial applications, and there was no clear relationship between the level of procurement activities and firm size.

**Table 4-9: Domestic Sourcing by U.S. Entities, by Product/Service**

| Product/Service | % where U.S. Source is Sole Source |
|---|---|
| Other Components, Modules, Materials, Machinery, Software, and Services | 12.8% |
| Raw Materials | 10.3% |
| Night Vision System Devices and Components | 9.6% |
| Optics Components and Lenses | 8.3% |
| Machinery/ Machine Tools | 7.7% |
| Image Intensifier ($I^2$) Devices | 6.4% |
| Substrates and Coatings | 5.1% |
| Electronics/Electrical Controls | 5.1% |
| Software/Programming | 4.5% |
| Infrared Cameras | 3.9% |
| Infrared Image Display Components | 3.9% |
| Semiconductor Materials for Infrared Devices | 3.9% |
| Infrared (Thermal) Imaging System Devices and Components (Uncooled) | 3.2% |
| Infrared Detectors | 3.2% |
| Night Vision Goggles | 1.9% |
| Photon Detector Systems | 1.9% |
| Other Complete Systems | 1.9% |
| Focal Plane Arrays (Cooled and Uncooled) | 1.9% |
| Micro Channel Plates | 1.3% |
| Infrared (Thermal) Imaging System Devices and Components (Cooled) | * |
| Night Vision Scopes and Monocular Devices | * |
| Infrared Microscopes | * |
| Bolometers | * |
| Testing and Calibration | * |
| **Total** | **100.0%** |

* < 1%
Source: DOC/BIS I&S Survey 2005

Approximately 66 percent of the 141 respondent firms procure products or services from at least one foreign firm. Leading foreign sole sourced items (based on the number of cases reported) were raw materials with 17.7 percent, image intensifier devices with 13.9 percent, and electronics/electrical controls at 10.1 percent. Table 4-10 illustrates the percent of products and services sole-sourced from foreign entities.

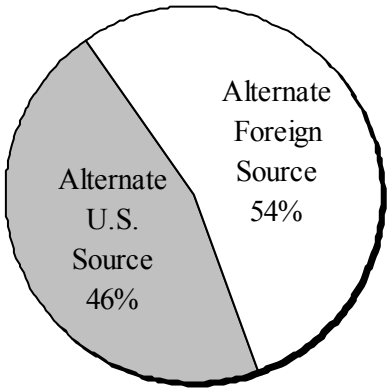
**Table 4-10: Foreign Sourcing by U.S. Entities, by Product/Service**

| Product/Service | % where Foreign Source is Sole Source |
|---|---|
| Raw Materials | 17.7% |
| Image Intensifier (I2) Devices | 13.9% |
| Other Components, Modules, Materials, Machinery, Software, and Services | 11.4% |
| Electronics/Electrical Controls | 10.1% |
| Optics Components and Lenses | 6.3% |
| Night Vision System Devices and Components | 3.8% |
| Focal Plane Arrays (Cooled and Uncooled) | 3.8% |
| Micro Channel Plates | 3.8% |
| Infrared Detectors | 3.8% |
| Software/Programming | 3.8% |
| Machinery/ Machine Tools | 3.8% |
| Infrared (Thermal) Imaging System Devices and Components (Cooled) | 2.5% |
| Infrared Cameras | 2.5% |
| Airborne Surveillance Systems | 2.5% |
| Semiconductor Materials for Infrared Devices | 2.5% |
| Infrared (Thermal) Imaging System Devices and Components (Uncooled) | 1.3% |
| Night Vision Scopes and Monocular Devices | 1.3% |
| Solid State, Low Light Imaging Systems | 1.3% |
| Other Complete Systems | 1.3% |
| Infrared Image Display Components | 1.3% |
| Substrates and Coatings | 1.3% |
| **Total** | **100.0%** |

Source: DOC/BIS I&S Survey 2005

Respondents indicated that there were few alternatives, either domestic or foreign, for their purchases of foreign-sourced inputs. Only 31 percent of firms that procured foreign inputs said that there was a domestic source available for the product or service, while 27 percent indicated that there were alternative foreign sources (see Figure 4-2).

**Figure 4-2: Alternate Sources**



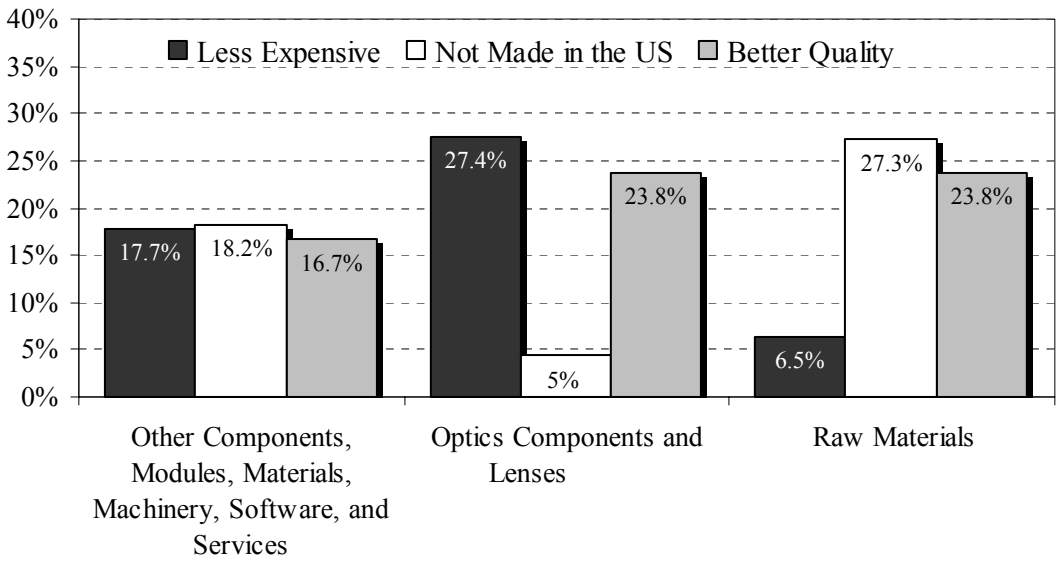

Source: DOC/BIS I&S Survey 2005

Reasons for foreign sourcing varied greatly. Table 4-11 provides the explanations given by U.S. firms for foreign procurement of goods and services. The top three reasons for foreign sourcing were that the foreign products and services were less expensive than domestic sources, the products and services the firms required were not available from domestic sources, or the foreign sources were of better quality. Additional comments from the BIS survey responses pointed out the scarcity of raw materials in the United States, the monopoly that some foreign firms have over particular components and materials, and the high prices and inflexibility of U.S. sources to meet the demands of the commercial market in light of the ready defense market provided by the U.S. Government.

| Table 4-11: Reasons Given by U.S. Firms for Foreign Procurement | |
|---|---|
| | **% of U.S. Firms Reporting** |
| **Less Expensive** | 24.7% |
| **Not Made in the U.S.** | 17.5% |
| **Better Quality** | 16.7% |
| **Business Relationship** | 15.1% |
| **Better Technology** | 13.9% |
| **Doesn't Require a License** | 2.4% |
| **Offset Arrangement** | 0.8% |
| **Delivery Time** | 0.4% |
| **Other** | 8.4% |
| Source: DOC/BIS I&S Survey 2005 | |

Figure 4-3 displays the top three reasons provided by the survey respondents for raw materials, optics components and lenses, and other components modules, materials, machinery, software and services, as those were among the top five product categories for both domestic and foreign sourcing.

**Figure 4-3: Top Reasons for Foreign Sourcing**




Source: DOC/BIS I&S Survey 2005

# V. Research and Development

## A. R&D – Manufacturers and Laboratories

The rapid advances in product capabilities and applications among global suppliers are an indication of the importance of Research and Development (R&D) funding to the imaging and sensors industry. To remain competitive in the global marketplace, U.S. suppliers of imaging and sensors products acknowledge that they must continue to invest aggressively in R&D, especially in commercial applications.

In order to assess the R&D funding activity by U.S. industry, BIS evaluated the survey results of 141 U.S. manufacturer respondents and 28 government/private laboratories for the application and sources of such investment.

### *A.1 Manufacturer R&D Trends*

Domestic manufacturers of imaging and sensor products spent over $1 billion on R&D from 2001 to 2005. Annual research expenditures averaged $39 million during the five-year period, while development spending averaged $161 million per year (see Figure 5-1).

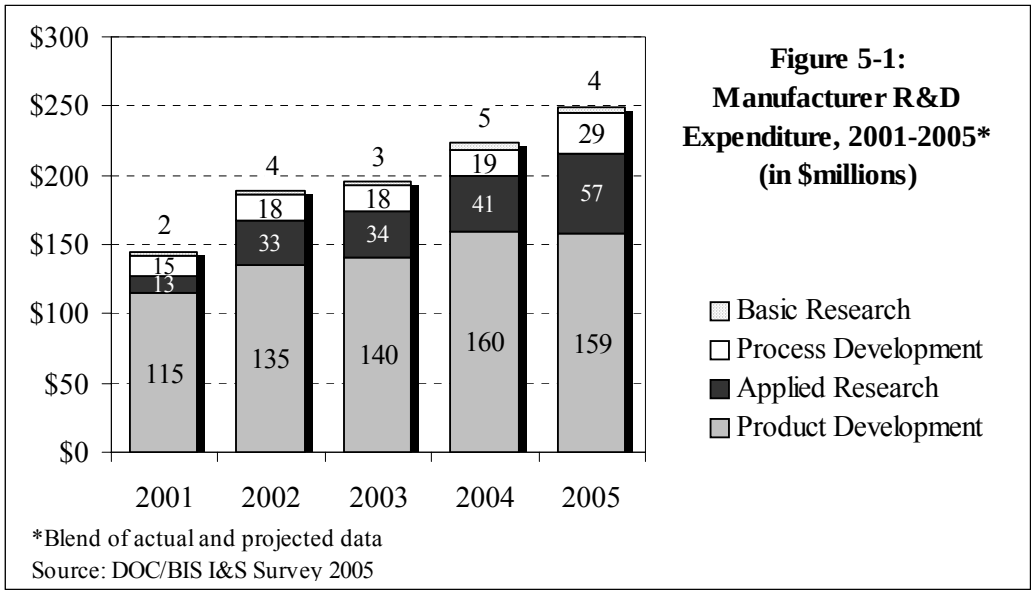



**Figure 5-1: Manufacturer R&D Expenditure, 2001-2005* (in $millions)**

*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

Total R&D expenditures for manufacturers increased from $146 million in 2001 to $249 million in 2005. This increase in R&D expenditures represented a compound annual growth of 11.2 percent from 2001 to 2005.

In addition to annual increases in total expenditures from 2001 to 2005, the proportion of research to development also changed. For instance, in 2001, for every $1 spent on research, $8 dollars were spent on development. By 2005, this proportion narrowed to $1 in research to every $3 in development.

### *A.2 Manufacturer R&D Sources*

Manufacturers of imaging and sensors products frequently support R&D initiatives using DOD funding, sourced from the various Armed Services. DOD allocated $350 million to manufacturer R&D in the 2003-2005 period. An additional $300 million on R&D funding was generated internally by the reporting firms and $75 million was generated from outside sources (see Table 5-1).

| Table 5-1: R&D Funding Sources<br>Imaging/Sensors Manufacturers (in $thousands) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **2003 $** | **2003 %** | **2004 $** | **2004 %** | **2005* $** | **2005* %** | **2003-2005 Totals** |
| Internal Funding | 91,850 | 40.5% | 98,892 | 37.9% | 108,698 | 45.9% | **299,440** |
| Total DOD | 117,863 | 52.0% | 129,577 | 49.7% | 102,065 | 43.1% | **349,505** |
| *- U.S. Air Force* | *56,988* | 25.1% | *55,797* | *21.4%* | *36,519* | *15.4%* | *149,303* |
| *- U.S. Army* | *23,900* | 10.5% | *34,479* | *13.2%* | *29,31* | *12.4%* | *87,692* |
| *- U.S. Navy* | *28,096* | 12.4% | *17,583* | *6.7%* | *15,028* | *6.4%* | *60,707* |
| *- Other U.S. DOD* | *8,880* | 3.9% | *21,719* | *8.3%* | *21,205* | *9.0%* | *51,803* |
| U.S. Industry (Peers) | 9,145 | 4.0% | 24,532 | 9.4% | 17,348 | 7.3% | **51,025** |
| U.S. Private Equity | 2,020 | 0.9% | 834 | 0.3% | 1,715 | 0.7% | **4,573** |
| Foreign Government | 200 | 0.1% | 200 | 0.1% | 200 | 0.1% | **600** |
| Foreign Private | 990 | 0.4% | 1,320 | 0.5% | - | - | **2,310** |
| Foreign University | - | - | 14 | 0.0% | 113 | 0.1% | **127** |
| Non-profit | - | - | - | - | 100 | 0.0% | **100** |
| Subcontractor | 2,387 | 1.1% | 961 | 0.4% | 3,618 | 1.5% | **6,966** |
| Other | 2,411 | 1.1% | 4,458 | 1.7% | 2,728 | 1.2% | **9,597** |
| **TOTAL*** | **$226,867** | 100% | **$260,792** | 100% | **$236,585** | 100% | **$724,244** |

Note: Percent totals may fluctuate due to rounding.
*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

Internal R&D spending from firms complemented DOD spending over the same period, rising from 40.5 percent of all R&D spending in 2003 to 45.9 percent in 2005. In 2005, internal R&D funding of $108.7 million surpassed DOD funding of $102 million. Other funding categories, private equity, other firms, and foreign governments, collectively accounted for less than 12 percent of all R&D funding.

## B. R&D – Research Organizations and Laboratories

Research organizations and laboratories have been at the forefront of developing imaging and sensors system technology in response to DOD's demand for enhanced applications.

A total of 28 survey respondents, consisting of laboratories and other research organizations, reported expenditures on R&D during the 2001-2005 period. According to survey respondents, expenditures on R&D increased 62.8 percent from $201 million in

2001 to over $327 million in 2005 (see Figure 5-2). This compound annual growth rate of over 10 percent resulted primarily from growing DOD requirements for imaging and sensors products used in military applications.

*B.1 Research Organization and Laboratory R&D Trends*

Laboratories and research groups reported that DOD-driven product development funding led most of their R&D activities during 2001-2005, with product development funding rising from $93.9 million in 2001 to $184 million in 2005. Among other R&D subcategories, expenditures devoted to basic research funding grew by 59.2 percent over the 2001-2005 period, rising from $9.8 million in 2001 to $15.6 million in 2005. Applied research expenditures increased from $73.3 million in 2001 to $98.9 million in 2005, or by 34.9 percent. Process development expenditures grew by 19.7 percent, rising from $23.9 million in 2001 to $28.6 million in 2005 (see Figure 5-2).

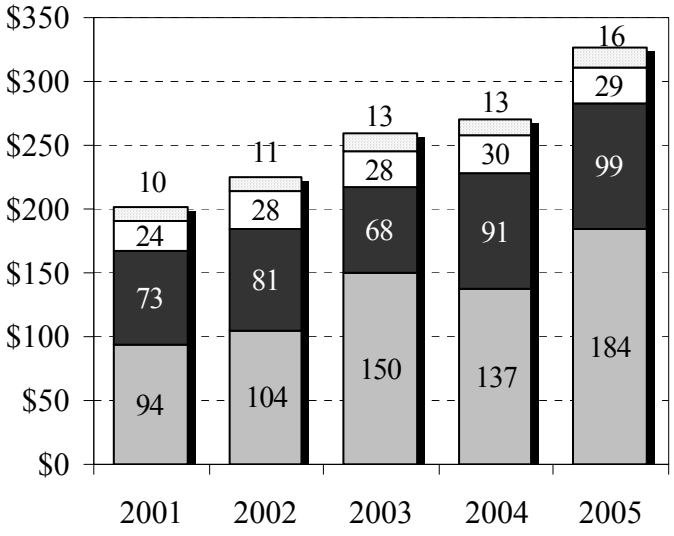



**Figure 5-2: Lab/Research Organization R&D Expenditure, 2001-2005* (in $millions)**

*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

BIS survey respondents indicated that university research laboratories devote R&D funds mostly for basic and applied research, while private sector organizations concentrate primarily on product development. DOD-affiliated research institutions, including those

of the Armed Forces, engage in both basic and applied research as well as process and product development.

# VI. Employment and Workforce

## A. Employment by Occupation

### *A.1 Manufacturers, System Integrators, and Service Providers*

The U.S. workforce in the thermal imaging and sensors industry experienced steady annual job growth during the 2001-2005 period. Total employment at the 135 companies involved in manufacturing, systems integration, and service that reported employment information climbed from 7,721 in 2001 to 10,918 in 2005, an increase of 41.4 percent, or 3,197 jobs. The survey respondents reported year-on-year job growth of 9.3 percent in 2002, 7.1 percent in 2003, 10.0 percent in 2004, and 9.8 percent in 2005, as documented in Table 6-1.

**Table 6-1: U.S. Imaging and Sensors Employment by Occupation for Manufacturers/Integrators/Service Providers**

| Occupation | 2001 | 2002 | 2003 | 2004 | 2005* |
|---|---|---|---|---|---|
| Production Managers/Supervisors | 363 | 463 | 470 | 543 | 573 |
| Development Staff (e.g., Engineers) | 1,206 | 1,560 | 1,692 | 1,951 | 2,102 |
| Research Staff (e.g., Scientists) | 116 | 136 | 131 | 160 | 219 |
| Production Line Workers | 2,555 | 2,791 | 3,043 | 3,324 | 3,651 |
| Support Technicians | 425 | 452 | 471 | 543 | 586 |
| Quality Control | 241 | 232 | 274 | 306 | 366 |
| Test Operators | 220 | 220 | 230 | 257 | 320 |
| Administrative Staff | 780 | 883 | 903 | 1002 | 1,156 |
| Other | 1,815 | 1,1704 | 1,826 | 1,861 | 1,945 |
| Total Employment | 7,721 | 8,441 | 9,040 | 9,947 | 10,918 |

*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

The industry saw the greatest growth in absolute numbers in production line jobs, where employment levels rose from 2,555 in 2001 to 3,651 in 2005. This was followed by job growth in product development (engineers), where employment levels in 2005 reached 2,102 up from 1,206 in 2001.

Almost half of the employment increase was concentrated in the ten largest employers in the industry, which reported job growth of 31 percent between 2001 and 2005 (see Table

6-2). In 2005, the top ten employers accounted for 6,734 workers, or 61.7 percent, of the total employment among survey respondents. By contrast, the remaining 125 BIS survey respondents reported total job growth of 62.1 percent between 2001 and 2005. In 2005, this group of firms accounted for 4,184 workers, or 38.3 percent of total employment, having accounted for only 2,581 jobs or 33.4 percent of the total employment in 2001 (see Table 6-2).

**Table 6-2: Total U.S. Imaging and Sensors Employment by Firm Size for Manufacturers/Integrators/Service Providers**

| | 2001 | | 2002 | | 2003 | | 2004 | | 2005* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No | % | No | % | No | % | No | % | No | % |
| Top 10 Employers | 5,140 | 66.6 | 5,951 | 70.5 | 6,158 | 68.1 | 6,491 | 65.3 | 6,734 | 61.7 |
| Remaining U.S. companies in BIS survey | 2,581 | 33.4 | 2,490 | 29.5 | 2,882 | 31.9 | 3,456 | 34.7 | 4,184 | 38.3 |

*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

*A.2 R&D Staff Degree Status*

The BIS survey asked manufacturers, systems integrators, and service providers to provide employment data by type of advanced degree held by development and research staff for the year 2004. Responses were received from all 135 companies. A total of 427 engineers held advanced degrees (masters and PhDs). Masters degrees were held by 345 engineers, while PhDs were held by 82 engineers. With regard to research staff (scientists), there were 34 scientists in 2004 with master degrees only, while 55 scientists had Doctorates (see Table 6-3).

The number of non-U.S. citizens working as engineers and scientists was relatively low, in great part because employment dealing with classified military programs, the majority of business for U.S. firms in the imaging and sensors field, precludes employment of non-U.S. citizens.

| Table 6-3: U.S. R&D Education for Manufacturers/Integrators/Service Providers, 2004 | | |
|---|---|---|
| | **Masters Only** | **PhDs** |
| | Numbers | Numbers |
| **U.S. Citizens** | | |
| Development Staff (e.g., Engineers) | 321 | 68 |
| Research Staff (e.g., Scientists) | 32 | 47 |
| **Non-U.S. Citizens** | | |
| Development Staff (e.g., Engineers) | 24 | 14 |
| Research Staff (e.g., Scientists) | 2 | 8 |
| **Total** | 379 | 137 |
| Source: DOC/BIS I&S Survey 2005 | | |

## B. Labor Concerns

### *B.1 Shortage of Workers*

The industry's overall growth potential could have translated into even greater job creation if it had not been for shortages of qualified personnel at all levels. The survey results indicate that labor shortages affected large defense contractors, small- and medium-sized companies, and government research laboratories alike. BIS survey respondents indicated that qualified and experienced employees are extremely hard to find in almost all specialty occupations, including optics design engineers and opto-mechanical engineers. Experienced integrated circuit design staff, as well as systems engineers with backgrounds in imaging, servos, sensors, and video tracking were also in short supply. The same is true for field-programmable gate array design engineers with backgrounds in imaging and video.

BIS survey respondents also noted that engineers, particularly software engineers, have migrated from their industry to the software and other non-defense industries. In addition, survey respondents complained that U.S. universities are not funded sufficiently to carry out basic imaging-and sensor-related research and do not train future scientists and engineers in adequate numbers.

The difficulty of recruiting experienced personnel goes beyond scientists and engineers and extends to skilled technicians and other trades. This shortage of qualified personnel may get worse in the coming years, as an aging workforce, particularly highly qualified engineers, starts to reach retirement age.

Filling these projected shortages with competent foreign nationals is one option, but this solution brings with it another set of problems. Firms employing foreign nationals must apply for deemed export licenses, and foreign nationals working with dual-use technologies must have an appropriate visa classification. Moreover, BIS survey respondents noted that hiring a foreign national or even a permanent resident is not even an option for companies engaged in sensitive military programs. These companies are limited to hiring U.S. citizens with security clearances, a factor that further reduces the available talent pool.

### *B.2 Workforce Age*

An aging workforce presents a major challenge for the imaging and sensors industry according to the respondents in the BIS survey. There were 913 U.S. and non-U.S. citizens over 50 years of age or 50.2 percent of the total number of engineers and scientists in this industry (see Table 6-4). There were 622 U.S. and non-U.S. citizens or 34.2 percent of the total between 35 and 50 years of age. Among BIS survey respondents, engineers and scientists below the age of 35 totaled 282, accounting for only 15.5 percent of skilled workers.

| Table 6-4: Age Range of U.S. Skilled Workers for Manufacturers/Integrators/Service Providers in 2004 | | | |
|---|---|---|---|
| | **<35 Years Old** | **35-50 Years Old** | **>50 Years Old** |
| **U.S. Citizens** | | | |
| Development Staff (e.g., Engineers) | 245 | 539 | 860 |
| Research Staff (e.g., Scientists) | 11 | 61 | 47 |
| **Non-U.S. Citizens** | | | |
| Development Staff (e.g., Engineers) | 21 | 19 | 3 |
| Research Staff (e.g., Scientists) | 5 | 3 | 3 |
| **Total:** | 282 | 622 | 913 |
| Source: DOC/BIS I&S Survey 2005 | | | |

*B.3 Labor Costs*

According to narrative information provided by BIS survey respondents, the shortage of skilled labor at all levels has resulted in rising wages for manufacturers, systems integrators, and service providers alike. These rising wages are squeezing smaller firms financially, particularly combined with increasing health care costs that have risen 12-18 percent annually in recent years. Also, for those firms providing retirement and pension plans, the aging workforce is a major cost.

Survey respondents also complained that this wage inflation has made retention of experienced employees very difficult. Large defense contractors are able to offer higher salaries and better benefit packages. As a result, the smaller firms cannot always compete for scarce skilled labor. Smaller companies also fail to retain experienced engineers who choose to take advantage of the labor shortage by becoming independent consultants.

## C. Research Organizations and Laboratories

*C.1 Employment (Federal vs. Private) (Defense vs. Non-Defense)*

Despite the difficulties expressed by many respondents in finding and hiring qualified engineers and scientists, overall employment also increased for research organizations

and laboratories during 2001-2005 (see Figure 6-1). Twenty-eight survey respondents reported that total employment climbed by almost 25 percent from 931 to 1,161 during the five-year period. The rate of growth for employment of foreign citizens (56.9 percent) was two-and-a-half times that of the growth for employment of U.S. citizens (22.8 percent), in part reflecting respondent firms' difficulty in finding qualified U.S. engineers and scientists. However, U.S. citizens accounted for 93.1 percent of total employment in 2005.

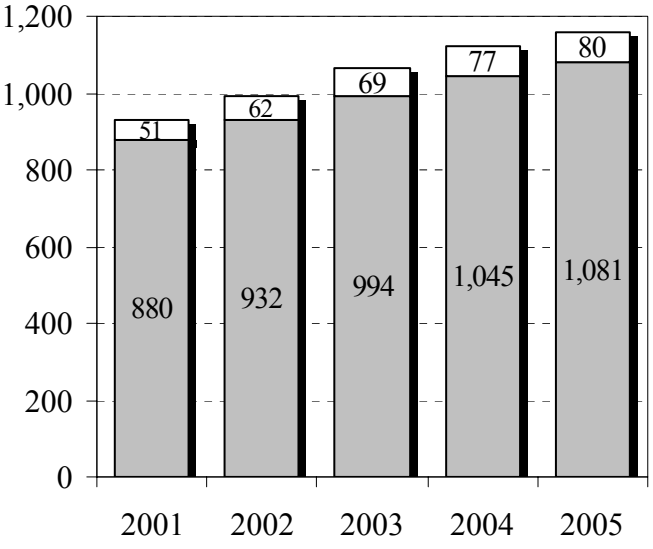



**Figure 6-1:**
**Total Employment at U.S. Research Organizations and Laboratories, 2001-2005* (# of Employees)**

*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

Almost all of the R&D organizations commenting on labor issues said that they have difficulty hiring qualified technical employees. Several organizations noted that they have internal training programs to develop the proper level of experience for new hires because experienced workers are not readily available. Another organization emphasized that it has difficulty in finding qualified U.S. citizens.

## D. Occupation – All Research Organizations and Laboratories, U.S. Citizens

*D.1 All Labs*

For all reporting research organizations and laboratories, U.S. development staff (primarily engineers) increased from 405 in 2001 to 533 in 2005, a 31.6 percent increase (see Figure 6-2). U.S. research staff (primarily scientists) increased from 318 in 2001 to 370 in 2005, a growth rate of 16.4 percent. A major portion of the employment growth can be attributed to an increased defense budget in recent years.

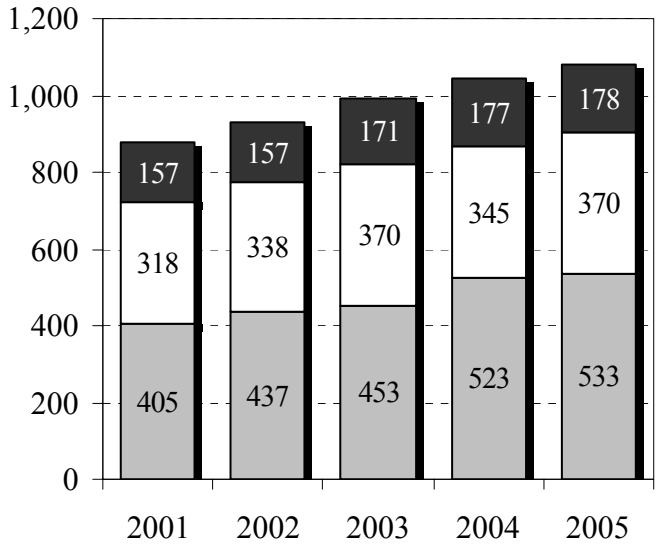



**Figure 6-2:**
**Private, Government and University Laboratory Employment - U.S. Citizens, 2001-2005***
**(# of Employees)**

*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

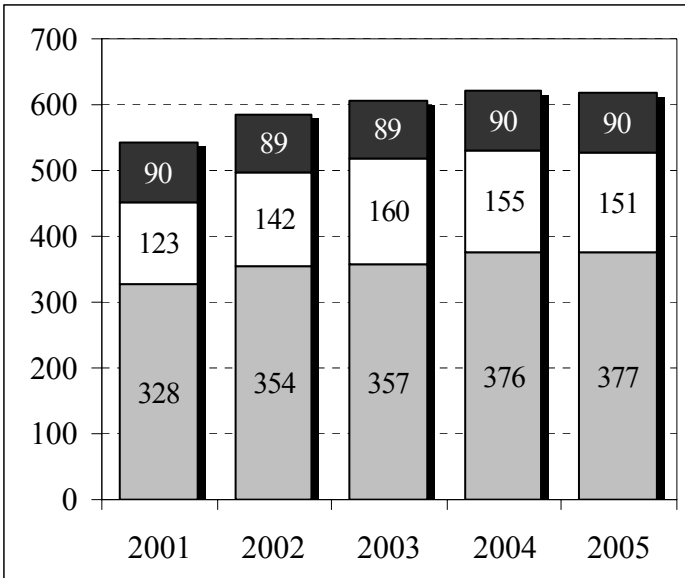



**Figure 6-3:**
**U.S. Government Laboratory Employment - U.S. Citizens, 2001-2005* (# of Employees)**

*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

*D.3 Private Industry Labs*

According to survey respondents, the number of development engineers (U.S. citizens) in private industry laboratories increased 128 percent from 60 in 2001 to 137 in 2005 (see Figure 6-4). The number of research staff, by comparison, was relatively steady during 2001 to 2005 (from 115 to 121, or a 5.2 percent increase). The increase in development engineers may be attributed to higher demand for new products.

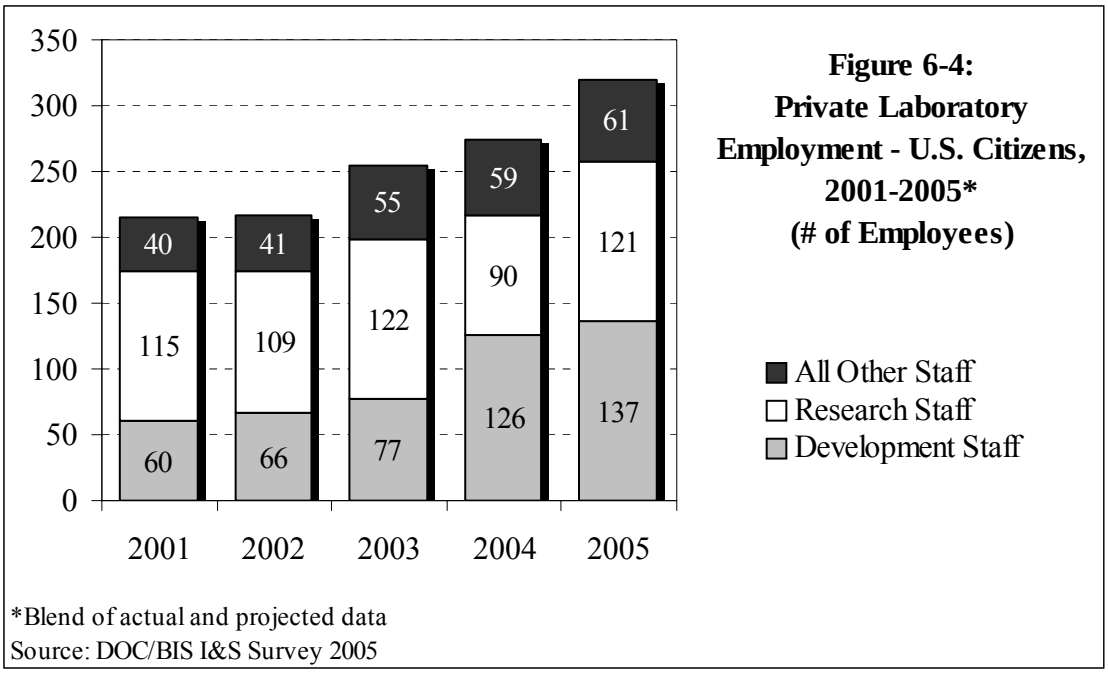



**Figure 6-4:**
**Private Laboratory Employment - U.S. Citizens, 2001-2005***
**(# of Employees)**

*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

*D.4 University Laboratories*

University staff levels for U.S. development staff (engineers) remained relatively constant during the five-year reporting period; development staff levels only increased by two persons (see Figure 6-5). According to respondents to the BIS survey, the number of U.S. research staff (scientists) at universities increased from 80 in 2001 to 98 in 2005, an increase of 22.5 percent.

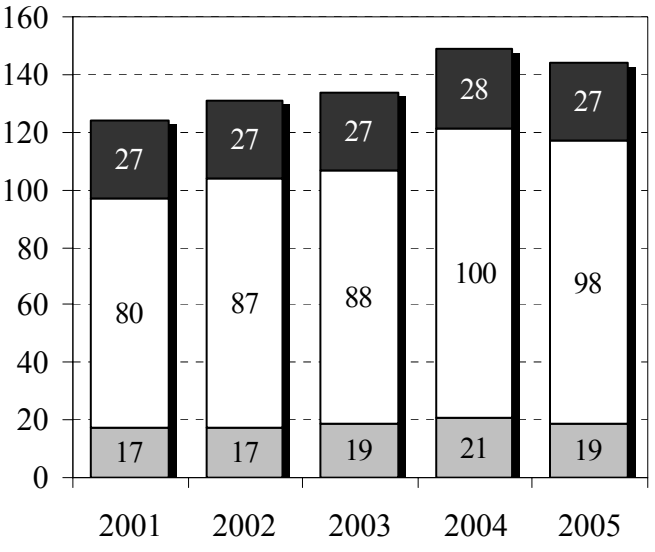



**Figure 6-5:**
**University Laboratory Employment - U.S. Citizens, 2001-2005***
**(# of Employees)**

*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

## E. Occupation – All Research Organizations and Laboratories, Non-Citizens

The employment of non-U.S. development staff increased 140 percent, from 5 to 12, during 2001-2005, while non-U.S. citizen research staff climbed 28 percent, from 25 to 32 (see Figure 6-6). While the percent change during the period for each category was substantial, the overall numbers were low. U.S. citizens still represented 97.8 percent of the development staff and 92 percent of research staff in 2005. However, the higher numbers of non-U.S. staff may provide some evidence of attempts by some laboratories to fill shortages of skilled personnel, especially in specialty occupations, by hiring foreign nationals (the U.S. Government does not employ non-U.S. citizens).

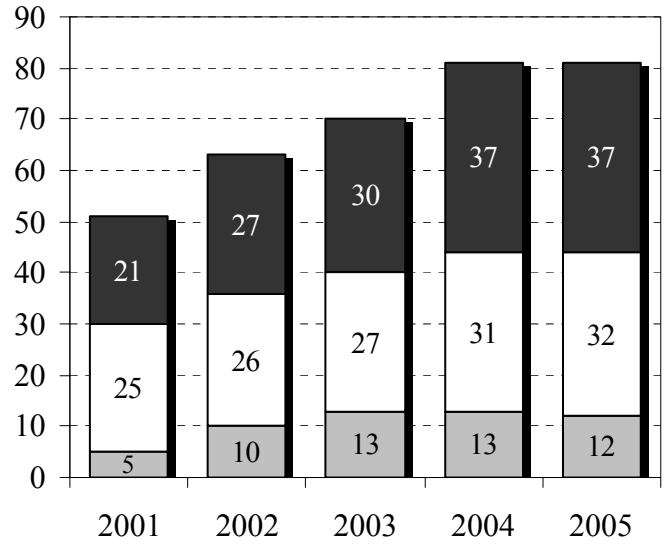



**Figure 6-6: Private, Government and University Laboratory Employment - Non-U.S. Citizens, 2001-2005* (# of Employees)**

*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

*E.1 Private Industry Laboratories*

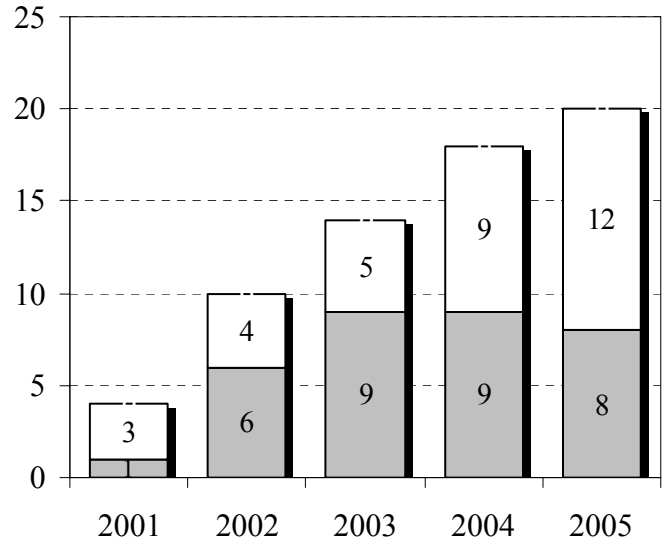



**Figure 6-7: Industry Employment Non-U.S. Citizens, 2001-2005* (# of Employees)**

*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

In private laboratories, scientists accounted for the largest group of non-U.S. research staff during 2005, accounting for 12 persons, an increase from three staff members in 2001. Non-U.S. engineers increased from one in 2001 to seven in 2005 (see Figure 6-7). The increase in scientists and engineers may be attributed to attempts by private laboratories to fill shortages of skilled personnel, particularly in specialty occupations by hiring foreign nationals.

*E.2 University Laboratories*

Non-U.S. citizens working at university laboratories numbered 61 in 2005, increasing from 46 in 2001 (see Figure 6-8). Almost all the growth was attributable to employees with non-technical disciplines, as the technical research and development staff remained flat (between 24 and 25 employees) during the period.

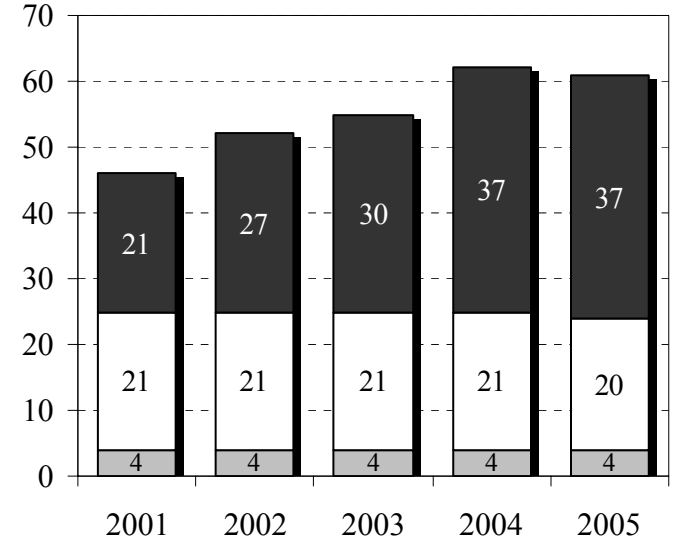



**Figure 6-8: University Laboratory Employment - Non-U.S. Citizens, 2001-2005* (# of Employees)**

*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

## F. Skilled Worker Age Range

### *F.1 Government, Private Industry, and University Laboratories*

The 28 research organizations and laboratories responding to the BIS survey provided age range data for only 743 of the 903 technical staff employed in research and development during 2004. Of the 743 technical employees, 307, or 45 percent, were between the ages of 35-50 with the remaining almost equally split between the "under 35" (27 percent) and "over 50" (28 percent) age ranges (see Table 6-5). The range of laboratory workers ages is much more manageable for pending retirements than the comparable age breakout of skilled manufacturer workers shown in Table 6-4.

Employment of these "under 35" workers in laboratories is almost split evenly between the development function and the research function. Skilled workers in the older two age groups were more likely to be involved in development rather than research, by a 60 percent to 40 percent ratio. For the manufacturing sector, by comparison, the research function was accounted for by 266 development staff compared to only 16 research staff.

**Table 6-5: Age Range of Skilled Workers**

| | <35 Years Old | 35-50 Years Old | Over 50 Years Old |
|---|---|---|---|
| **U.S. Citizens** | | | |
| Development Staff | 89 | 195 | 121 |
| Research Staff | 87 | 125 | 84 |
| **Non-U.S. Citizens** | | | |
| Development Staff | 6 | 3 | 1 |
| Research Staff | 18 | 14 | 0 |
| **Total** | 200 | 337 | 206 |

Source: DOC/BIS I&S Survey 2005

## G. Laboratory Staff Degree Status

Research organizations and laboratories reported that they employed 333 technical workers with advanced degrees in 2004. Among U.S. citizens with masters degrees, 101 were employed in a development function and 80 performed research duties (see Table 6-6). For non-U.S. citizens with masters degrees, those involved in research outnumbered the development staff 15 to 6.

For employees holding PhDs, those in a research function outnumbered development workers 76 to 24 – an indication of the specialized technical requirement for pure and applied research. Non-U.S. citizens accounted for about 30 percent of all PhDs employed by reporting organizations.

As with other parts of the imaging and sensors industry, the relatively lower levels of employment by non-U.S. citizens with advanced degrees may attributed to defense-related work conducted by survey respondents, for which non-U.S. staff would be excluded.

**Table 6-6: U.S. R&D Education for Government, Private and University Laboratories**

| | Masters Only | PhDs |
|---|---|---|
| **U.S. Citizens** | | |
| Development Staff | 101 | 24 |
| Research Staff | 80 | 76 |
| **Non-U.S. Citizens** | | |
| Development Staff | 6 | 0 |
| Research Staff | 15 | 31 |
| **Total** | 202 | 131 |

Source: DOC/BIS I&S Survey 2005

## H. Labor Concerns

Seventeen out of 28 research organization and laboratory respondents provided information regarding labor concerns. Specifically, the problems cited by these organizations included: difficulties in locating skilled technicians, engineers and scientists; inconsistencies in cash flow orders from the military and the government; shortages of sensor experts; and inability to find qualified optics engineers.

One firm responded that it had experienced high turnover in the senior scientist position over the past five years. The labor concerns of two companies related to excessive retirement of experienced workers. According to one of these firms, cash flow difficulties prevented the company from retaining expertise in this area. Four firms cited an inability to offer salaries competitive with other industry sectors. Defense organizations indicated that government salaries are significantly lower than those of comparable private organizations. Finally, three firms cited other labor concerns, such as finding graduate students, skilled technicians, engineers and scientists, and inconsistent orders from the military.

# VII. Imaging/Sensors Imports and Exports

## A. Overview

Historically, the United States has been a net importer of imaging and sensors products. According to the U.S. Customs Service,[12] imports of telescope rifle sights, electrochemical instruments, and electrical spectrophotometers have historically outpaced exports. During 2001-2005, the trade deficit in these products has substantially decreased to $169 million in 2005 from a high of $272 million in 2001. It should be noted that imaging and sensors devices fall into a broad set of Harmonized Tariff Schedule (HTS) numbers that include other non- imaging and sensors devices (such as certain laboratory equipment). These HTS numbers were used to obtain data on the overall balance of trade in imaging and sensors products.

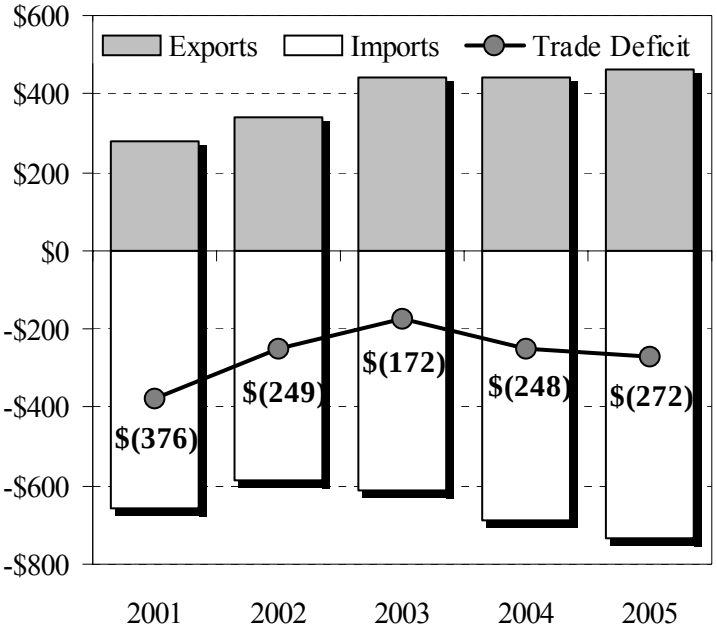



**Figure 7-1: U.S. Imports and Exports of Imaging and Sensors Products 2001-2005* (in $millions)**

*Blend of actual and projected data
Source: U.S. Customs Service and DOC/BIS I&S Survey DOC/BIS I&S Survey 2005

[12] U.S. Customs Service data are somewhat broader in scope than the products covered in the BIS survey, but is heavily populated with imaging and sensors products. For this reason, the U.S. Customs data provide a good proxy for imports of the targeted imaging and sensors products.

## B. Imports of Imaging and Sensors Products

After a slight decline of 11 percent from 2001 to 2002, U.S. imports of imaging and sensors products climbed steadily in subsequent years, reaching $734 million in 2005 (see Figure 7-1). This increase in imports is consistent with concerns stated by a number of survey respondents that foreign producers are attracting buyers in the U.S. market for a wide range of imaging and sensors products.

There is also evidence from BIS survey results that a portion of this growth in U.S. imports is attributed to increased foreign presence in the United States in the form of subsidiaries, distributors, sales organizations and licensee/licensor relationships.

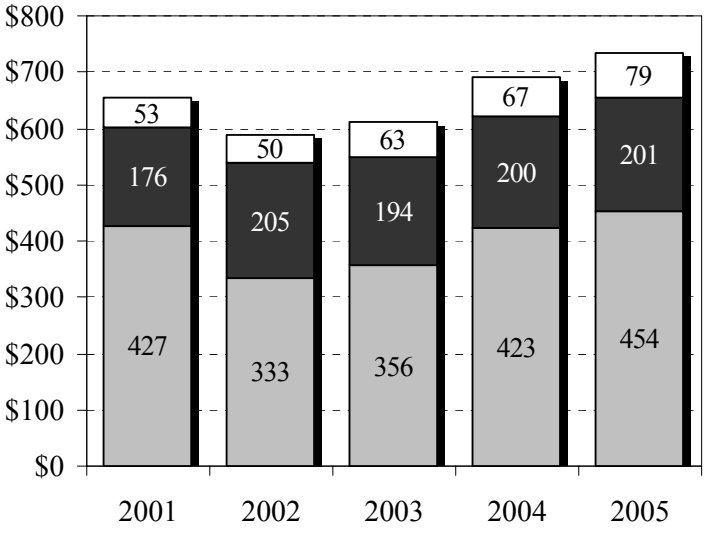



**Figure 7-2:**
**U.S. Imports of Imaging and Sensors Products**
**2001-2005* (in $millions)**

Source: U.S. Customs Service
*Other category includes: Electrochemical Instruments Using Optical Radiation (Non-Electric); UV or IR Ray Apparatus, Parts & Accessories; and Telescopic Rifle Lenses

For 2001-2005, the majority of U.S. imports of imaging and sensors equipment included electrical instruments that use optical radiations (almost $2 billion) and electrical spectrophotometers using optical radiations ($976 million) (see Figure 7-2). Import data for the remaining three imaging and sensors import categories captured by the U.S. Customs Service include infrared ray and ultraviolet apparatus and parts ($148 million),

non-electrical instruments using optical radiation ($138 million), and telescope rifle sights ($26 million).

Imports of electrical spectrophotometers remained relatively stable during this period, valued at close to $200 million annually (see Figure 7-2). Imports of electrochemical instruments (not electrical) utilizing optical radiation jumped 61 percent from 2004 to 2005 to more than $40 million. After a sharp decline in 2002, imports of electrochemical instruments utilizing optical radiation rose to $454 million in 2005, or an increase of 36 percent.

*B.1 Import Sources*

Ten countries accounted for 85 percent of imports during 2001 to 2005 (see Table 7-1). Imports from Japan and Germany, the two largest sources, were valued at $667 million and $474 million, respectively, during the five-year period.

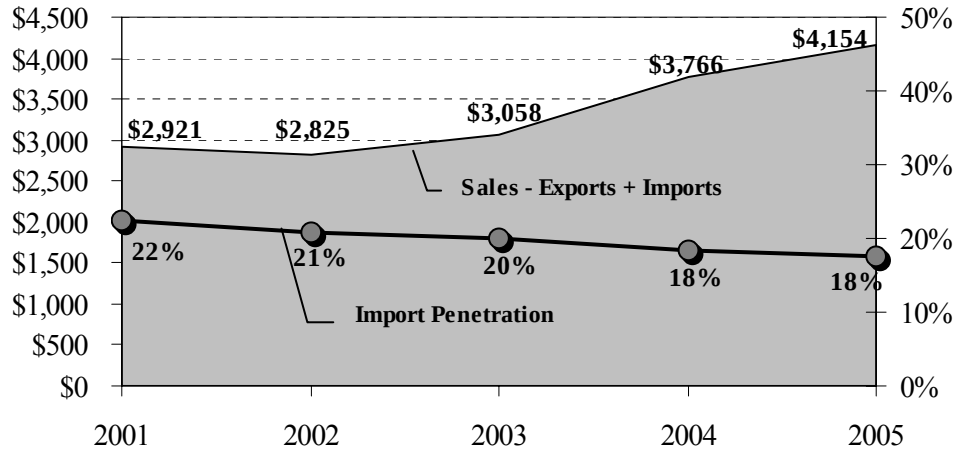
**Table 7-1: U.S. Imaging and Sensors Import Sources, 2001-2005 (in $millions)**

| | 2001 | 2002 | 2003 | 2004 | 2005* | Cumulative |
|---|---|---|---|---|---|---|
| Japan | 195.6 | 124.0 | 113.5 | 109.9 | 123.8 | **$666.9** |
| Germany | 108.0 | 88.1 | 75.2 | 97.2 | 105.5 | **$473.9** |
| Canada | 43.8 | 47.3 | 52.1 | 65.6 | 74.7 | **$283.5** |
| UK | 61.3 | 49.5 | 42.7 | 62.1 | 60.0 | **$275.6** |
| Sweden | 42.7 | 41.7 | 54.2 | 66.1 | 67.9 | **$272.6** |
| Singapore | 58.7 | 44.6 | 48.9 | 56.2 | 58.5 | **$266.9** |
| Switzerland | 37.9 | 35.1 | 51.7 | 41.3 | 46.5 | **$212.6** |
| Ireland | 14.8 | 22.6 | 31.9 | 22.2 | 25.4 | **$116.8** |
| France | 18.3 | 20.2 | 22.6 | 23.6 | 30.9 | **$115.7** |
| Israel | 5.7 | 20.1 | 30.1 | 31.4 | 24.8 | **$112.1** |
| Other | 69.3 | 94.1 | 89.5 | 114.5 | 115.5 | **$482.8** |
| **TOTAL** | **$656.1** | **$587.3** | **$612.4** | **$690.1** | **$733.5** | **$3,279.4** |

*Blend of actual and projected data
Source: U.S. Customs Service

As illustrated in Figure 7-3, despite the rising value of U.S. imports, the level of import penetration[13] in the U.S. marketplace has declined. An expanding domestic market, fueled primarily by U.S. defense sales, has more than offset the increase in imaging and sensors imports.

**Figure 7-3: Imaging and Sensors Import Penetration in U.S. Market, 2001-2005* (in $millions and percent)**




*Blend of actual and projected data

Source: U.S. Customs Service and DOC/BIS I&S Survey DOC/BIS I&S Survey 2005

## C. Exports of Imaging and Sensors Products

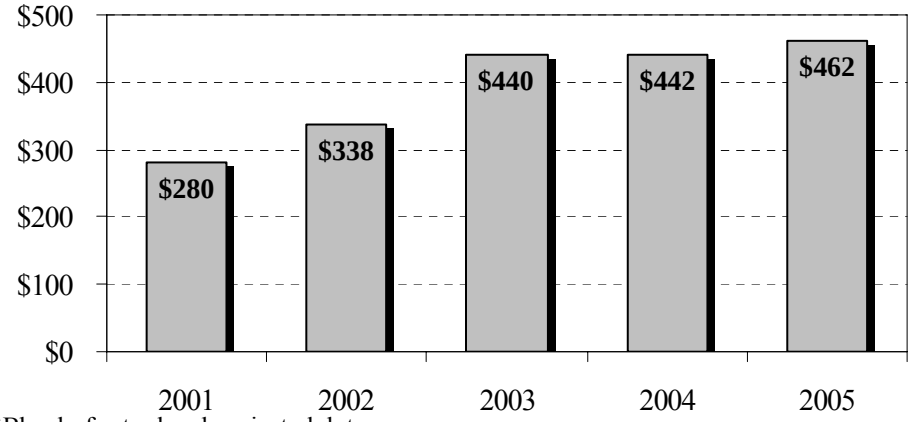
A total of 91 firms reported exports of imaging and sensors products during 2001-2005. U.S. exports reached $462 million in 2005, from $280 million in 2001 (see Figure 7-4). This 65 percent growth in exports since 2001 compares to import growth of 12 percent during the same period.

Exports in two product categories, night vision system devices/components and infrared (thermal) imaging system devices/components (cooled) dominated the value of U.S. exports. Combined, these two categories captured more than 47 percent ($930.1 million) of the value of total exports ($1.96 billion) during 2001-2005. The bulk of the increase in

[13] Import penetration is defined as the share of imports as a percent of total supply of goods and services available for consumption. Calculated as {Imports} / {Sales – Exports + Imports}.

export value for night vision system devices/components was due to defense-related exports.

**Figure 7-4: Total Imaging and Sensors Exports - Surveyed U.S. Manufacturers, 2001-2005* (in $millions)**




*Blend of actual and projected data

Source: DOC/BIS I&S Survey DOC/BIS I&S Survey 2005

In contrast to the growth in cooled thermal products, exports of uncooled devices declined significantly during 2002-2005, falling from a peak level of $59.5 million in 2002 to less than $20 million in 2005. This decline is related to increased foreign competition coupled with industry's concerns with U.S. export control licensing delays. Several U.S. firms indicated that foreign competitors benefit from less restrictive export controls applied by their government.

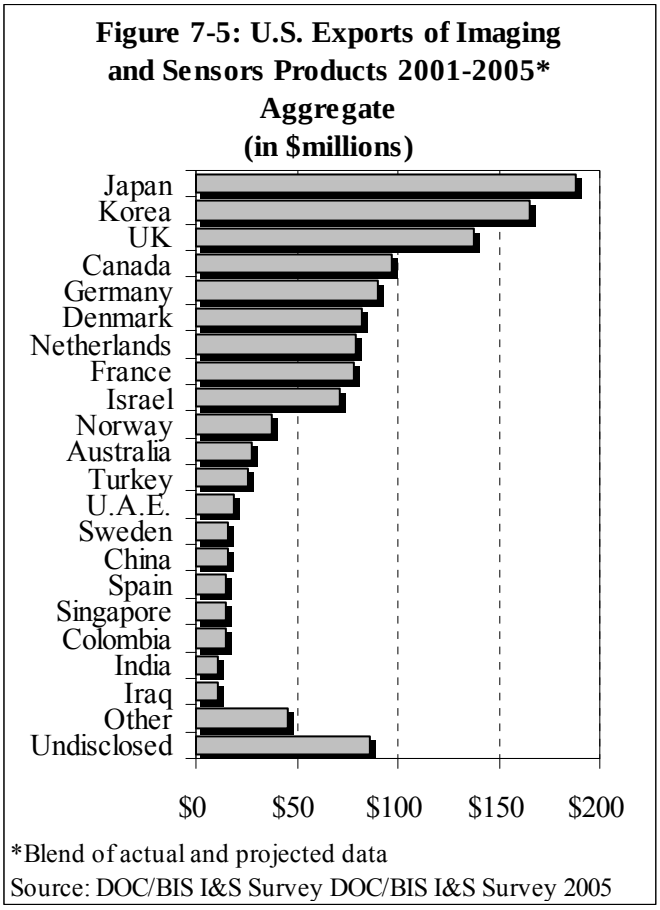
| Table 7-2: U.S. Exports of Image and Sensor Products (in $millions) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **2001** | **2002** | **2003** | **2004** | **2005*** | **2001-2005 Total** | **% Change 2001-2005** |
| Night Vision System Devices and Components | $49.3 | $37.0 | $163.6 | $110.8 | $126.1 | $486.7 | 155.8% |
| Infrared (Thermal) Imaging System Devices & Components (Cooled) | $54.9 | $71.5 | $75.2 | $117.2 | $124.6 | $443.4 | 127.0% |
| Night Vision Goggles | $29.0 | $60.3 | $44.8 | $38.9 | $57.2 | $230.2 | 97.2% |
| Infrared (Thermal) Imaging System Devices & Components (Uncooled) | $54.6 | $59.5 | $34.7 | $27.1 | $19.7 | $195.6 | -63.9% |
| Image Intensifier (I2) Devices | $16.0 | $28.2 | $23.3 | $22.1 | $25.9 | $115.5 | 61.9% |
| Infrared Cameras | $15.5 | $19.1 | $21.5 | $22.3 | $17.6 | $95.9 | 13.5% |
| Electronics/Electrical Controls | $4.7 | $11.9 | $12.9 | $22.6 | $28.1 | $80.2 | 497.9% |
| Infrared Detectors | $10.2 | $9.0 | $6.6 | $9.7 | $10.6 | $46.0 | 3.9% |
| Optics Components and Lenses | $10.7 | $8.4 | $8.7 | $10.2 | $7.2 | $45.2 | -32.7% |
| Infrared Target Detection Systems | $0.3 | --- | $0.4 | $26.8 | $8.2 | $35.7 | 2633.3% |
| Substrates and coatings | $4.0 | $5.0 | $6.6 | $7.8 | $9.3 | $32.6 | 132.5% |
| Other | $30.8 | $28.1 | $41.6 | $26.4 | $27.4 | $154.3 | -11.0% |
| **TOTAL** | **$279.9** | **$337.9** | **$439.9** | **$441.8** | **$461.9** | **$1,961.4** | **65.0%** |

*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

### *C.1 Export Destinations*

The majority of U.S. exports of imaging and sensor products were primarily destined for Western Europe and Asia – especially Japan and South Korea. For instance, from 2001 to 2005, Japan and South Korea each received more than $150 million in exports during the five-year period (see Figure 7-5).

The top ten export destinations represent 75 percent of total U.S. exports in imaging and sensor equipment. Following Japan and South Korea, the United Kingdom, Canada and Germany were also important U.S. export markets (see Figure 7-5).

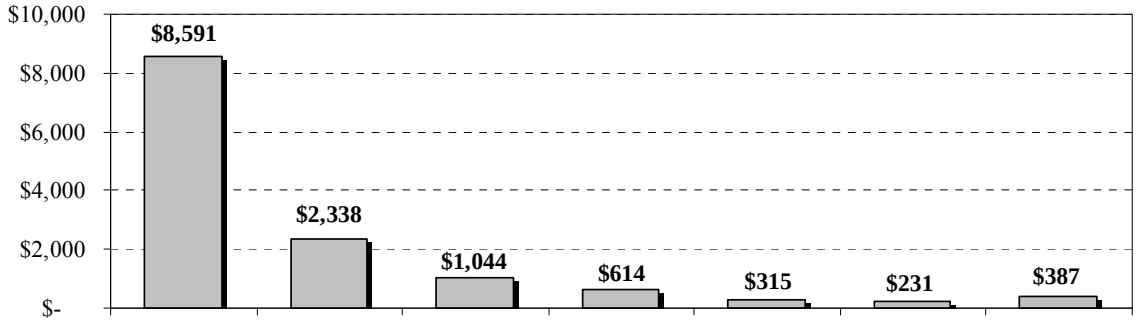



*C.2 Exports Reported by Retailers, Distributors, Brokers, and Resellers*

A total of 14 companies classified as retailers, distributors, brokers, or resellers of imaging and sensor products reported earnings attributed to exports during 2001-2005. Cumulative exports for this group during the five-year period totaled $13.5 million. Four of the top five export categories were night vision products, representing 93 percent of the total $13.5 million for the five-year period. A single product group, night vision scopes and monocular devices, claiming 63.5 percent of all exports, dominated the retail

export market. Night vision scopes and monocular devices exports reached $8.6 million, more than triple that of the next category, night vision binoculars at $2.3 million.

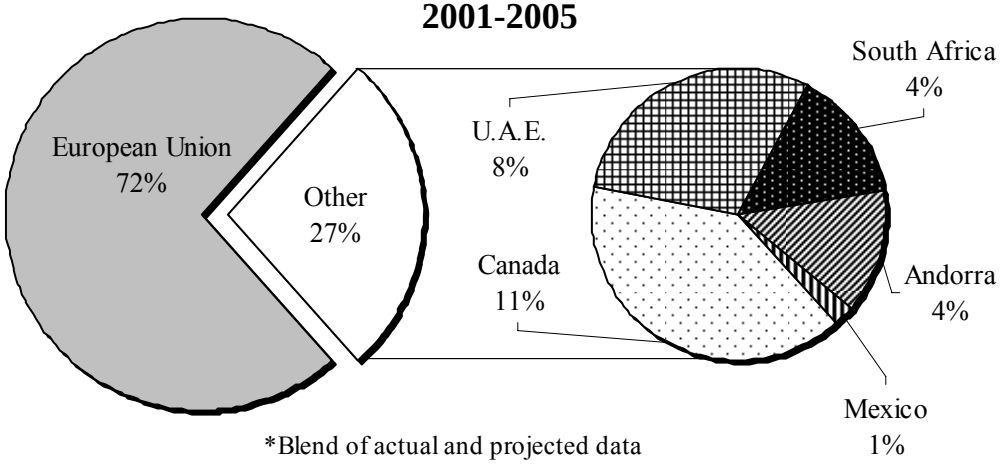
**Figure 7-6: Cumulative Export Value, 2001-2005 (in $thousands)**




*Blend of actual and projected data
Source: DOC/BIS I&S Survey DOC/BIS I&S Survey 2005

Nations of the European Union were the largest consumers of U.S. imaging and sensors exports of retailers, distributors, brokers, and resellers, representing 72 percent of cumulative exports during 2001-2005 (see Figure 7-7). Firms in this group exported to nine of the total 25 member states with Germany receiving the bulk of exports, followed by the United Kingdom, Italy, and Spain. The remaining 27 percent of cumulative exports went to other countries, including Canada, the United Arab Emirates (U.A.E.), South Africa, Andorra, and Mexico at 11 percent, eight percent, four percent, four percent and one percent, respectively.

**Figure 7-7: Top Export Destinations Reported by Retailers, Distributors, Brokers and Resellers 2001-2005**




*Blend of actual and projected data
Source: DOC/BIS I&S Survey DOC/BIS I&S Survey 2005

## D. U.S. Share of the Global Export Market

Trade data from foreign governments is reported in various degrees of specificity for imaging and sensors products. Some countries capture trade data in these products in narrowly defined categories, while others capture trade data aggregated with other related products.

The "other related products" category includes sensors that measure the visible and ultraviolet spectrum, as well as the infrared spectrum, such as electrochemical instruments, electro spectrophotometers, and rifle scopes. For this reason, the export data for most countries, except the United States (which is based on BIS survey results), as shown in Table 7-3 are somewhat different than the U.S. data.[14] However, the vast

[14] The reporting countries account for more than 90 percent of total global exports. U.S. export values were obtained from responses to the DOC/BIS 2005 survey, while all other countries' export data was reported by the individual governments of the countries shown in Table 8-3.

By comparing other countries' export data with corresponding U.S. export data obtained from the Census Bureau, the U.S. share of global exports declined from 10 percent in 2001 to 4 percent in 2005 (9.7 percent – 2001; 9.7 percent – 2002; 7.5 percent – 2003; 7.88 percent – 2004; 4.0 percent – 2005).

majority of the foreign export data captured in Table 7-3 is related to the imaging and sensor products that are the focus of this report.

It is clear that the global market for this industry sector has grown in recent years. Global exports climbed to $4.3 billion in 2005 from $2.7 billion in 2001, or an annual compound growth rate of 10 percent. Overall, U.S. exports, as reported by respondents to the BIS survey, grew at a compound annual rate of 10.5 percent, the seventh largest growth rate behind Belgium-Luxembourg, China, France, Canada, Germany, and Ireland.

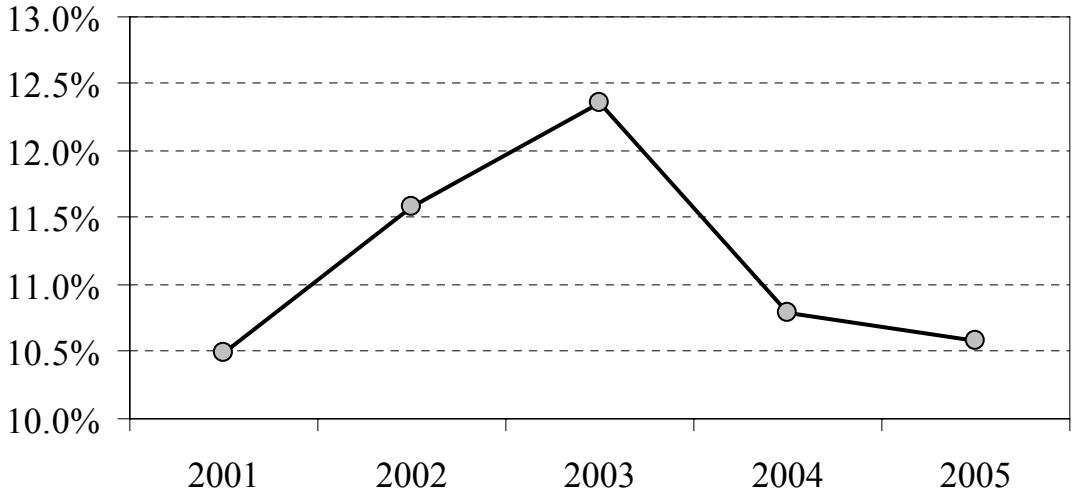
**Table 7-3: Global Exports of Imaging and Sensors Products, by Country (in $millions)**

| Country | 2001 | 2002 | 2003 | 2004 | 2005* | CAGR |
|---|---|---|---|---|---|---|
| Germany | 758.6 | 845.6 | 1032.4 | 1319.2 | 1463.1 | 14.0% |
| United States | 279.9 | 337.9 | 439.9 | 441.8 | 461.9 | 10.5% |
| U.K. | 310.9 | 293.3 | 398.5 | 356.1 | 350.3 | 2.4% |
| Switzerland | 194.3 | 229.1 | 284.3 | 272.5 | 316.8 | 10.3% |
| France | 105.3 | 154.2 | 237.5 | 301.5 | 264.4 | 20.2% |
| Japan | 306.3 | 173.1 | 213 | 236.8 | 229.1 | -5.6% |
| Netherlands | 107.6 | 178.5 | 185.2 | 175 | 172.1 | 9.8% |
| Belgium-Luxembourg | 58.3 | 88.3 | 112.8 | 133.8 | 157.6 | 22.0% |
| Canada | 71.2 | 73.2 | 89.2 | 115.8 | 139.7 | 14.4% |
| Sweden | 123.1 | 151.7 | 91.1 | 104.9 | 131.3 | 1.3% |
| China | 35.1 | 36 | 47.1 | 54.1 | 91 | 21.0% |
| Finland | 62.7 | 66.2 | 71.7 | 74.2 | 76.1 | 3.9% |
| Ireland | 40.7 | 51.2 | 39.9 | 79.1 | 75.5 | 13.2% |
| Australia | 44.1 | 61.9 | 61.7 | 79.8 | 73.1 | 10.6% |
| Austria | 47.2 | 44 | 50.2 | 55.5 | 69.3 | 8.0% |
| Italy | 44.6 | 47.8 | 61.4 | 68.8 | 66.2 | 8.2% |
| Denmark | 39.1 | 43.6 | 54.4 | 58.3 | 56.6 | 7.7% |
| All Others | 39.8 | 43.8 | 47.2 | 85 | 69.3 | 11.7% |
| **TOTAL** | **$2,668.80** | **$2,919.40** | **$3,517.60** | **$4,012.20** | **$4,263.40** | **9.8%** |

*Blend of actual and projected data
Source: U.S. exports from DOC/BIS I&S Survey 2005. Data for all other countries from the Countries' official export statistics.

During the five-year period, the U.S. share of global exports slightly increased by 0.3 percentage points from 10.5 percent (2001) to 10.8 percent (2005), as shown in Figure 7-8. The U.S. share of global exports peaked in 2003 at 12.5 percent before declining to 10.8 percent in 2005.

**Figure 7-8. U.S. Share of Global Exports for Imaging and Sensors Products, 2001-2005**




*Blend of actual and projected data
Source: U.S. Exports - DOC/BIS I&S Survey 2005.
All Other Countries - Countries' Official Export Statistics

Germany was the largest source of global exports for imaging and sensors products, averaging more than $1 billion annually during the five-year period. In 2005, Germany's exports of $1.46 billion were more than three times that of the United State's $461.9 million 2005 exports.

Belgium-Luxembourg's five-year export growth of 170.3 percent led all major exporting countries, followed by China, one of the smaller exporters of these products, with a growth of 159.3 percent (see Table 7-4).

Among the largest exporters, France posted a 151.1 percent five-year export growth, while export leader Germany saw its exports climb by almost 93 percent. Because of steady annual increases in exports, the United States posted a gain of 65 percent during the period, slightly above the global industry average of 60 percent. Among the 17 largest imaging and sensor product exporting countries, the five-year export growth of the United States ranked eighth.

| Table 7-4: Five-Year* Growth Rate of Imaging and Sensors Exports, By Country | |
|---|---|
| Belgium-Luxembourg | 170.3% |
| China | 159.3% |
| France | 151.1% |
| Canada | 96.2% |
| Germany | 92.9% |
| Ireland | 85.5% |
| Australia | 65.8% |
| United States | 65.1% |
| Switzerland | 63.0% |
| Netherlands | 59.9% |
| Italy | 48.4% |
| Austria | 46.8% |
| Denmark | 44.8% |
| Finland | 21.4% |
| U.K. | 12.7% |
| Sweden | 6.7% |
| Japan | -25.2% |
| All Others | 74.1% |
| Total | 59.8% |
| *Blend of actual and projected data for CY2005<br>Source: U.S. exports from DOC/BIS I&S Survey 2005. Data for all other countries from the Countries' official export statistics. | |

# VIII. Export Controls

## A. Export Licensing

U.S. exports of imaging and sensors products are controlled by two federal agencies, the U.S Department of Commerce (DOC) and the U.S. Department of State (DOS). Export licensing jurisdiction is generally determined by the application and design of the product (commercial and/or military).

Where products are dual-use in nature (have both commercial and military applications) and are controlled on the Commerce Control List, Commerce's Bureau of Industry and Security (BIS) generally has licensing jurisdiction, and the products are subject to the Export Administration Regulations (EAR).[15]

The U.S. Department of State (DOS), Directorate of Defense Trade Controls (DDTC), has licensing jurisdiction for products specially designed or modified for military applications. Products controlled by DOS/DDTC are subject to the International Traffic in Arms Regulations (ITAR).[16] In instances where jurisdiction is unclear, a commodity jurisdiction review for the product is done in order to determine licensing jurisdiction.

The EAR classifies imaging and sensors products into two major export control classification numbers (ECCNs): sensors are classified under ECCN 6A002 and cameras are classified under ECCN 6A003.

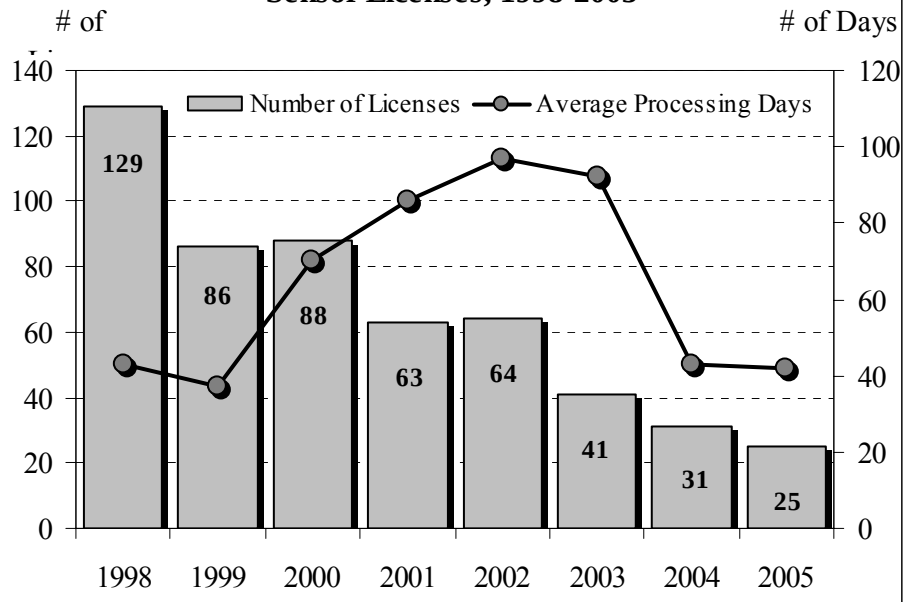
The level of restrictions imposed by the EAR on the export of imaging and sensors products is a function of the country receiving the item, the intended end use and the end user. Decisions on applications for licenses to export 6A002 and 6A003 items are made based on the recommendations of the Departments of Commerce, Defense and State.

[15] Export Administration Regulations, 15 C.F.R. 730-774
[16] Section 38 of the Arms Control Act, 22 C.F.R. 120-130

## B. DOC Export Licensing History

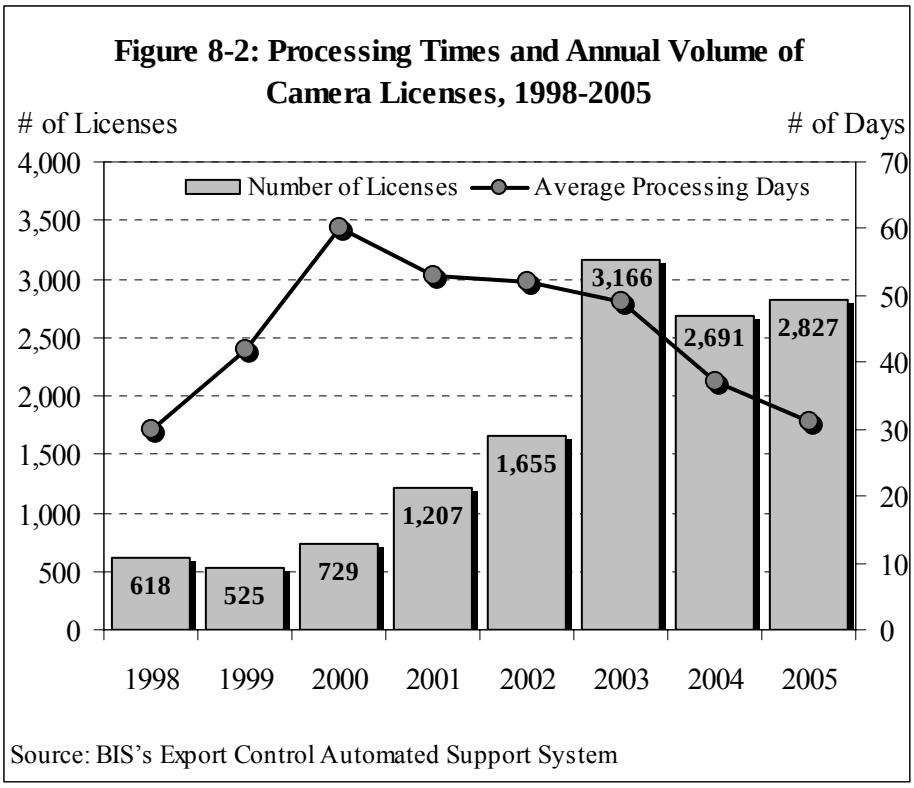
An examination of the licensing history of sensors (ECCN 6A002) from DOC over the past eight years indicates that the annual volume of licenses steadily dropped from 129 in 1998 to only 25 in 2005. The average processing time (in days) was nearly the same in 1998 (43 days) as in 2005 (42 days), though average processing times rose as high as 97 days in 2002 (see Figure 8-1). For results from jurisdictions issue, see IX-9.

**Figure 8-1: Processing Times and Annual Volume of Sensor Licenses, 1998-2005**




Source: BIS's Export Control Automated Support System

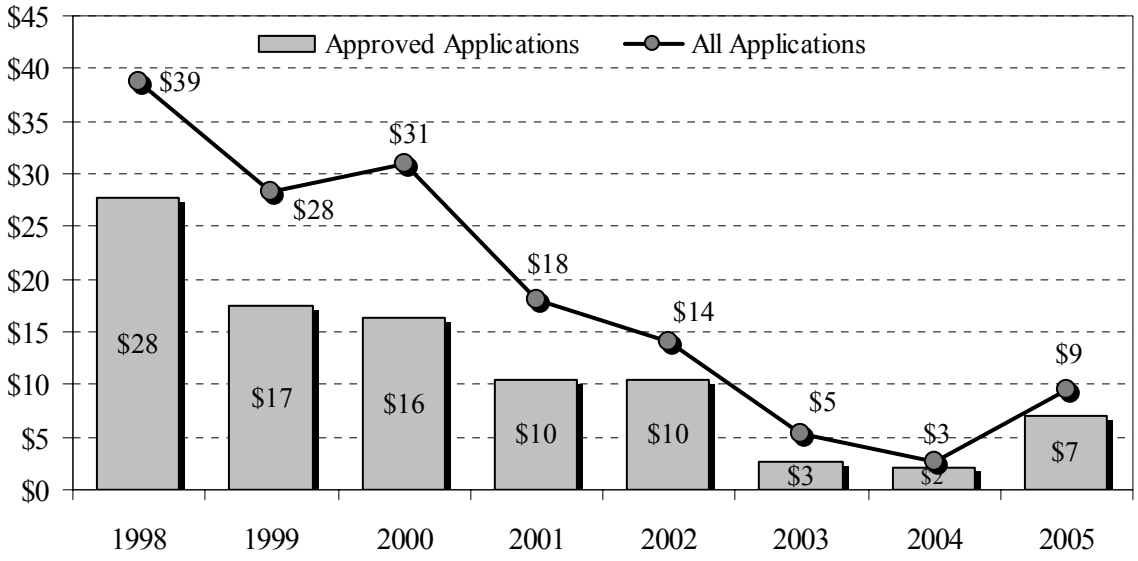
In contrast, the licensing history of cameras (ECCN 6A003) from DOC over the same eight year period indicates rapid growth in annual volume, from 618 licenses in 1998 to 2,877 in 2005, with a spike to 3,166 in 2003. After a 15-percent drop in 2004, license volume climbed 5 percent in 2005. Average processing times rose steadily from 1998 (30 days) to 2001 (53 days) then dropped back to the 1998 levels in 2005 despite a 450% increase in annual volume (see Figure 8-2).




Figures 8-3 and 8-4 illustrate the dollar value of export licenses issued for sensors and cameras (ECCN 6A002 and 6A003, respectively) controlled by Commerce over an eight-year period. Note that an approved license does not necessarily equate to an export, as some export licenses issued go unused.

Figure 8-3 highlights the corresponding drop in the dollar value of sensor licenses as the numbers of license applications fell. In 1998, all sensor applications were valued at $39 million and approved applications were $28 million. By 2005, these figures dropped to $9 million and $7 million, respectively.

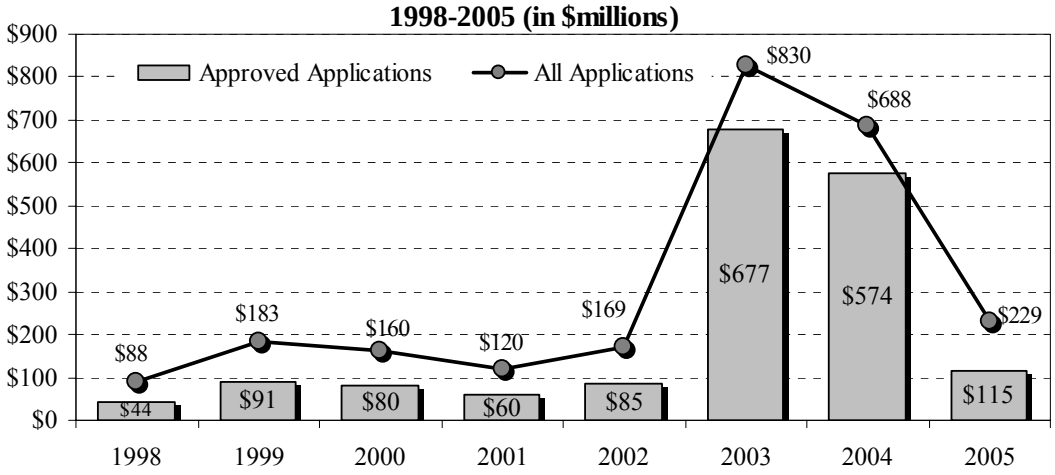
**Figure 8-3: License Applications for Sensors-DOC, 1998-2005 (in $millions)**




Source: BIS's Export Control Automated Support System

Tracking the rise in the volume of camera licenses shown in Figure 8-2, Figure 8-4 highlights the corresponding rise in camera license values. All applications for cameras rose from $88 million in 1998 to $219 million in 2005, while approved applications increased from $44 million in 1998 to $104 million in 2005. However, in an examination of more recent trends, between 2003 and 2005 the value of total camera licenses declined by 23 percent and the value of approved camera licenses dropped by 21 percent, outpacing the 11 percent decline in license application volume for the same period (Figures 8-2 and 8-4).

**Figure 8-4: License Applications for IR Cameras-DOC, Un-normalized 1998-2005 (in $millions)**

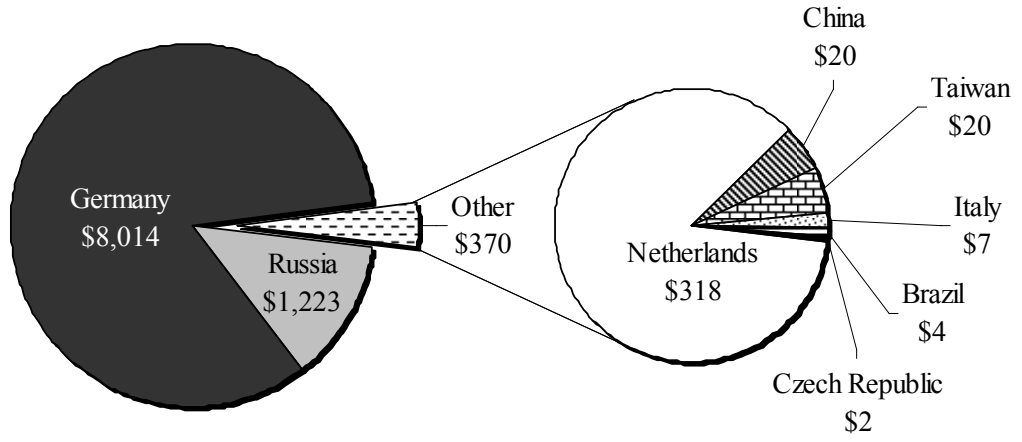



*From 2001 to 2004, portions of the EAR that affect export controls of sensors and cameras were amended, though amendments did not have a significant impact on the total annual license values or volume. One exception however involved the decontrol of night vision cameras used in automobiles produced by foreign manufacturers. To avoid disclosure of proprietary business information, the value of the licenses for these exports is omitted from Figure 7-4.

Source: BIS's Export Control Automated Support System

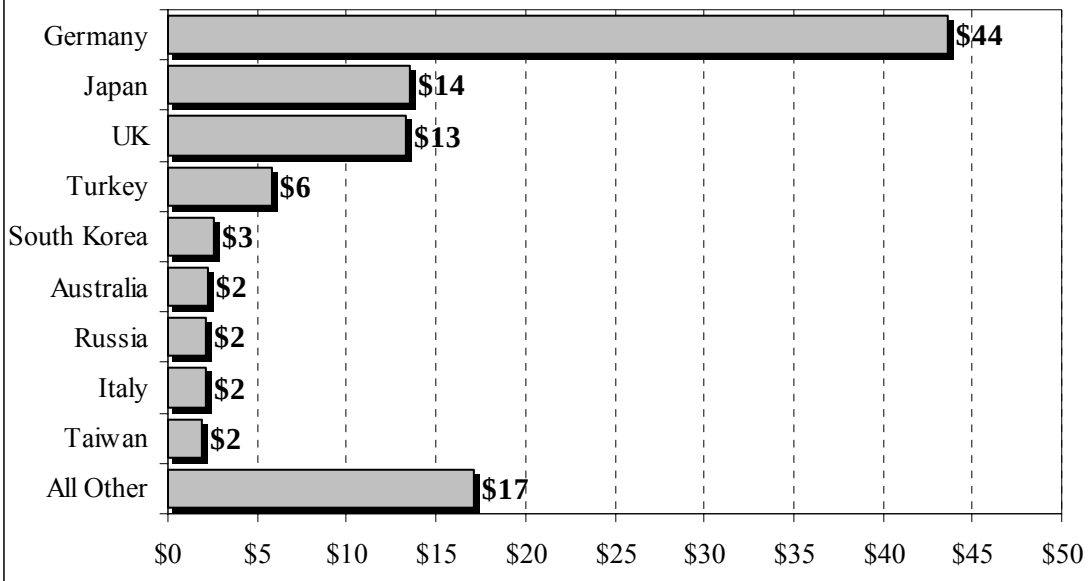
Figures 8-5 and 8-6 illustrate the DOC-approved dollar value of licenses of sensors and cameras (ECCN 6A002 and 6A003, respectively) in 2005 by the country of destination.

**Figure 8-5: Optical Sensors; DOC Approved License Data By Country, 2005 (in $thousands)**




Source: BIS's Export Control Automated Support System

**Figure 8-6: Cameras; DOC Approved License Data By Country, 2005 (in $millions)**




Source: BIS's Export Control Automated Support System

## C. ITAR Controls

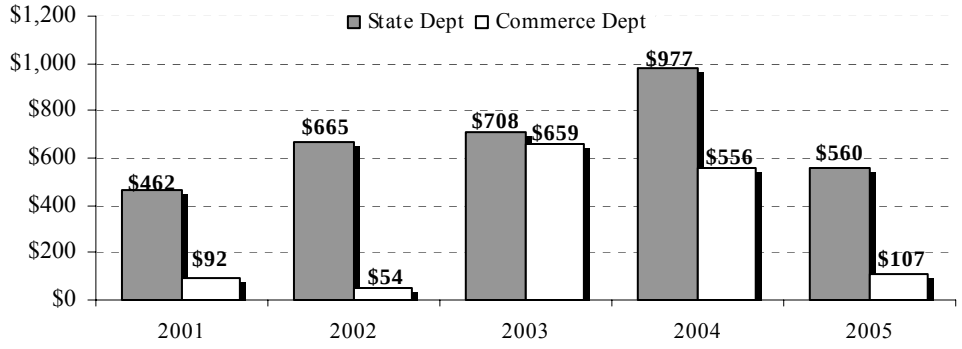
The ITAR classifies imaging and sensors products into one section of the regulations, Category XII, paragraph C, entitled Fire Control, Range Finder, Optical and Guidance and Control Equipment. The ITAR operates differently from the EAR in terms of product coverage. If an item is subject to the ITAR then it is always controlled for export regardless of the destination.

Given the sensitive nature of ITAR-controlled exports (i.e., have significant military applications) discussion of the details, scope and nature of the ITAR licensing process is limited in this report.

*C.1 Comparison of Exports Controlled by the ITAR and the EAR*

Figure 8-7 compares the dollar value of imaging and sensors technology exports regulated by the ITAR and the EAR for the years 2001 to 2005. The chart shows that the ITAR consistently regulates more imaging and sensors products by dollar value than the EAR, though in 2003 they were nearly the same.

**Figure 8-7: Approved Dollar Value of Cameras, Sensors, and Imaging and Sensors Product Exports Regulated by State and Commerce, 2001-2005 (in $millions)**




Source: BIS's Export Control Automated Support System, ODTC's 655 Reports

Export data for the DOC in the years 2003 and 2004 each contain export transactions for the sale of cameras that greatly impact the total dollar value of exports for those years. In 2001, $462 million dollars of cameras, sensors and imaging and sensors products were approved by State. This rose to a high of $977 million in 2004, dropping to $560 million in 2005.

| Table 8-1: ITAR Product Categories | Dollar Value (in $millions) |
|---|---|
| Thermal Imagers | $172.5 |
| Miscellaneous Night Vision | $121.8 |
| Forward Looking Infrared (FLIR) Systems and Parts | $101.1 |
| Infrared Viewers and Parts | $59.4 |
| Night Vision, AN/PVS-7A/B Goggles | $34.4 |
| Image Intensifiers and Spare Parts | $30.9 |
| Infrared Detectors and Spare Parts | $13.4 |
| Night Vision, AN/PVS-13 Sight GEN III | $11.5 |
| Night Vision | $10.0 |
| Night Vision Scopes (Handheld), Spares and Components | $2.8 |
| Infrared Glow Sticks | $2.1 |
| **TOTAL** | **$560.0** |
| Source: U.S. State Dept. 655 Report on Exports, 2005 | |

The top six categories in Table 8-1 account for the bulk of imaging products subject to ITAR. Collectively, exports in these six categories had a total value of $361 million in 2005. The total for all categories is $560 million in 2005.

Products captured under "miscellaneous night vision" include components and raw materials unique to night vision products including lens filters, filter glass, specially designed battery cartridges, lamps, motors and cameras. This group of products represents the second largest export category (as measured by the dollar value of ITAR-controlled products). Export licenses suggest that a large amount of raw materials unique to the production of night vision products are shipped to foreign competitors and off-shore production facilities established by U.S. manufacturers. Table 8-2 outlines the country destinations for the export approvals.

Israel, Japan, South Korea and Sweden are the largest approved customers for ITAR-controlled products. Table 8-2 highlights the top 10 countries receiving ITAR-controlled products.

| Table 8-2: Top 10 Countries Receiving ITAR-Controlled Night Vision and Sensor Products, 2004 (in $millions) | |
|---|---|
| **Country** | **Value** |
| Sweden | $77.9 |
| South Korea | $66.9 |
| Japan | $40.6 |
| Israel | $36.3 |
| United Arab Emirates | $28.8 |
| United Kingdom | $24.7 |
| Italy | $20.6 |
| Australia | $19.5 |
| Iraq | $16.7 |
| Norway | $15.7 |
| Source: U.S. State Department 655 Report | |

**D. Denied Export Licenses**

A small segment (13 of 204) of BIS survey respondents reported having applications for U.S. imaging and sensors export licenses denied. The 13 firms represent large, medium and small contractors with extensive experience in global defense and commercial markets. In addition, the firms all have working experience with both the EAR and ITAR.

During 2001 to 2005, denied export licenses for imaging and sensors products had a total value of $149.8 million according to 13 survey respondents. For comparison, this was 9.8 percent of these 13 respondents' total exports over the 2001-2005 period. Total U.S. imaging and sensors product exports from 2001 to 2005 were $1.96 billion.

The license denials by State and Commerce cover mostly defense-related products – night vision goggles and scopes, high-end cameras, thermal imaging devices, and other components, materials and machinery. Denied license applications spanned a variety of countries from allied and friendly European and Asian nations to a mix of Middle

Eastern, South American and other Asian countries. Denied customers were primarily defense ministries, with some universities and private firms represented as well.

The impact of denied licenses is greater than the value of the initial export contract when the potential for follow-on business from foreign customers is included. Respondents to the BIS survey indicated that follow-on export orders could generate sales of up to three times the value of the initial $149.8 million in contracts.

Perhaps of equal concern for U.S. producers is the value of the foreign business lost because firms did not enter a bid against global competitors, knowing that a license would not be granted. Survey respondents said this is of particular concern when the customer is in China, one of the fastest growing global markets for commercial applications of imaging and sensors products. These respondents provided examples of several large foreign competitive-bid contracts for which they did not compete because U.S. export controls would have prevented them from supplying the products if they were awarded the contracts. Survey respondents indicated that these contracts were worth potentially millions of dollars in U.S. exports.

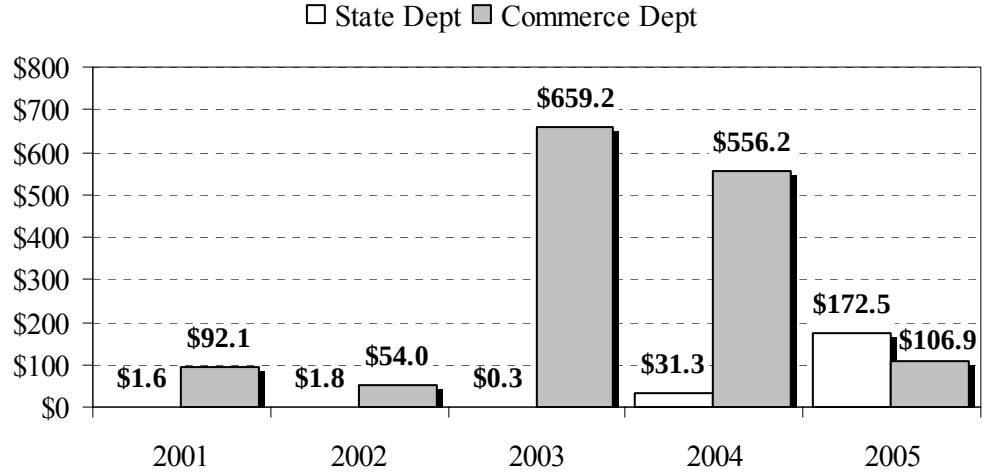
*D.1 Export Controls and the Uncooled Thermal Imaging Sector*

The U.S. industry segment producing thermal imaging devices expressed concern over growing foreign competition in uncooled thermal products. Manufacturers of uncooled thermal imaging sensors and cameras represent a distinct sector of the U.S. imaging and sensors industry. Whereas advanced image enhancement technology is primarily manufactured for use by the military and is generally controlled for export under ITAR, 53 percent of uncooled thermal imaging cameras are now manufactured for use by the civil sector, according to BIS survey data and discussions with major producers of uncooled devices.

Thermal imaging cameras used in non-defense applications allow operators to conduct predictive maintenance on moving parts, high voltage, and in other industrial situations. Thermal imaging cameras are also used in a number of other civil application including search and rescue, fire fighting, automotive applications (night driving), and construction. Military end uses for uncooled thermal imaging products include target recognition, use in close combat (seeing through walls, etc.), and combat in zero light conditions.

Manufacturers of infrared (thermal) imaging system devices and components (uncooled) that responded to the survey indicated that 47 percent of their products were sold for defense use and 53 percent were for non-defense. In regards to overall exports of thermal imaging cameras by value, licenses for commercial cameras exceeded licenses of military cameras over the past five years, with the exception of 2005. The sales of military cameras include both cooled and uncooled systems, where civil sales are predominately uncooled (see Figure 8-8).

**Figure 8-8: Approved Dollar Value of Thermal Imaging Products Regulated by State and Commerce 2001-2005 (in $millions)**




Source: DOC/BIS I&S Survey 2005

*D.2 Foreign Competition*

The European Union (EU) is the most significant source of uncooled thermal imaging cameras outside of the United States. While the EU member states adhere to the same control lists as other Wassenaar Arrangement (WA) Participating States, EU member states' implementation of export controls on thermal imaging cameras is less restrictive than those implemented by the United States. EU member states allow thermal imaging cameras to be exported within the EU[17] and to the United States, Australia, New Zealand, Japan, Canada, and Switzerland without an export license under the Community General Export Authorization. The General Export Authorization is an open authorization to export within the EU and to certain other destinations without the vetting of end-users.

On the other hand, the United States controls the export of dual-use cameras classified under (ECCN) 6A003.b.4 for National Security 2 (NS 2), Regional Stability 1 (RS1), Anti-Terrorism 1 (AT 1), and United Nations (UN) reasons. Currently, the U.S. requires a license for the export and re-export of these cameras to all destinations except Canada.

The disparity in implementation of controls between the United States and EU is of concern to U.S. industry given the importance of the EU market for U.S. producers. The EU was the destination for 38 percent of approved licenses in FY2005.

Japan also represents a significant market for U.S. producers of thermal imaging products. In Japan, thermal imaging cameras can be exported under a bulk license to Ireland, the United States, Argentina, Italy, the United Kingdom, Australia, Austria, the Netherlands, Canada, Greece, Switzerland, Sweden, Spain, Korea, Czech Republic, Denmark, Germany, New Zealand, Norway, Hungary, Finland, France, Belgium, Poland, Portugal, and Luxemburg. Bulk licenses are valid for three years and allow for unlimited exports to unknown end users within the eligible territory, provided that certain

[17] The EU member states are Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.

recordkeeping and control plans are in place. According to discussions with survey respondents, Japanese camera and focal plane array (FPA) manufacturers use this advantage over U.S. producers to market their products in these countries.

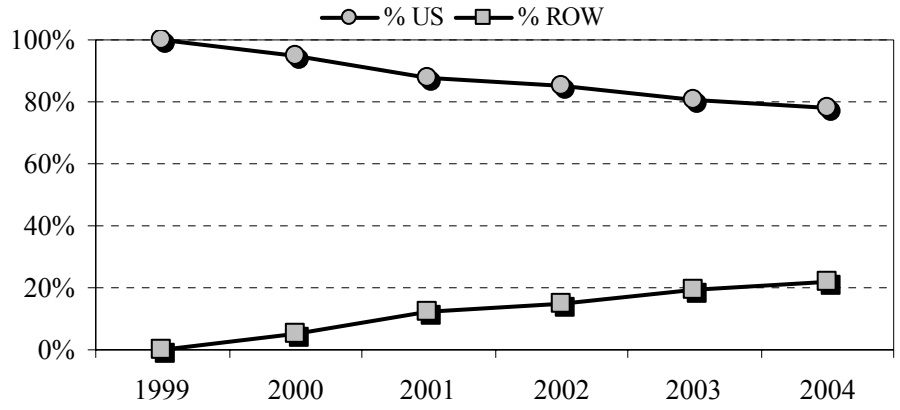
China, which has several companies that export thermal imaging cameras and is not a WA Participating State, does not require an export license for any exports of dual-use thermal imaging cameras. Survey respondents expect China to be a major competitor in future years.

*D.3 U.S. Loss of Foreign Market Share and the Impact of Export Controls*

SIES was unable to validate the value of the global market share lost due to export controls from data collected in the BIS survey. However, data from an independent source is provided for this purpose (see Figures 8-9 and 8-10).[18] Before 1999, the United States was the only producer and exporter of uncooled FPAs. Between 1999 and 2000, European and other foreign producers of uncooled FPAs began large volume production and increased exports of uncooled FPAs. Within the last four years, foreign producers of uncooled FPAs had taken approximately 22 percent of the market from U.S. producers (see Figure 8-9). According to industry sources, it is expected that foreign manufacturers' share will increase significantly over the next few years due in large part to new foreign production of FPAs and relatively less stringent or non-existent export controls on FPAs and thermal imaging cameras applied by the rest of the world.[19]

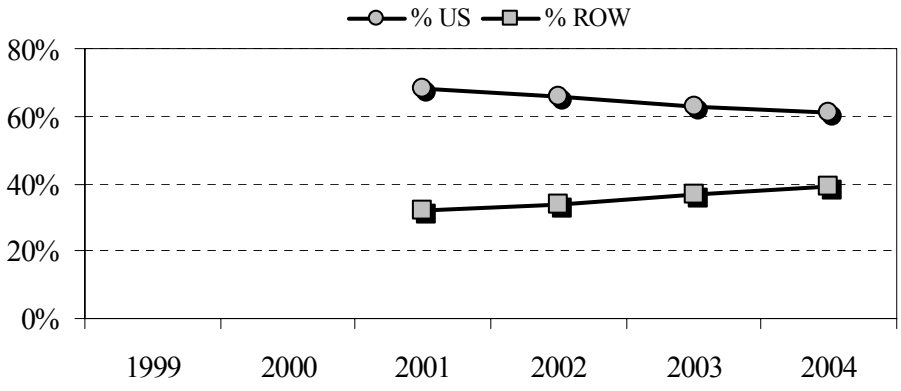
[18] Maxtech International, Inc.
[19] Ibid.

**Figure 8-9: Uncooled Infrared FPA/Module Market 1999-2004**




Source: Maxtech International, Inc.

**Figure 8-10: Uncooled Infrared Camera Shipments 1999-2004**




Source: Maxtech International, Inc.

Overall the world wide market for thermal imaging cameras will grow at a rate between 10 and 20 percent annually, depending on application.[20] This forecast reflects the "cross-over" of this technology into core commercial applications such as building and infrastructure maintenance, automotive, and medical.

[20] Dr. Gabor Fulop, Maxtech International, Inc.

Several foreign producers, according to their product literature, have developed advanced uncooled FPAs that are comparable or better than those that U.S. firms will be using in new defense technology (uncooled amorphous silicon 640x480 FPAs with a 25 micron pitch and uncooled Vanadium Oxide 640x480 FPAs with a 23.5 micron pitch). The U.S. industry has informed BIS that they are not currently exporting commercial cameras from the United States integrated with 640x480 FPAs. They noted however that they are currently marketing such cameras for domestic sales are in large part using foreign made 640x480 FPAs in their cameras. U.S. industry also claimed that foreign firms within the EU are currently exporting commercial cameras that integrate 640x480 FPAs.

*D.4 Response of Some U.S. Manufacturers to U.S. Loss of Foreign Market Share and the Impact of Export Controls*

Five major U.S. manufacturers of uncooled products informed BIS that foreign purchasers and U.S. foreign subsidiaries have cancelled or not renewed contracts for purchases of U.S. manufactured FPAs because of U.S. export controls. The firms stated that in large part because of export controls, their FPA manufacturing plants are not running at capacity, while foreign producers, like ULIS in France, are increasing their capacity. They noted they are finding it also increasingly hard to compete with foreign producers' prices because higher volume offshore production runs are causing prices to decline.

U.S. industry has also informed BIS that, in order to participate in certain foreign markets, U.S. companies have modified their marketing and manufacturing strategies. Major U.S. firms producing uncooled thermal products said they have set up or are considering setting up manufacturing capabilities offshore to take advantage in other Wassenaar Arrangement countries' less restrictive export controls on thermal imaging exports. In at least one instance, a U.S. company has formed a foreign subsidiary to take advantage of less restrictive export controls of the European host country. That subsidiary now procures and incorporates high-value foreign-made devices from a third country, a product requiring an export license if it originated in the United States, to

reach a broader global commercial market. Several other companies said they are involved in cooperative arrangements with foreign firms to manufacture uncooled devices offshore incorporating a foreign-made detector.

**E. Export License Approved, but Sale Lost**

Firms interviewed by phone stated that the global disparity in implementation of export controls for uncooled products had negatively impacted profitability, R&D investment, and U.S. exports. Several firms said that, even when export licenses are approved for uncooled devices, exports were often not realized because licensing processing times or the conditions imposed on the export were unacceptable to the foreign customers. U.S. firms noted that foreign suppliers of uncooled products were able to ship their product within days of the order and with fewer conditions than that of U.S. suppliers.

Ten firms reported $50.2 million in lost sales (both cooled and uncooled) because of licensing delays and conditions during the 2001-2005 period. This compares to $1.15 billion of total U.S. exports for the same 10 firms over the 2001-2005 period. The 10 firms represent mostly medium-and smaller-sized customers with experience in global defense and commercial markets. These firms also have experience with DOC and DOS export control systems.

The license delays by DOC-and-DOS covered products including infrared cameras, optical components, focal plane arrays and night vision devices. End uses included industrial applications (predictive maintenance, quality control), fire fighting, automotive, defense systems, and maritime and police security. Customers ranged from NATO allies, other Western European nations, and Middle Eastern and Asian countries (allied and other).

One firm stated that the restrictions placed on their export license authorization eliminated follow-on sales, which eventually went to a foreign supplier. Another U.S. firm reported that it lost a sale to a non-U.S. firm because its customer feared the U.S.

government would change its licensing policy and interfere with U.S. shipments mid-program. Another respondent stated they had received 350 approved export licenses from 2002-2004 that went unused due to their customers' impatience with the U.S. export licensing process. Respondents also reported being informed by foreign customers that follow-on sales were unlikely given the slowness in receiving licensing authority to ship U.S. products. These lost contract opportunities will potentially cost U.S. manufacturers tens of millions dollars of sales.

**F. Recommendations for Modifications in Export Control Policies**

Survey respondents were asked to comment on the steps the U.S. government could take to improve the competitive position of the U.S. imaging and sensors industry in both the domestic and global marketplace. Over 106 companies made a variety of recommendations, of which a total of 33 firms (31 percent) specifically recommended that current U.S. export control policies be changed, as they are an impediment to how they do business. Fourteen of these respondents had either reported a denied export license, lost sales due to the licensing process, or a combination of the two, as reported in Sections D and E.

Twelve of the 33 respondents were large companies each with sales ranging from $10 million to more than $885 million in 2005. Of the 12 large companies, three recommended that existing policies be changed in order to speed up the export licensing process. One company in particular noted that one of their international competitors believed that the U.S. export licensing process gave their business an unfair advantage over U.S. imaging and sensors exporters.

Of the smaller companies, 13 of 21 (61.9 percent) indicated that the speed of the export licensing process is a problem. Two companies mentioned that they would like to provide sales quotes for customers, but cannot due to the unpredictability of the licensing

process. Another two small companies suggested that export licensing be web-based in order to streamline the application process.

A total of eight companies, three large and five small, reported lost export sales due to the length of the export licensing process. Nine companies, or 27 percent, suggested that the United States harmonize export licensing regulations with friendly regions/nations such as Europe, Australia, and Japan. Seven of these nine companies recommended that U.S. export licensing regulations should match those of Europe.

A consensus among U.S. companies producing or considering the production of uncooled products offshore is that changing the controls of uncooled cameras from Regional Stability 1 (RS1) to Regional Stability 2 (RS2) would likely result in bringing back current production or foregoing future offshore production plans.[21]

[21] Source: American Council for Thermal Imaging (ACTI)

# IX. Findings

## Technology Overview

- Imaging and sensors devices were originally developed for the military in the 1950s for detecting the enemy in near total darkness. Initial versions of this equipment were cumbersome and marginally effective. As the technology evolved from the early designs, so have the applications of these devices. Today, these devices are used in a wide variety of military and commercial applications. They range from less sophisticated image intensifiers for recreational activity (hunting and wildlife observation) to the most technologically advanced thermal imager types for the military (homing and targeting for missiles).

- Seventy percent of the value of total imaging and sensors sales reported during 2001-2005 were classified as defense sales, including Infrared (thermal) imaging system devices and components (cooled), night vision system devices and components, infrared (thermal) imaging system devices & components (uncooled), and night vision goggles. Non-defense sales, accounting for the remaining 30 percent of sales during the period, were concentrated in four main product categories: other components, modules, materials, machinery, software & systems, spectroscopic accessories, infrared (thermal) imaging system devices and components (uncooled), infrared (thermal) imaging system devices and components (cooled), and infrared cameras.

- Manufacturers of infrared (thermal) imaging system devices and components (uncooled) that responded to the survey indicated that 47 percent of their products were sold for defense use and 53 percent were for non-defense use. These cameras include those used in firefighting and predictive and preventative maintenance.

**Financial Performance**

- The U.S. imaging and sensors manufacturers witnessed robust overall sales growth during 2001-2005. Over the same period, earnings from sales as reported by retailers, distributors, resellers, and brokers also grew at a positive rate.

- Total sales for the imaging and sensors manufacturers climbed from approximately $2.5 billion in 2001 to about $3.9 billion in 2005. Defense sales accounted for more than two-thirds of total industry sales. The total sales of the top ten firms were dominated by defense system integrators and manufacturers, which accounted for 82.7 percent of total sales in 2005. Between 2001 and 2005, defense sales and non-defense sales grew by 51.3 percent and 55.5 percent, respectively.

- The primary driving force for increased defense sales during the survey period was the requirement for imaging and sensors equipment for the Iraq and Afghanistan operations. Non-defense sales growth during the same period reflected heightened demand for imaging and sensors equipment by law enforcement, electronics, firefighting, medical, and automotive industries.

- Based on data reported to BIS, average industry sales per employee totaled $250,229 (during 2001 to 2005). The sales per employee figure calculated from respondent data is higher than the $178,905 average reported in 2002 by the U.S. Census Bureau, which is based on a broader but related industrial sector captured by the North American Industry Classification System (NAICS).

- Total investment in plant, machinery, and equipment grew 5.2 percent from 2001 to 2005. However, only the industry's biggest players, particularly major defense contractors, made significant investments; few small- and medium-sized companies made investments over the five-year period. The top ten companies

accounted for 86.9 percent of total investments in plant, machinery, and equipment, while the top twenty firms accounted fully for 95.3 percent.

- Profitability of imaging and sensors operations exhibited a steep upward trend during 2001-2005. Operating profits jumped to $335.9 million in 2005 from $141.7 million in 2002, or by 137 percent. Defense operating income topped $190 million in 2005, climbing 78 percent from $106.7 million in 2002. Non-defense operating income rose 62 percent during the same period, from $45.2 million in 2002 to $73.3 million in 2005.

- Earnings reported by retailers, distributors, resellers, and brokers of imaging and sensors equipment experienced a compound annual growth of 17.1 percent, reaching over $65 million in 2005 from $29.6 million in 2001. Earnings attributed to the top five companies in 2005 amounted to over $46 million, or 71 percent of the total.

- For the foreseeable future, the financial performance of the overall U.S. imaging and sensors industry will depend on U.S. Department of Defense (DOD) acquisitions and, to a lesser extent, on commercial demand. However, the future health of the uncooled thermal device subsector will depend on the ability of U.S. manufacturers to compete on a level playing field with European and Asian competitors.

**Domestic and Foreign Business Relationships, Content and Sourcing**

- Image- and sensor-related firms depend on business relationships, and specifically on vertical business relationships, to ensure the exclusive specifications of their imaging and sensors products. Business relationships with domestic firms accounted for 81.7 percent of the 219 relationships reported by survey respondents. Manufacturer and wholly owned subsidiary relationships were most significant in U.S. firms' relationships with foreign entities.

- Similar to the manufacturers, integrators, and service providers, 64.3 percent of the 28 research organizations and laboratories that responded to the survey reported having a business relationship with other entities. Research facilities that were only involved in domestic relationships constituted 28.6 percent of the survey respondents, and research facilities only involved in foreign relationships represented 7.1 percent of survey respondents. Facilities involved in both foreign and domestic business relationships made up 28.6 percent.

- Based on the survey for distributors, resellers, retailers, and brokers, approximately 22 percent of the 63 survey respondents specified the type of business relationship shared with other entities. In addition, 11 percent of the survey respondents indicated having at least one business relationship with a foreign entity.

- There were a number of significant mergers and acquisitions in the imaging and sensors industry, involving both large defense industrial firms and second-tier suppliers.

- Most products and services within this industry were procured from domestic sources. Domestic sole sources ranged from 10.3 percent for raw materials, 3.9 percent for infrared cameras, and 1.9 percent for night vision goggles. Almost 57

percent of the 141 respondents indicated that the domestic source was their sole source for one or more products or services.

- Approximately 66 percent of the 141 respondent manufacturing firms procure products or services from at least one foreign firm. Leading foreign sole sourced items were raw materials 17.7 percent, image intensifier devices at 13.9 percent, and electronics/electrical controls 10.1 percent. The top three reasons for foreign sourcing were: foreign products and services were less expensive than domestic sources; the products and services the firms required were not available from domestic sources; or the foreign products and services were of better quality.

**Research and Development (R&D)**

- Domestic manufacturers of imaging and sensor products spent over $1 billion on R&D from 2001 to 2005. Total R&D expenditures for manufacturers increased from $146 million in 2001 to $249 million in 2005. This increase in R&D expenditures represented a compound annual growth of 11.2 percent over the period. Expenditures for R&D by laboratories and research organizations rose from $200.9 million to $327.1 million between 2001 and 2005, or by 62.8 percent.

- Manufacturers of imaging and sensors products frequently support R&D initiatives using DOD funding dispersed from the various Armed Services. DOD allocated $350 million to manufacturer R&D of imaging and sensors in the 2003-2005 period. A significant portion of R&D investment by manufacturers was also sourced internally. Internal R&D funding from 2003 to 2005 represented $300 million. All other R&D sources accounted for $75 million.

- Internal R&D spending from firms rose from 40 percent in 2003 to 46 percent in 2005. In 2005, internal R&D funding at $108.7 million surpassed DOD funding

of $102 million. Other funding categories, private equity, other firms, and foreign governments, collectively accounted for less than 12 percent of all funding.

- R&D expenditures by laboratories and research organizations rose from $200.9 million to $327.1 million in the 2001-2005 period, or by 62.8 percent.

**Employment and Workforce**

- The U.S. workforce in the imaging and sensors industry experienced steady annual job growth during the 2001-2005 period. Total employment of the 135 manufacturing companies that responded to the BIS survey climbed from 7,721 in 2001 to 10,918 in 2005, an increase of 41.4 percent, or 3,197 jobs. By comparison, employment among private and federal R&D laboratories grew 23 percent in the period to 1,081 jobs.

- The industry's overall growth potential could have translated into even greater job creation if it had not been for shortages of qualified personnel at all levels. Labor shortages affected large defense contractors and small- and medium-sized companies. The difficulty of recruiting experienced personnel goes beyond scientists and engineers and also extends to skilled technicians and other trades. This shortage of qualified personnel may get worse in the coming years as an aging workforce, particularly highly qualified manufacturing-related engineers, start to reach retirement age.

- Overall employment increased for research organizations and laboratories during 2001-2005. Twenty-eight survey respondents reported that total employment climbed by almost 25 percent from 931 to 1,161 during the five-year period. U.S. citizens accounted for 93.1 percent of total employment in 2005.

- Seventeen out of 28 research organization and laboratory respondents provided information regarding labor concerns. Specifically, the problems cited by these

firms included: difficulties in locating skilled technicians, engineers and scientists; inconsistencies in cash flow orders from the military and the government; shortages of sensor experts; and inability to find qualified optics engineers.

**Imaging/Sensor Imports and Exports**

- Historically, the United States has been a net importer of imaging and sensors products. During 2001-2005, the trade deficit in these products decreased to $272 million in 2005 from a high of $376 million in 2001.

- After a slight decline of 11 percent from 2001 to 2002, U.S. imports of imaging and sensors products climbed steadily in subsequent years, reaching $734 million in 2005. For 2001-2005, the majority of U.S. imports of imaging and sensors equipment included electrical instruments that use optical radiations (almost $2 billion) and electrical spectrophotometers using optical radiations ($976 million).

- Ten countries accounted for 85 percent of imports during 2001 to 2005. Imports from Japan and Germany, the two largest sources, were valued at $667 million and $474 million, respectively, during the five-year period. Despite the rising value of U.S. imports, the level of import penetration in the U.S. marketplace has declined. An expanding domestic market fueled by U.S. defense sales has more than offset the increase in imaging and sensors imports.

- A total of 91 firms reported exports of imaging and sensors products during 2001-2005. U.S. exports of imaging and sensors products peaked at $442 million in 2005, from $280 million in 2001. Exports in two product categories, night vision system devices/components and infrared (thermal) imaging system devices/components (cooled), dominated the value of U.S. exports. Combined, these two categories captured almost 47 percent ($930.1 million) of the value of total exports ($1.96 billion) during 2001-2005.

- Although the value of overall exports increased during 2001-2005, exports of three product categories declined. Exports of Infrared (Thermal) Imaging System Devices and Components (uncooled) declined by 63.9 percent; exports of Optic Components and Lenses declined 32.7 percent; and exports of the "Other" category declined 11 percent.

- The majority of U.S. exports of imaging and sensors products were primarily destined for Western Europe and Asia – especially Japan and South Korea. The top ten export destinations represent 75 percent of total U.S. exports market in imaging and sensors equipment.

- A total of 14 companies classified as retailers, distributors, brokers, or resellers of imaging and sensors products reported earnings attributed to exports during 2001-2005. Cumulative exports for this group during the five-year period totaled $13.5 million. Four of the top five export categories were night vision products, representing 93 percent of the total $13.5 million for the five year period. The European Union (EU), during 2001-2005, was the largest consumer of U.S. imaging and sensor products, representing 72 percent of cumulative exports over five years.

- The global market for defense and commercial imaging and sensor products has grown in recent years. Global exports climbed to $4.3 billion in 2005 from $2.7 billion in 2001, or an annual compound growth rate of 9.8 percent. U.S. exports, as reported by survey respondents, grew at a compound annual rate of over 10.5 percent, the seventh largest growth rate behind Belgium-Luxembourg, China, France, Canada, Germany, and Ireland.

- Despite double-digit U.S. export growth, the U.S. share of global exports increased by only 0.3 percentage points from 10.5 percent in 2001 to 10.8 percent in 2005.

**Export Controls**

- An examination of the licensing history of sensors (6A002) from the U.S. Department of Commerce (DOC) over the past eight years indicates that the annual volume of licenses steadily dropped from 129 in 1998 to only 25 in 2005. This drop was primarily due to licensing jurisdictional changes with DOS.

- The licensing history of cameras (6A003) from DOC over the same eight-year period indicates rapid growth in annual volume, from a low in 1998 of 618 licenses to a high in 2003 of 3,166, before declining to 2,827 in 2005.

- Between 2003 and 2005, the value of total camera licenses declined by 27 percent in 2004, but increased almost five percent in 2005. Similarly, the value of approved camera licenses for the same period dropped 28 percent from 2003 to 2004, but increased nine percent by 2005. According to industry sources, this occurred during a period when the worldwide market for thermal imaging products reportedly grew at a rate of 10-20 percent.

- In 1998, all sensor export control applications were valued at $39 million and approved applications were $28 million. By 2005 these figures dropped to $9 million and $7 million, respectively. Export applications for cameras rose from $88 million in 1998 to $219 million in 2005, while approved applications increased from $44 million in 1998 to $104 million in 2005.

- Five major U.S. manufacturers of higher-end uncooled thermal products incorporating 640x480 focal plane arrays (FPAs) noted that because of export controls they are not currently exporting these products from the United States However, U.S. manufacturers stated that foreign firms within the EU are currently exporting these devices with EU-manufactured 640x480 FPAs. The firms indicated that this trend could not only jeopardize the U.S. industry's ability to

compete in the current high technology FPA market but also in the development of future generations of uncooled devices (e.g., devices that integrate megapixle FPAs).

- U.S. manufacturers of FPAs reported that they are operating some of their manufacturing lines at less than capacity. This trend is reportedly due in large part to disparities in EU and U.S. export control policies, which have encouraged manufacturers of uncooled devices to integrate non-U.S. FPAs in their products.

- The Export Administration Regulations (EAR) administered by the Department of Commerce (DOC) consistently regulate less imaging products by dollar value than the International Traffic in Arms Regulations (ITAR) controlled by the U.S. Department of State (DOS). The ITAR controls a broader range and higher dollar value of products. In 2001, $462 million of cameras, sensors and imaging and sensors products were approved by State. This rose to a high of $977 million in 2004 before dropping to $560 million in 2005.

- In regards to overall exports of thermal imaging cameras by value, DOC licenses of commercial cameras exceeded licenses of military cameras over the 2001-2005 period, except for 2005.

- A small segment (13 of 204) of BIS survey respondents reported having applications for U.S. imaging and sensors export licenses denied. The 13 firms represent large-, medium- and small-sized contractors with extensive experience in global defense and commercial markets. During 2001 to 2005, denied export licenses for imaging and sensors products had a total value of $149.8 million. This represented 7.6 percent of these 13 respondents' total exports over the 2001-2005 period. For comparison, U.S. imaging and sensor product total exports from 2001 to 2005 were $1.96 billion.

- The license denials by DOC and DOS cover a mix of mostly defense-related products – night vision goggles and scopes, high-end cameras, thermal imaging devices, and other components, materials and machinery. Countries varied from allied and friendly European and Asian nations to a mix of Middle Eastern, South American and Asian countries. Customers were primarily defense ministries, with some universities and private firms represented as well.

- The impact of denied licenses is greater than the value of the initial export contract when considering the potential for follow-on business from foreign customers. Respondents to the BIS survey indicated that follow-on export orders could generate sales of up to three times the value of the initial contract.

- The EU and Japan were the largest markets for U.S. exporters. Survey respondents noted a disparity in implementation of export controls in both markets for their products.

- Due to disparities in U.S. and EU export controls, some major U.S. thermal imaging manufacturers have reported that they are actively looking to move production offshore. A number of U.S. firms already have offshore production of uncooled thermal imaging devices facilitated by mergers or acquisitions, or established through strategic alliances with foreign manufacturers. In some cases, firms reported that they are providing capital for the development and marketing of uncooled thermal devices overseas.

- Also of concern for U.S. producers is the value of the foreign business lost because they did not enter a bid against global competitors, knowing that a license would not be granted. For example, the impact of not entering bids for Chinese contracts, one of the fastest growing global markets for commercial applications of imaging and sensors products, represents a loss of significant business for U.S. firms.

- Firms reported that profit margins from exports of commercial uncooled thermal devices are higher than profit margins for comparable defense sales in the United States. Decreased export opportunities for these products could impact future corporate profitability, R&D and capital expenditures.

- Firms also noted that, even when export licenses are granted, the ability of U.S. firms to compete in global markets is still hampered. For example, although the majority of licensing approval decisions by the Department of Commerce were made within the 30-day statutory requirement, U.S. firms indicated that the lengthy approval process and/or the numerous conditions imposed on the product exports were unacceptable to the foreign customer and the sale was lost.

- During the 2001-2005 period, 10 of 204 firms reported $50.2 million in lost sales because of such licensing delays and conditions. This compares to $1.96 billion of total U.S. exports for these same firms over the 2001-2005 period. The 10 firms represent mostly medium- and smaller-size customers with experience in global defense and commercial markets.

- The license delays covered products including infrared cameras, optical components, focal plane arrays and night vision devices. End uses included industrial applications (predictive maintenance, quality control, process control), fire fighting, automotive, medical, defense systems, and maritime and police security. Customers ranged from NATO allies, other Western European nations, and Middle Eastern and Asian countries (allied and other).

- Survey respondents were asked to comment on the steps the U.S. Government could take to improve the competitive position of the U.S. imaging and sensors industry in both the domestic and global marketplace. Over 106 companies made a variety of recommendations, of which a total of 33 firms (31 percent) specifically recommended that current U.S. export control policies be changed as they are an impediment to how firms conduct business.

- Modifications to export control policies related to uncooled thermal devices may be warranted based on declining U.S. production and exports, transfer of U.S. facilities, foreign product acquisition, and outflow of capital investment.

# Appendices

**Appendix A:** Letter from U.S. Army, Night Vision & Electronic Sensor Directorate

**Appendix B:** U.S. Imaging and Sensors Industry Survey

**Appendix C:** Selected Major Weapons Programs Utilizing Imaging and Sensors Technology

**Appendix D:** Selected U.S. Civilian Programs Utilizing Imaging and Sensors Technology

**Appendix E:** Selected Federal Laboratories and Research Centers Related to Imaging and Sensors Technology

**Appendix F:** U.S. Department of Defense EO/IR Budgets, FY 2001-2007

**Appendix G:** U.S. Department of Commerce, BIS/OTE Publication List

# Appendix A:
# Letter from U.S. Army, Night Vision & Electronic Sensor Directorate

**DEPARTMENT OF THE ARMY**
U.S. ARMY RESEARCH, DEVELOPMENT & ENGINEERING COMMAND (PROVISIONAL)
COMMUNICATIONS-ELECTRONICS RESEARCH, DEVELOPMENT & ENGINEERING CENTER
NIGHT VISION & ELECTRONIC SENSORS DIRECTORATE
10221 BURBECK ROAD
FORT BELVOIR, VIRGINIA 22060-5806

REPLY TO
ATTENTION OF

March 2, 2005

Office of the Director

Mr. Matthew Borman
Deputy Assistant Secretary for Export Administration
Bureau of Industry and Security
U.S. Department of Commerce
Room 3886
Washington, DC 20230

Dear Mr. Borman:

The U.S. Army has long been the primary funding source, developer, and proponent of thermal imaging and image intensification technology. We are distinctly aware that U.S. manufacturers of items employing these technologies are confronting and assessing their financial, production, and international competitive challenges. As you know, this industry is critical to U.S. military preparedness and the ability of Army forces to control the battlefield.

Therefore, we are fully supporting your Office of Strategic Industries and Economic Security (SIES) in conducting a defense industrial base assessment to examine the economic health of this industry and its ability to meet current and future defense requirements. In supporting you we expect to receive copies of the completed survey for our information, which will greatly assist us in identifying areas of concern in these industries.

I am aware of the analytical skills and mandatory survey capabilities of SIES and believe this office is well suited to conduct this type of detailed analysis. To help facilitate this effort, our staff is prepared to provide you with information on the technologies of this industry and insights regarding industry concerns that have been brought to our attention.

To meet Army planning needs, I request that this assessment be completed no later than December 2005. If you have any questions, please contact me at 703-704-1199 or Emilie Lynton, NVESD Export Specialist, at 703-704-1813. We look forward to working with you on this important project.

Sincerely,

John H. Pollard

Dr. John H. Pollard
Senior Scientist

# Appendix B:
# U.S. Imaging and Sensors Industry Survey

BUSINESS CONFIDENTIAL

**SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS**

Ref. Part B

OMB Control No. 0694-0119
Expiration Date: 4/30/2006

# DEFENSE INDUSTRIAL BASE ASSESSMENT: U.S. IMAGING AND SENSORS INDUSTRY

***Please note that all capitalized terms used in the survey refer to those terms defined in the section titled "DEFINITIONS OF TERMS USED IN SURVEY" on pages 5 and 6***

***This MSWord survey file contains more pages than the on-line survey***

## SCOPE OF ASSESSMENT

The U.S. Department of Commerce, Bureau of Industry and Security, Office of Strategic Industries and Economic Security, in consultation with other government agencies, is conducting a study of the U.S. Imaging and Sensors Industry. The principal goal of this study is to analyze the health and competitiveness of the industry in terms of financial and economic performance. The study will include an analysis of the industry's ability to meet the demand of commercial, defense and homeland security markets. The final assessment will provide Government policymakers with information needed to monitor this important defense industry. Industry executives will be able to benchmark their firm's performance against the average performance of firms in the industry.

## RESPONSE TO THIS SURVEY IS REQUIRED BY LAW

A response to this survey is required by law (50 U.S.C. app. Sec. 2155). Failure to respond can result in a maximum fine of $10,000, imprisonment up to one year, or both. Information furnished herewith is deemed confidential and will not be published or disclosed except in accordance with Section 705 of the Defense Production Act of 1950, as amended (50 U.S.C. App. Sec. 2155). Section 705 prohibits the publication or disclosure of this information unless the President determines that its withholding is contrary to the national defense. Information will not be shared with any non-government entity, other than in aggregate form. The information will be protected pursuant to the appropriate exemptions from disclosure under the Freedom of Information Act (FOIA), should it be the subject of a FOIA request.

Upon completion of this survey, press the **FINISH** button on the last page. This will automatically submit your completed survey electronically to the U.S. Department of Commerce. **Please submit your survey response no later than 30 days after your Firm has received the survey**.

Not withstanding any other provision of law, no person is required to respond to nor shall a person be subject to a penalty for failure to comply with a collection of information subject to the requirements of the Paperwork Reduction Act unless that collection of information displays a currently valid OMB Control Number.

**Burden Estimate And Request For Comment:**

Public reporting burden for this collection of information is estimated to average 6 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information to BIS Information Collection Officer, Room 6883, Bureau of Industry and Security, U.S. Department of Commerce, Washington, D.C. 20230, and to the Office of Management and Budget, Paperwork Reduction Project (OMB Control No. 0694-0119), Washington, D.C. 20503.

BUSINESS CONFIDENTIAL

## SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

# GENERAL INSTRUCTIONS

1. **ORGANIZATION OF SURVEY INSTRUMENT:** The survey is divided into the following sections: (**E-SURVEY** pages)


| | |
|---|---|
| General Instructions (page 2) **PAGE 2**<br>Who Must Respond/Exemptions (page 3) **PAGE 3** | Changes in Government expenditures (page 19) **PAGE 29**<br>Corporate Actions (page 18) **PAGE 29-30** |
| Product/Service Types (pages 4-5) **PAGE 4-5** | Competition (page 20) **PAGE 31** |
| Definitions (pages 5-6) **PAGE 5-6** | Employment Data (pages 21-22) **PAGE 31-32** |
| General Questions (pages 7-8) **PAGE 7-9** | Research and Development (pages 23-24) **PAGE 33-34** |
| Production, Sales, and Sourcing Data (pages 8-11) **PAGE 10-15** | Competitive Factors and Benchmarking (page 25) **PAGE 35-37** |
| Export Information (pages 12-16) **PAGE 16-25** | Survey Certification (page 26) **PAGE 38** |
| Financial Data (pages 17-18) **PAGE 25-28** | |


2. **ESTIMATES ARE ACCEPTABLE** - It is not our desire to impose an unreasonable burden on any respondent. If information is not available from your records in the form requested, you may furnish estimates. If your 2005 fiscal year has not been completed as of the date of submission of this survey, please provide estimates for the 2005 fiscal year. If an item does not apply to your Firm, please indicate with a check in the "If Not Applicable...." box provided.

3. **POINTS OF CONTACT -** Questions related to the survey should be directed to Ron DeMarines, Trade and Industry Analyst, (202) 482-3755, (rdemarin@bis.doc.gov); Stephen Baker, Trade and Industry Analyst, (202) 482-2017, (sbaker@bis.doc.gov); or Lee Frazier, Trade and Industry Analyst, (202) 482-4253, (lfrazier@bis.doc.gov). Our fax number is (202) 482-5650.

4. **SAVE YOUR RESPONSE AS YOU COMPLETE THE SURVEY** - Once you click the **SAVE** button, the following message will appear: **"Response Saved. Add this page to your favorites or bookmarks."** Retaining the link in your Favorites or Bookmarks will enable you to come back to the survey later if you cannot complete it in one session. It is highly recommended that you use the **SAVE** button after each page is completed. Doing this will ensure that you will not have to re-enter your responses if you are interrupted or lose connectivity with the survey software.

5. **HOW TO FORWARD A PARTIALLY COMPLETED SURVEY TO OTHER RELEVANT PERSONNEL -** To forward a partially completed survey response to another e-mail address, copy (**CTRL-C**) and paste (**CTRL-V**) the *entire* .url address of the partially completed survey into the body of a new e-mail, which you may then send to other relevant personnel. Do **not** attempt to complete a partially completed survey simply by forwarding the original e-mail you received (containing the survey link) to another e-mail address, as this will erase the previously entered data.

6. **RECORDKEEPING OPTIONS-**

**A- SAVE AT THE CONCLUSION OF SURVEY -** Once the survey has been completed, an .htm file of your response is available for recordkeeping. To save your response in .htm format, once you have completed the survey, click on the **Review** button on page 25. Then, click on the **Save Summary** button. Should you wish to print and retain a hard-copy of your completed survey, please note that the entire file is more than 400 pages long. Accordingly, you may wish to print pages individually using Adobe Acrobat.

**B- SAVE EITHER AT THE CONCLUSION OF SURVEY OR AS YOU COMPLETE EACH PAGE -** At any time **PRIOR** to hitting **FINISH** at the end of the survey, you may wish to print completed pages individually in order to retain them for your records. To do this, press the key labeled '**Prnt Scrn**' on your keyboard (which will automatically copy the current screen), then paste the copied screen (**CTRL-V**) into a blank MS Word or WordPerfect document, which you may then print. Please note that screens copied in this manner will only capture the viewable screen, and you may need to adjust the scrollbars and repeat this procedure several times in order to capture the entire page.

BUSINESS CONFIDENTIAL

# SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS
# WHO MUST RESPOND/ EXEMPTIONS

## WHO MUST RESPOND

Did your Firm manufacture products or provide services for the Imaging/Sensors Products/Services industry, or integrate products and/or services for the Imaging/Sensors Products/Services industry, at any time since January 1, 2001?

Yes: ❒ No: ❒

If yes, please read the instructions and other material on pages 1-5 and then complete the on-line survey.

If no, please complete the "Exemption From Survey" box below, the requested address information in items 1 and 2 on page 7, and the "Certification" on page 38.

## EXEMPTION FROM SURVEY

If your Firm's operations do not fall within any of the Imaging/Sensors Products/Services, as defined on page 4, you may be exempt from completing this survey. Please notify one of the contacts listed on page 2 to verify your status. Then:

a. Briefly explain the products and/or services provided_____
_____

b. Complete items 1and 2 on page 7 and the "Certification" section on page 38 of this survey.

BUSINESS CONFIDENTIAL

**SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS**

# Product and Service Type Listing and Applications

The Imaging/Sensors Products/Services covered by this survey include infrared imaging, image intensifier, and other thermal sensor devices, as well as the related sub-components, materials, and electrical/electronic controls and services related to these devices. They support the applications listed below. Subcomponents covered by this survey include infrared detectors (thermal & photon), cryocoolers, infrared optics, cooled and uncooled focal point arrays, infrared modules, scanning devices, image intensifier tubes, software, and circuit boards. Further, infrared semiconductor and raw material suppliers are considered within the study's scope. These include, but are not limited to, suppliers of: Indium Antimonide (InSb), Platinum Silicide (PtSi), Gallium Arsenide (GaAs), Aluminum Gallium Arsenide (AlGaAs), Mercury Cadmium Telluride (HgCdTe), Indium Gallium Arsenide (InGaAs), Indium Phosphorus (InP), Indium Gallium Arsenide Phosphorus (InGaAsP), Aluminum Indium Phosphorus (AlInP), Lead Selenide (PbSe), Lead Sulphide (PbS), etc.

| **Applications** | |
|---|---|
| Night Vision Enhancement | Defense (Including Homing, Targeting, Heat Seeking, Tracking and Imaging) |
| Predictive Maintenance | Concealed Weapon Detection |
| Quality Control | Mine Detection |
| Medical | See Through Walls |
| Fire Fighting | Heads-up Display |
| Astronomy | Thermal Signature |
| Telecommunications | Recreation/Hunting |

| **Complete Systems** | | | |
|---|---|---|---|
| 1. | Night Vision System Devices and Components | 15. | Infrared Homing System Devices |
| 2. | Infrared (Thermal) Imaging System Devices and Components (Cooled) | 16. | Infrared Microscopes |
| 3. | Infrared (Thermal) Imaging System Devices and Components (Uncooled) | 17. | Infrared Telescopes |
| 4. | Image Intensifier ($I^2$) Devices | 18. | Infrared Analytical Instruments, Lab Types |
| 5. | Combination Infrared and $I^2$ Devices | 19. | Photon Detector Systems |
| 6. | Night Vision Scopes and Monocular Devices | 20. | Bolometers |
| 7. | Night Vision Goggles | 21. | Thermopiles |
| 8. | Night Vision Binoculars | 22. | Multicolor Devices |
| 9. | Infrared Cameras | 23. | Hyperspectral Devices |
| 10. | Vision Enhancement Systems, Aerospace | 24. | 3-D Imaging Devices |
| 11. | Vision Enhancement Systems, Automotive | 25. | Solid State, Low Light Imaging Systems |
| 12. | Heads-up Display Systems | 26. | Staring Devices |
| 13. | Airborne Surveillance Systems | 27. | Space-based surveillance |
| 14. | Infrared Target Detection Systems | 28. | Other (Please Specify) _____ |
| **Components, Modules, Materials, Machinery, Software, and Services** | | | |
| 29. | Focal Plane Arrays (Cooled and Uncooled) | 36. | Semiconductor Materials for Infrared Devices |
| 30. | Micro Channel Plates | 37. | Software/Programming |
| 31. | Optics Components and Lenses | 38. | Electronics/Electrical Controls |
| 32. | Scanning Devices | 39. | Testing and Calibration |
| 33. | Infrared Image Display Components | 40. | Machinery/ Machine Tools |
| 34. | Infrared Detectors | 41. | Raw Materials |
| 35. | Substrates and Coatings | | |

**SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS**

# Product and Service Type Listing and Applications

Major components covered by this survey include infrared detectors (thermal and photon), cryocoolers, infrared optics, cooled and uncooled focal point arrays, infrared modules, scanning devices, image intensifier tubes, software, and circuit boards. Infrared semiconductor and raw material suppliers are considered within the survey's scope. For the purpose of further clarification, we have also provided a list of the North American Industry Classification System (NAICS) Codes which includes Imaging/Sensors Products/Services categories.

| NAICS | Description |
|---|---|
| 333314 | Optical Instrument and Lens Manufacturing |
| 334511 | Infrared Homing Systems, Aeronautical, Manufacturing |
| 334513 | Instruments and Related Product Manufacturing for Measuring, Displaying and Controlling |
| 334516 | Analytical Laboratory Instrumentation Manufacturing |
| 334519 | Other Measuring and Controlling Device Manufacturing |
| 541380 | Thermal Testing Laboratories |

## DEFINITIONS USED IN SURVEY

1. **AUTHORIZING OFFICIAL-** An executive officer of the Firm or such other individual who may have such authority to execute this survey on behalf of the Firm.

2. **CURRENT ASSETS -** Refers to cash, accounts receivable, inventory, marketable securities, pre-paid expenses and other assets convertible to cash within one year. Such assets shall refer to current assets held by the Firm as a whole, or to a specific business unit, as determined by each particular question referring to Current Assets.

3. **CURRENT LIABILITIES** - Refers to accounts payable, notes payable, current maturities and accrued liabilities. Such liabilities shall refer to current liabilities held by the Firm as a whole, or to a specific business unit, as determined by each particular question referring to Current Liabilities.

4. **DEFENSE SALES -** Sales to domestic and foreign military and para-military purchasers.

5. **FIRM or COMPANY -** An entity that owns, controls or otherwise is affiliated with one or more U.S. entities that, directly or indirectly, manufactures, produces, provides services for and/or integrates products and/or services pertaining to Imaging/Sensors Products/Services. Such entity may be an individual proprietorship, partnership, joint venture, business trust, laboratory, cooperative, entity subject to a U.S. Bankruptcy Court or other corporation (including any subsidiary entity in which the U.S. entity owns more than 50 percent of the outstanding economic or voting interest).

6. **FOREIGN-MADE -** Any Imaging/Sensors Products/Services item for which 50 percent or less of the value added of such item (excluding distribution, advertising and other marketing costs) was produced, conducted, created or otherwise generated within the United States, as defined herein.

7. **IMAGING/SENSORS PRODUCTS/SERVICES -** Included in this industry are infrared imaging, image intensifier, and thermal sensor devices, as well as the related modules, sub-components, materials, and electrical/electronic controls, technical service agreements and other services related to these devices. The Product and Service Type Listing, Applications, Product/Service Designation Numbers and Components, Modules, Materials, Machinery, Software and Services included in this definition are specified and enumerated on page 3 of this survey.

## SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

8. **INVENTORY -** Includes finished goods, work in progress and raw materials.

9. **NON-DEFENSE SALES -** Total Sales less Defense Sales.

10. **OPERATING INCOME** - Gross profits less operating expenses (sales and marketing costs, R & D, and general and administrative costs, including salaries).

11. **OPERATING PROFIT/LOSS** - Operating income less interest expenses, all other expenses and losses on disposals.

12. **SALES -** Refers to the Firm's sales of its Imaging/Sensors Products/Services operations before interest and taxes.

13. **TOTAL ASSETS** - Refers to all tangible and intangible assets, including fixed assets and Current Assets. Such assets shall refer to total assets held by the Firm as a whole, or to a specific business unit, as determined by each particular question referring to Total Assets.

14. **TOTAL LONG-TERM LIABILITIES** - Refers to all debt with maturity dates greater than one year from issuance, and including mortgages, lease payments, pensions, revolving notes, and general debt. Such liabilities shall refer to long-term liabilities held by the Firm as a whole, or to a specific business unit, as determined by each particular question referring to Long-Term Liabilities.

15. **U.S.-MADE -** Any Imaging/Sensors Products/Services item for which more than 50 percent of the value added of such item (excluding distribution, advertising and other marketing costs) was produced, conducted, created or otherwise generated within the United States, as defined herein.

16. **UNITED STATES -** The term "United States" or "U.S." includes the fifty states, Puerto Rico, the District of Columbia, the island of Guam, the Trust Territories, and the Virgin Islands.

BUSINESS CONFIDENTIAL

**SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS**

# GENERAL QUESTIONS

**1. COMPANY INFORMATION -** Please provide the name and address of your Firm and the division responsible for the Firm's Imaging/Sensors Products/Services operations. If there is no such division within the Firm, please indicate "N/A" in the Division Name field.

_____ _____
*(Company Name)* *(Division Name*

_____ _____
*(Street Address)* *(Suite Number)*

_____ _____ _____
*(City)* *(State)* *(Zip Code)*

**2. A** **OWNERSHIP -** Please indicate all entities and/or individuals holding 20 percent or more of the Firm's voting rights and the percentage owned.

***If not applicable, check here ☐ and go to Question 3. A.***

_____ _____%
*(Parent Entity/ Individual Name)* *(Percentage)*

_____ _____
*(Parent Entity/ Individual Address)* *(Parent Entity/ Individual City)*

_____ _____ _____
*(Parent Entity/ Individual State)* *(Parent Entity/ Individual Zip or Postal Code)* *(Parent Entity/ Individual Country)*

**2.B** If your Firm is owned by two or more entities or individuals each holding 20 percent or more of the Firm's equity, please provide the additional names and addresses, as well as the percent ownership, in the space provided below (See 3A and 3B for entities or individuals owning less than 20 percent equity in Firm).

_____

_____

_____

_____

_____

## SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

**3.A** **DOMESTIC CORPORATE RELATIONSHIPS -** Using the following list of relationships, please indicate your Firm's contractual relationships with domestic entities (D.E.), including wholly-owned or partially-owned subsidiaries, joint ventures, licensing arrangements, and any relationship with manufacturers/integrators/service providers of Imaging/Sensors Products/Services. You may list as many as necessary to fully characterize the relationship(s) with each entity (ex. B, G, H).

***If not applicable, check here ☐ and go to Question 3. B.***

| | |
|---|---|
| A- | My firm is partially owned (less than 20%) by another U.S. Firm |
| B- | My firm has a joint venture with another U.S. Firm. |
| C- | My firm is a Licensor to another U.S. Firm. |
| D- | My firm is a Licensee for another U.S. Firm. |
| E- | My firm is a manufacturer for another U.S. Firm. |
| F- | My firm is a service provider for another U.S. Firm. |
| G- | My firm is a service integrator for another U.S. Firm. |
| H- | My firm has a co-production relationship with another U.S. Firm. |
| I- | My firm is a product integrator for another U.S. Firm. |
| J- | Other: For each domestic relationship, please specify below: |

| Name of Domestic Entity | Relationship(s) (Specify letter code from listing above) | State | Percent Ownership |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**3.B** **FOREIGN CORPORATE RELATIONSHIPS -** Using the following list of relationships, please indicate your Firm's contractual relationships with foreign entities (F.E.), including wholly-owned or partially-owned subsidiaries, joint ventures, licensing arrangements, and any relationship with manufacturers/integrators/service providers of Imaging/Sensors Products/Services. You may list as many as necessary to fully characterize the relationship(s) with each entity (ex. B, G, H).

***If not applicable, check here ☐ and go to Question 4.***

| | |
|---|---|
| A- | My firm is partially owned (less than 20%) by a foreign Firm |
| B- | My firm has a joint venture with a foreign Firm. |
| C- | My firm is a Licensor to a foreign Firm. |
| D- | My firm is a Licensee for a foreign Firm. |
| E- | My firm is a manufacturer for a foreign Firm. |
| F- | My firm is a service provider for a foreign Firm. |
| G- | My firm is a service integrator for a foreign Firm. |
| H- | My firm has a co-production relationship with a foreign Firm. |
| I- | My firm is a product integrator for a foreign Firm. |
| J- | Other: For each foreign relationship, please specify below: |

## SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

| Name of Foreign Entity | Relationship(s) (Specify letter code from listing above) | Country | Percent Ownership |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**4**. Briefly describe relationship(s) indicated in questions 3.A and 3.B.

***If not applicable, check here ☐ and go to Question 5.***

_____

_____

_____

_____

**5.** **BUSINESS APPLICATIONS -** Please check all Imaging/Sensors Products/Services applications that pertain to your Firm's operations. Please briefly describe your Imaging/Sensors Products/Services operations specifying the application(s) for each such product or service, including any application(s) not provided in the list. If a product or service differs significantly based upon the application, please briefly describe such difference.

| | | | |
|---|---|---|---|
| ❑ | Night Vision (Thermal) | ❑ | Defense (Including Homing, Heat Seeking, Tracking and Imaging) |
| ❑ | Night Vision (Image Intensification) | ❑ | Concealed Weapon Detection |
| ❑ | Predictive Maintenance | ❑ | Mine Detection |
| ❑ | Quality Control | ❑ | See Through Walls |
| ❑ | Medical | ❑ | Heads-up Display |
| ❑ | Fire Fighting | ❑ | Thermal Signature |
| ❑ | Astronomy | ❑ | Other (Specify) - |
| ❑ | Telecommunications | ❑ | Other (Specify) - |

**6.** **BUSINESS DESCRIPTION** — Please briefly describe your business, including the products or services that you provide.

_____

_____

_____

BUSINESS CONFIDENTIAL

**SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS**

# PRODUCTION, SALES AND SOURCING DATA

***NOTE: Imaging/Sensor Products/Services includes infrared imaging, image intensifier, and thermal sensor devices, as well as the related modules, sub-components, materials, electrical/electronic controls, technical service agreements, and other services related to these devices.***

**7.** **IMAGING/SENSORS SALES -** Please indicate the dollar amount of your Firm's Defense and Non-Defense Imaging/Sensors Product/Services sales only for 2001-2005 (Please estimate expected sales for 2005).

***NOTE: Please enter all monetary figures as whole dollars, separated by commas and without a dollar sign i.e., 1,543,250***

| | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Total Sales $ | | | | | |
| Defense $ | | | | | |
| Non-Defense $ | | | | | |

**8.** **SALES BY PRODUCT -** Please provide dollar sales for each of your Firm's Imaging/Sensor Product/Service category using the numbered entries of **Complete Systems** and **Components, Modules, Materials, Machinery, Software, and Services** on page 4 of this document or the dropdown menu within the web-based survey for a list of product categories) for the years 2001 to 2004, with an estimate for 2005. Either write in the name or cite the number (1-41) for each entry.

Below each yearly total, please provide the value of your Firm's Defense Sales and Non-Defense Sales of Imaging/Sensor Products/Services. The sum of the Defense Sales and Non-Defense Sales should equal the Total Sales figure.

We have provided a wide range of product classes to address the many products of this industry. For your response to the survey questions, please select the product classification(s) that most accurately matches your organization's products.

***NOTE: Please enter all monetary figures as whole dollars, separated by commas and without a dollar sign i.e., 1,543,250***

| Product #1 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

| Product #2 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

| Product #3 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

| Product #4 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

# SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

| Product #5 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

| Product #6 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

| Product #7 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

| Product #8 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

| Product #9 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

| Product #11 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

| Product #11 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

| Product #12 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

| Product #13 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

| Product #14 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

## SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

| Product #15 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

| Product #16 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

| Product #17 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

| Product #18 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

| Product #19 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

| Product #20 | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| | Total Sales | | | | | |
| | Defense Sales | | | | | |
| | Non-Defense Sales | | | | | |

**9.** **U.S.- and Foreign-Made Sales -** Based on your answers in Question 8 (on the previous pages) of Total sales by each product, below each yearly total, please provide the percent of foreign content ( i.e., 0 to 100 percent) for each Imaging/Sensor Product/Service identified.

| Product #1 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

| Product #2 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

| Product #3 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

| Product #4 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

## SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

| **Product #5** | **2001** | **2002** | **2003** | **2004** | **2005** |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

| **Product #6** | **2001** | **2002** | **2003** | **2004** | **2005** |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

| **Product #7** | **2001** | **2002** | **2003** | **2004** | **2005** |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

| **Product #8** | **2001** | **2002** | **2003** | **2004** | **2005** |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

| **Product #9** | **2001** | **2002** | **2003** | **2004** | **2005** |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

| **Product #10** | **2001** | **2002** | **2003** | **2004** | **2005** |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

| **Product #11** | **2001** | **2002** | **2003** | **2004** | **2005** |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

| **Product #12** | **2001** | **2002** | **2003** | **2004** | **2005** |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

| **Product #13** | **2001** | **2002** | **2003** | **2004** | **2005** |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

| **Product #14** | **2001** | **2002** | **2003** | **2004** | **2005** |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

| **Product #15** | **2001** | **2002** | **2003** | **2004** | **2005** |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

| **Product #16** | **2001** | **2002** | **2003** | **2004** | **2005** |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

| **Product #17** | **2001** | **2002** | **2003** | **2004** | **2005** |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

# SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

| Product #18 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

| Product #19 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

| Product #20 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Total Sales | | | | | |
| Percent Foreign Content | | | | | |

**10.** **U.S. SOURCING -** For your Imaging/Sensors Products/Services operations, please list the **five** most significant products and/or services (including components, subassemblies, machinery, raw materials and supplies) your Company procures from **domestic** sources and the name and location of the supplying Firm. In the last column, indicate if your Firm is dependent (i.e., that supplier is the only U.S. source for the item, or the only feasible U.S. source) on that source of supply.

| | Product/Service Type | Source U.S. Firm | City | State | Sole U.S. Source? (Y/N) |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |

**11.A** **FOREIGN SOURCING -** For your Imaging/Sensors operations, please list the five most significant Imaging/Sensors Products/Services (including components, subassemblies, machinery, raw materials and supplies) your Firm procures from **foreign** sources and the name and location of the supplying Firm. In the column labeled 'Sole Source Y/N?', indicate if your Firm is dependent on that source of supply (i.e, the supplying Firm is the only viable source, or there is no other readily available source). If not, and an alternate source(s) exists, please indicate whether such alternate source(s) are foreign, domestic or both.

| | Product/Service Type | Foreign Source Firm | City | Country | Sole Foreign Source? (Y/N) | Alternate Foreign Source Available? (Y/N) | Alternate U.S. Source Available? (Y/N) |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |
| 5 | | | | | | | |

## SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

**11.B** **REASONS FOR FOREIGN SOURCING -** For the same product(s) you cited in question **11.A** that you procure from foreign sources, select one or more of the listed reason(s) your Firm sourced these products/services offshore.

**REASONS**:

A. Better Quality
B. Not Made in the U.S.
C. Less Expensive
D. Better Technology
E. Business relationship
F. Offset Arrangement
G. Doesn't Require a License
H. Other (Specify) _____

| Product/Service Type Designation No. | Reason(s) (A – H) |
|---|---|
| | |
| | |
| | |
| | |
| | |

Comments - _____

_____

_____

**12.** **SUPPLIER LEAD TIME -** Please describe any unscheduled extensions, interruptions or delays of deliveries from suppliers of essential components, services and/or raw materials, including but not limited to increased "lead times," experienced by your Firm since January 1, 2001, as well as any adverse effects resulting from such delay to your Firm's Imaging/Sensors Products/Services operations. Also, please indicate any significant actions taken or proposed to resolve such issues.

| | Product/Service Type | Year | Duration (in months) | Problem and Actions taken to resolve |
|---|---|---|---|---|
| **1.** | | | | |
| **2.** | | | | |
| **3.** | | | | |
| **4.** | | | | |
| **5.** | | | | |

## SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

## EXPORT INFORMATION

*Please note that all references to **"EXPORTS"** should include all Earnings derived from sales to foreign distributors, resellers, retailers, brokers or consumers, regardless of whether your Firm's Imaging/Sensors Products/Services are subsequently resold to U.S. consumers.*

**13.A EXPORT ACTIVITY -** Did your Firm export Imaging/Sensors Products/Services at any time during 2001 - 2005 (inclusive)?

☐ Yes? ☐ No?

***If your Firm had no Sales derived from exports of Imaging/Sensors Product/Services since 2001, check here ☐ and go to Question 15.***

**13.B TOTAL EXPORTS -** Please indicate your Firm's annual Sales derived from exports of Imaging/Sensors Products/Services for 2001 through 2005, with an estimate for 2005 if not yet completed.

***NOTE: Please enter all monetary figures as whole dollars, separated by commas and without a dollar sign i.e., 1,543,250***

| | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Total Sales form Exports | $ | $ | $ | $ | $ |

**BUSINESS CONFIDENTIAL**

## SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

**13.C** **TOTAL EXPORTS BY PRODUCT CATEGORY - P**lease indicate your Firm's annual exports of Imaging/Sensors Products/Services for each Product Category, by their number from the table on page 4 . For each fiscal year indicated, please provide the Sales and the total number of units sold for each Product Category with an estimate for 2005 if not yet completed. Please use the text-box provided to describe any Imaging/Sensors Products/Services not listed in the dropdown list-box.

| | | 2001 | | 2002 | | 2003 | | 2004 | | 2005 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Exported Product #** | **Units** | **$** | **Units** | **$** | **Units** | **$** | **Units** | **$** | **Units** | **$** |
| 1 | | | | | | | | | | | |
| 2 | | | | | | | | | | | |
| 3 | | | | | | | | | | | |
| 4 | | | | | | | | | | | |
| 5 | | | | | | | | | | | |
| 6 | | | | | | | | | | | |
| 7 | | | | | | | | | | | |

**14.** **TOP EXPORT DESTINATIONS -** Please provide your Firm's top five export markets (by value and by country) for your Imaging/Sensors Products/Services for 2001 to 2005, with an estimate for 2005 if not yet completed. List in descending order, by value.

***NOTE: Please enter all monetary figures as whole dollars, separated by commas and without a dollar sign i.e., 1,543,250***

| 2001 | | 2002 | | 2003 | |
|---|---|---|---|---|---|
| **Country** | **Export $ Value** | **Country** | **Export $ Value** | **Country** | **Export $ Value** |
| 1. | | 1. | | 1. | |
| 2. | | 2. | | 2. | |
| 3. | | 3. | | 3. | |
| 4. | | 4. | | 4. | |
| 5. | | 5. | | 5. | |

| 2004 | | 2005 | |
|---|---|---|---|
| **Country** | **Export $ Value** | **Country** | **Export $ Value** |
| 1. | | 1. | |
| 2. | | 2. | |
| 3. | | 3. | |
| 4. | | 4. | |
| 5. | | 5. | |

**15.** **EXPORT OPPORTUNITIES** - Describe your expectations for your firm's exports of Imaging/Sensor Products/Services for 2006-2009.

_____

_____

_____

_____

**BUSINESS CONFIDENTIAL**

## SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

**16.** **FOREIGN COMPETITORS -** Please list any Foreign-Made Imaging/Sensors Products/Services that competed directly with your Firm's Imaging/Sensor Products/Services or integration in the U.S. for 2001 through 2005, with an estimate for 2005 if not yet completed. For each item, rate the quality of the Foreign- Made Imaging/Sensors Products/Services relative to your Firm's Imaging/Sensors Products/Services. In addition, explain the basis of the quality rating by citing one or more performance comparisons based on a technical parameter common to both Imaging/Sensors Products/Services.

| Item No. | Foreign Product Name | Foreign Product Model No. | Company | Country | Based on U.S. Technology (Yes or No) | If based on U.S. Technology, Wholly or Partially? (enter W, P, or N/A) | Quality of Foreign-Made Product relative to your Firm's Product: Worse, Equal, or Better (enter W, E, or B) | Technical Basis for Rating |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |

**BUSINESS CONFIDENTIAL**

## SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

*The following set of questions is aimed at determining your Firm's experiences with export licensing for your Imaging/Sensors Products/Services.*

**17. A** **EXPORT LICENSING-** Does your Firm manufacture, provide services for, or integrate different versions of any of its domestically-sold Imaging/Sensors Products/Services for export markets?

☐ Yes? ☐ No?

If "Yes", please describe the Imaging/Sensors Products/Services and how the export versions differ.

_____

_____

_____

_____

_____

_____

**BUSINESS CONFIDENTIAL**

## SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

**17. B** For those Imaging/Sensors Products/Services that have been **denied** an export license since January 1, 2001, please indicate the name of the potential distributor, reseller, retailer, broker, or customer, as well as the destination country and the intended end use. Please estimate the Earnings that would have resulted for each such incident had the export license(s) been approved. Also, if possible, please indicate whether another Firm subsequently was awarded the Imaging/Sensors Products/Services contract, and if the Imaging/Sensors Products/Services was comparable to your Firm's Imaging/Sensors Products/Services. Use the additional space below the dropdown lists (labeled "Other P/S Denied #1", etc.) to write in other Imaging/Sensors Products/Services product not shown on the dropdown list, if needed.

***NOTE: Please enter all monetary figures as whole dollars, separated by commas and without a dollar sign i.e., 1,543,250***

***If not applicable, check here ☐ and go to Question 17. D on the next page.***

| | Type of Product/Service/Integration Denied Export or Lost Sale due to Licensing Delay (see page 4) | Potential Customer | Country | End Use | Estimated Value ($) | Comparable Item? | Winning Company |
|---|---|---|---|---|---|---|---|
| 7 (example) | | Berlin FD | Germany | FF imaging | 5,000,000 | yes | Deutsch IR |
| **1** | | | | | | | |
| **2** | | | | | | | |
| **3** | | | | | | | |
| **4** | | | | | | | |
| **5** | | | | | | | |
| **6** | | | | | | | |
| **7** | | | | | | | |

## SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

**17. C** Additional Comments. For each occurrence listed in question **17. B** where a sale went to a foreign competitor because your Firm was denied an export license, in the space provided below, please include a discussion of your Firm's expectations (in dollar value) for follow-on sales of Imaging/Sensors Products/Services associated with the denied license. Please also discuss the reason(s) (if known) indicated by the purchaser for choosing the foreign competitor's Imaging/Sensors Products/Services.

_____

_____

_____

_____

## SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

**17.D** This question relates to those product/services for which an export license was **approved** but the sale was lost because of the lengthy approval process; and/or export licensing conditions. For each such occurrence, please indicate the name of the potential customer, destination country, and intended end-use. Also, if possible, please indicate whether a competing Imaging/Sensor Product/Service from another vendor subsequently was awarded the supply contract and if it was a comparable Imaging/Sensor Product/Service. Please estimate the revenue that would have resulted for each such incident had the export license(s) been approved in a timely manner. Please use the additional space below to elaborate or clarify your response, if needed.

***NOTE: Please enter all monetary figures as whole dollars, separated by commas and without a dollar sign i.e., 1,543,250***

***If not applicable, check here ☐ and go to Question 17. E on the next page.***

| | Type of Product/Service/Integration Approved but not Exported or Lost Sale due to Licensing Delay (see page 4) | Potential Customer | Country | End Use | Estimated Value ($) | Comparable Item? | Winning Company |
|---|---|---|---|---|---|---|---|
| 7 (example) | | Berlin FD | Germany | FF imaging | 5,000,000 | yes | Deutsch IR |
| **1** | | | | | | | |
| **2** | | | | | | | |
| **3** | | | | | | | |
| **4** | | | | | | | |
| **5** | | | | | | | |
| **6** | | | | | | | |
| **7** | | | | | | | |

Additional Comments -. For each occurrence listed in question **17. D** where a sale went to a foreign competitor because your Firm experienced a delay in receiving an export license, please include a discussion of your Firm's expectations (in dollar value) for follow-on sales of Imaging/Sensors Products/Services associated with the delayed license. Please also discuss the reason(s) (if known) indicated by the purchaser for choosing the foreign competitor's Imaging/Sensors Products/Services.

_____

_____

_____

**17E**. Please address any other foreign competitive concerns below.

_____

_____

_____

_____

_____

_____

**17F**. Has your firm decided **not** to apply for export licenses because of previous experiences with denials or extended delays by licensing agencies?

Yes ❒ No ❒

If "Yes", please provide examples of denials/delays and include product/service descriptions and comments.

_____

_____

_____

_____

_____

_____

**17G** Between FY 2001 and FY 2005 (inclusive), were any employees of or consultants to your Firm permanently terminated or temporarily laid-off as a result of denials or delays of export license applications?

.

| Action Taken | Number of Employees and Consultants Terminated or Laid-Off | | | | |
|---|---|---|---|---|---|
| | 2001 | 2002 | 2003 | 2004 | 2005 |
| Terminated | | | | | |
| Laid-off | | | | | |

# FINANCIAL DATA

**18.** Indicate your Firm's fiscal year end: _____ ____
(month) (day)

***(Note: Question 19 relates to your Firm's Imaging/Sensor Products/Services operations and Question 20 relates to your firm's overall operations.)***

**19.** **IMAGING/SENSORS PRODUCTS/SERVICES BUSINESS UNIT BALANCE SHEET -** Please provide the data requested for your firm's Imaging/Sensors Products/Services operations for 2001 through 2005 (inclusive), estimating 2005 if not yet completed:

***NOTE: Please enter all monetary figures as whole dollars, separated by commas and without a dollar sign i.e., 1,543,250***

| BALANCE SHEET FOR IMAGING/SENSORS PRODUCTS/SERVICES BUSINESS UNIT | | | | | |
|---|---|---|---|---|---|
| | 2001 | 2002 | 2003 | 2004 | 2005 |
| Current Assets | | | | | |
| Non-Current Assets | | | | | |
| Total Assets | | | | | |
| Current Liabilities | | | | | |
| Non-Current Liabilities | | | | | |
| Owner's Equity | | | | | |
| Total Liabilities | | | | | |

## SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

**20. FIRM'S OVERALL BALANCE SHEET -** Please provide the data requested for your Firm's overall operations for fiscal years 2001 through 2005 (inclusive), estimating 2005 if not yet completed.

***❒ Check here if 100% of your Firm's operations support Imaging/Sensors Products/Services and go to question 21 on the next page.***

***NOTE: Please enter all monetary figures as whole dollars, separated by commas and without a dollar sign i.e., 1,543,250***

| BALANCE SHEET FOR FIRM'/S OVERALL OPERATIONS | | | | | |
|---|---|---|---|---|---|
| | **2001** | **2002** | **2003** | **2004** | **2005** |
| Current Assets | | | | | |
| Non-Current Assets | | | | | |
| Total Assets | | | | | |
| Current Liabilities | | | | | |
| Non-Current Liabilities | | | | | |
| Owner's Equity | | | | | |
| Total Liabilities | | | | | |

**BUSINESS CONFIDENTIAL**

**SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS**

**21. FINANCIAL DATA FOR FIRM'S IMAGING/SENSORS PRODUCTS/SERVICES OPERATIONS -** Please provide the data requested for your Firm's Imaging/Sensors Products/Services operations for fiscal years 2001 through 2005, estimating 2005 if not yet completed.

***NOTE: Please enter all monetary figures as whole dollars, separated by commas and without a dollar sign i.e., 1,543,250***

| INCOME STATEMENT FOR FIRM'S IMAGING/SENSORS PRODUCTS/SERVICES BUSINESS UNIT | | | | | |
|---|---|---|---|---|---|
| | **2001** | **2002** | **2003** | **2004** | **2005** |
| Operating Income | | | | | |
| Defense Operating Income | | | | | |
| Non-Defense Operating Income | | | | | |
| Operating Profit/Loss of Imaging/Sensors Products/Services Business Unit | | | | | |

**22. FINANCIAL DATA FOR FIRM'S OVERALL OPERATIONS -** Please provide the data requested for your Firm's overall operations for fiscal years 2001through 2005, estimating 2005 if not yet completed.

| INCOME STATEMENT FOR FIRM'S OVERALL OPERATIONS | | | | | |
|---|---|---|---|---|---|
| | **2001** | **2002** | **2003** | **2004** | **2005** |
| Operating Income | | | | | |
| Operating Income Derived from Defense Activity | | | | | |
| Operating Income Derived from Non-Defense Activity | | | | | |
| Operating Profit/Loss of Firm | | | | | |

**23. INVENTORY AND BACKLOG -** Please indicate the following as of the last day of each respective fiscal year, estimating 2005 if not yet completed.

| | **2001** | **2002** | **2003** | **2004** | **2005** |
|---|---|---|---|---|---|
| Value of Total Firm Inventory | | | | | |
| Value of Imaging/Sensors Products/Services Inventory | | | | | |
| Value of Imaging/Sensors Products/Services Backlog | | | | | |

**24. PLEDGE OR GUARANTEE -** Are any of your Firm's Imaging/Sensors Products/Services assets, including but not limited to accounts receivable, intellectual property, real property and/or Earnings, pledged, collateralized or otherwise hypothecated, and/or has your Firm's Imaging/Sensors Products/Services business unit served as co-signatory, guarantor or co-guarantor for your Firm, your officers and/or directors, and/or any portion or unit of your Firm?

Yes ❒ No ❒

If Yes, please describe the reasons for such concern in detail below:

_____

_____

_____

**25. A** **FIRM GOING CONCERN -** At any time during each respective fiscal year has an internal or independent auditor expressed doubt over your Firm's ability to remain a Going Concern?

If yes, please describe the reasons for such concern in detail below:

| 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|
| Yes ❒ | Yes ❒ | Yes ❒ | Yes ❒ | Yes ❒ |
| No ❒ | No ❒ | No ❒ | No ❒ | No ❒ |

_____

_____

_____

**25. B** **IMAGING/SENSORS PRODUCTS/SERVICES GOING CONCERN -** At any time during each respective fiscal year has an internal or independent auditor expressed doubt over your Firm's Imaging/Sensors Products/Services business unit's ability to remain a Going Concern?

| 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|
| Yes ❒ | Yes ❒ | Yes ❒ | Yes ❒ | Yes ❒ |
| No ❒ | No ❒ | No ❒ | No ❒ | No ❒ |

If yes, please describe the reasons for such concern in detail below:

_____

_____

_____

**BUSINESS CONFIDENTIAL**

**SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS**

## CHANGES IN GOVERNMENT EXPENDITURES

**26.** **EFFECT OF CHANGES IN DEFENSE EXPENDITURES -** How have changes in spending and allocations by the Department of Defense impacted your Firm and your Imaging/Sensors Products/Services operations, and what strategies have you developed to address these issues?

_____

_____

**27.** **EFFECT OF CHANGES IN NON-DEFENSE GOVERNMENT EXPENDITURES (Federal, State, Local) -** How have changes in federal, state and/or local governmental expenditures (non-defense related) impacted your Firm and your Imaging/Sensors Products/Services operations, and what strategies have you developed to address these issues?

_____

_____

## CORPORATE ACTIONS

**28.** **ACQUISITION/DIVESTITURE -** Between 2001 and 2005 (inclusive), did your Firm acquire or sell any significant Imaging/Sensors Products/Services operations or assets? Generally, "significant" refers to transactions valued at 20 percent or more of your Imaging/Sensors Products/Services operations or assets. However, you may determine that transactions of lesser value are "significant" to your assets and/or operations.

Yes ❒ No ❒

If "yes", please complete the following table. Under the column titled "Value of Transaction," please indicate the value of the transaction at the time of purchase or sale.

| Acquired or Sold | Year Acquired Sold | Name of Operation (unit) or description of Asset Acquired or Sold | Value of Transaction | Name of Purchasing Firm or name of Firm From Whom Purchase Was Made |
|---|---|---|---|---|
| Acquired ❒ Sold ❒ | | | | |
| Acquired ❒ Sold ❒ | | | | |
| Acquired ❒ Sold ❒ | | | | |
| Acquired ❒ Sold ❒ | | | | |
| Acquired ❒ Sold ❒ | | | | |

**29.** **MERGERS -** Between 2001 and 2005 (inclusive), was your Firm's Imaging/Sensors Products/Services operations involved in a merger?
Yes ❒ No ❒ If "yes", please complete the following table:

| Year of Merger | Brief Description or Post-Merger Name of Merged Organization/Unit | Percent of Ownership in Merged Company/Unit | Name of Merger Partner |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

**30.** **DISTRIBUTOR/WHOLESALER/RESELLER/RETAILER SALES -** For the most recently completed fiscal year, please provide the percentage of your Firm's Sales which were garnered, in whole or in part, by sales conducted via distributors, wholesalers, brokers, resellers, and retailers (as opposed to your Firm's direct sales efforts).

_____ %

**31.** **IMAGING/SENSORS NEW INVESTMENT -** Please enter the total dollar amount of your Firm's new investment in Imaging/Sensors Products/Services activities for 2001-2005, estimating 2005 if not yet completed.

***NOTE: Please enter all monetary figures as whole dollars, separated by commas and without a dollar sign i.e., 1,543,250***

| IMAGING/SENSORS NEW INVESTMENT | | | | | |
|---|---|---|---|---|---|
| **Category** | **2001** | **2002** | **2003** | **2004** | **2005** |
| New Machinery and Equipment | | | | | |
| New Plant | | | | | |
| Total | | | | | |

**BUSINESS CONFIDENTIAL**

**SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS**

## COMPETITION

**32.** **MAJOR COMPETITORS -** Please identify the top five U.S. competitors for each of your Firm's Imaging/Sensors Products/Services in the tables below.

| Product/Service Type (use numbers from page 4) | | Company Name of competing Firm | City | State |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |

## EMPLOYMENT

**33.** **EMPLOYMENT -** For the years listed below, please provide the average number of full-time or full-time equivalent employees (35-40 hours/week for a full 12 months) in your Firm's Imaging/Sensors Products/Services operations. Please note that, in this context, "full-time equivalent" refers to part-time workers who, in the aggregate, work a 35-40 hour work-week (e.g., 10 part-time employees working 20 hours/week for a full 12 month period each are the full-time equivalent of five full-time employees for that 12 month period). Please estimate full year 2005, if not yet completed.

| Occupation Breakdown – Imaging/Sensors Business Unit Workforce – U.S. | | | | | |
|---|---|---|---|---|---|
| Occupation | 2001 | 2002 | 2003 | 2004 | 2005 |
| Administrative Staff (Front Office) | | | | | |
| Production Managers/ Supervisors | | | | | |
| Development Staff (i.e., Engineers) | | | | | |
| Research Staff (i.e., Scientists) | | | | | |
| Production Line Workers | | | | | |
| Support Technicians | | | | | |
| Quality Control | | | | | |
| Test Operators | | | | | |
| Other | | | | | |
| Total Employment | | | | | |

34. **RESEARCH AND DEVELOPMENT STAFF DEGREE STATUS -** Please provide the number and type of Imaging/Sensors Products/Services research or development staff with advanced degrees employed by your Firm for your last completed fiscal year.

| U.S. R&D Staff Degree Status - 2004 | | |
|---|---|---|
| | **Masters Only** | **PhDs** |
| **U.S. Citizens:** | | |
| Development Staff (i.e., Engineers) | | |
| Research Staff (i.e., Scientists) | | |
| **Non-U.S. Citizens:** | | |
| Development Staff (i.e., Engineers) | | |
| Research Staff (i.e., Scientists) | | |

**35.** **SKILLED WORKER AGE RANGES -** Please provide the number of your Firm's Imaging/Sensors Products/Services staff that fall within the functions and age ranges listed in the table below. Non-U.S. citizens include holders of residency visas (e.g., "green card"), as well as non-immigrant and/or work visa holders (e.g., H-1B, EB-2).

| Skilled Worker Age Ranges - 2004 | | | |
|---|---|---|---|
| **Occupation:** | **< 35** | **35-50** | **> 50** |
| U.S. Citizens: | | | |
| Development Staff (i.e., Engineers) | | | |
| Research Staff (i.e., Scientists) | | | |
| Non-U.S. Citizen: | | | |
| Development Staff (i.e., Engineers) | | | |
| Research Staff (i.e., Scientists) | | | |

**36.** **LABOR CONCERNS** — Check the box next to as many of the following labor issues that adversely affected your Imaging/Sensors operations over the **last five years:**

❒ Shortages of certain skills
❒ High turnover
❒ Unanticipated liability claims
❒ Inability to offer salaries competitive with other industry sectors
❒ High benefit requirements
❒ Labor/management disputes
❒ Excessive retirement of experienced workers
❒ Other:

Please discuss your responses below:

_____

_____

_____

**BUSINESS CONFIDENTIAL**

**SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS**

# RESEARCH & DEVELOPMENT DATA

**37. RESEARCH AND DEVELOPMENT -** On the upper portion of the table below, please enter your Firm's Imaging/Sensors Products/Services-related research and development ("R&D") expenditures for 2001-2005, estimating 2005 if not yet completed. This includes R&D conducted by your Firm for others, or on your own behalf, and R&D paid for by your Firm but contracted to another. On the lower portion of the table, please enter the source(s) of funding for R&D for 2003-2005 (inclusive), by the categories listed.

**Definitions**

**IMAGING/SENSORS RESEARCH AND DEVELOPMENT** — Basic and applied research in the engineering sciences, as well as design and development of prototype products and processes. Research and development includes activities carried on by persons trained, either formally or by experience, in the physical sciences including related engineering, if the purpose of such activity is to do one or more of the following functions:

**1- BASIC RESEARCH —** A systematic study to gain knowledge or understanding of the fundamental aspects of observable facts without specific applications toward processes or products in mind.

**2- APPLIED RESEARCH —** A systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met. It is a systematic application of knowledge toward the production of useful materials, devices and systems or methods, including design development and improvement of prototypes and new processes to meet specific requirements.

**3- PRODUCT DEVELOPMENT —** The design, development, simulation, or experimental testing of prototype or experimental hardware or systems, to validate technological feasibility or concept of operation, to reduce technological risk, and to provide test systems prior to production approval.

**4- PROCESS DEVELOPMENT —** Studies to improve or optimize economic operations by systematic review of production systems and processes.

| **Research And Development Expenditures for Imaging/Sensors** | | | | | |
|---|---|---|---|---|---|
| **CATEGORY** | **2001** | **2002** | **2003** | **2004** | **2005E** |
| Basic Research | | | | | |
| Applied Research | | | | | |
| Product Development | | | | | |
| Process Development | | | | | |
| **Total R&D** | | | | | |
| **Amount by Source of R&D Funding for Imaging/Sensors (In $000s) - 2003/2004** | | | | | |
| | | | **2003** | **2004** | **2005E** |
| Your Firm | | | | | |
| U.S. Army | | | | | |
| U.S. Air Force | | | | | |
| U.S. Navy | | | | | |
| Other U.S. Dept. of Defense | | | | | |
| U.S. Private Entity | | | | | |
| U.S. Industry | | | | | |
| Foreign Government | | | | | |
| Foreign Private | | | | | |
| Foreign University | | | | | |
| Parent Company | | | | | |
| Non-Gov't Org. (non-profit) | | | | | |
| Subcontractor | | | | | |
| Other (Specify) | | | | | |

**38.** **EXTERNAL R&D FUNDING BREAKDOWN** — Please provide the data requested in the table below for the research and development funding for Imaging/Sensors technology that your firm received from external sources. Please estimate full year 5

***NOTE: Please enter all monetary figures as whole dollars, separated by commas and without a dollar sign i.e., 1,543,250***

| Source of Funding | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| **Research Funding:** | | | | | |
| U.S. Government | | | | | |
| Foreign Government | | | | | |
| U.S. University | | | | | |
| Foreign University | | | | | |
| Other U.S. **(source)** _____ | | | | | |
| Other Foreign **(source)** _____ | | | | | |
| **Development Funding:** | | | | | |
| U.S. Government | | | | | |
| Foreign Government | | | | | |
| U.S. University | | | | | |
| Foreign University | | | | | |
| Other U.S. **(source)** _____ | | | | | |
| Other Foreign **(source)** _____ | | | | | |
| **Total** | | | | | |

**39.** **SUCCESSFUL R&D PROGRAMS** — Please identify and describe your firm's best-funded Imaging/Sensors Products/Services research and development programs during the 2001-2005 (inclusive).

_____

_____

_____

_____

_____

**BUSINESS CONFIDENTIAL**

**SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS**

# COMPETITIVE FACTORS AND BENCHMARKING

**40.** **COMPETITIVE PROSPECTS —** Place a check (✔) next to one of the following that best describes your Firm's Imaging/Sensors Products/Services operations in the next five years, and explain the reason(s) for this selection.

Improve Greatly____ Improve Some____ Stay the Same _____ Decline Some ____ Decline Greatly ____

Reason(s) _____

_____

_____

**41.** **PAST ACTIONS TO IMPROVE COMPETITIVENESS —** What actions have you taken in the last five years to improve your Firm's competitiveness?

_____

_____

_____

_____

**42.** **FUTURE PLANS TO IMPROVE COMPETITIVENESS —** What plans do you have to increase your Firm's competitiveness in the next five years?

_____

_____

_____

_____

**43.** **U.S. GOVERNMENT ACTION —** What additional actions, policy changes, regulatory reforms, or assistance could the Federal Government take to improve your Firm's/industry's overall competitiveness?

_____

_____

_____

_____

**44**. **PRODUCTIVITY —** Please answer the following questions:

a) Briefly explain in the space provided below how you measure productivity in your firm's Imaging/Sensors Products/Services operations.

_____

_____

b) Based on your response to "a" above, what has been the average annual productivity increase (+)/decrease (-) for your company's imaging/sensors operations over the past two years? _____%; past five years? _____%

c) What are your firm's expectations for average annual imaging/sensors productivity gains over the next five years _____%

**45. COMPETITIVE STATUS BENCHMARK -** Please complete the following tables, ranking each variable according to its competitive importance to your Firm as H=High, M=Medium, or L=Low. Enter a check (✔) in the appropriate column on the table's right that best describes your firm's status relative to worldwide competitors.

| **Competitiveness Measured Against Worldwide Competition** | | | | |
|---|---|---|---|---|
| **Your Customer's View** | **Importance (H - M - L)** | **Do your customers view your firm as:** | | |
| | | **Strong** | **Neutral** | **Weak** |
| On-Time Delivery | | | | |
| Product/Service Quality | | | | |
| Pricing | | | | |
| Customer Support Capabilities | | | | |

| **Self-Assessment** | **Importance (H - M - L)** | **How would you evaluate your firm?** | | |
|---|---|---|---|---|
| | | **Strong** | **Neutral** | **Weak** |
| Production Technologies | | | | |
| Long-Term Planning | | | | |
| *Soft Technologies | | | | |
| Workforce Experience | | | | |
| Customer Relations | | | | |
| Supplier/Vendor Relations | | | | |
| Productivity | | | | |
| Credit Worthiness | | | | |

*Soft technologies are intangibles, such as organization of workflow, workflow development, management methods, and other practices that affect efficiencies and human behavior in the work environment.

**BUSINESS CONFIDENTIAL**

**SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS**

| Other Competitive Factors | Importance (H - M - L) | How these factors affect your Firm? | | |
|---|---|---|---|---|
| | | Strong | Neutral | Weak |
| Government Assistance Programs | | | | |
| Material Costs | | | | |
| Labor Costs | | | | |
| Capital Availability Costs | | | | |
| Business Location | | | | |
| Government Health and Safety Regs | | | | |
| Availability of Market Opportunities | | | | |
| Labor / Management Relations | | | | |
| Other Variables (specify Below) | | | | |

_____

_____

_____

_____

_____

**BUSINESS CONFIDENTIAL**

**SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS**

# CERTIFICATION

The undersigned certifies that the information herein supplied in response to this questionnaire is complete and correct to the best of his/her knowledge. It is a criminal offense to willfully make a false statement or representation to any department or agency of the United States Government as to any matter within its jurisdiction. (18 U.S.C.A. 1001 (1984 & SUPP. 1197))

_____ _____
Company Name Company's Web Address

_____ _____ _____
Name of Authorizing Official Title of Authorizing Official Email address of Auth. Official

(_____)_____ _____ _____
Phone Number Ext. Date

If the point-of-contact is the same as above, check here: ☐

_____ _____
Point-of-Contact Name Title

_____ _____ _____
Email Phone Number Ext.

_____
E-mail address of Point-of-contact

Check Here ☐ if you would like a free copy of the final report.

Comments (optional): In the space below, provide any additional comments or any other information you wish to include regarding your Imaging/Sensors operations or other related issues that impact your Firm. If you would like to send additional information, please address it to: Ron DeMarines at the U.S. Department of Commerce, Bureau of Industry and Security, 14th St. and Constitution Ave., NW, Room H3876, Washington, DC 20230, or, alternatively, e-mail to rdemarin@bis.doc.gov.

_____

_____

_____

_____

# Appendix C: Selected Major U.S. Weapons Programs Utilizing Image and Sensor Technology

## SELECTED MAJOR U.S. WEAPONS PROGRAMS UTILIZING IMAGE AND SENSOR TECHNOLOGY[1]

| Weapons Program | Manufacturer | Description | Imaging/Sensor Capability | Use |
|---|---|---|---|---|
| A-10/OA-10 THUNDERBOLT II | Fairchild Republic Co. | close air support aircraft | night vision imaging system, goggle compatible single-seat cockpits | Air Force |
| AC-130H/U GUNSHIP | Lockheed Martin and Boeing | close air support, air interdiction, and force protection aircraft | AN/AAD-4 FLIR for airborne infrared reconnaissance and surveillance and the AN/AAQ-17 FLIR detection set | Air Force |
| AGM-130 | Boeing | air-to-surface guided and powered bomb | imaging infrared focal plane array (256 x 256) midwave (3 to 5 microns) mercury cadmium telluride seeker | Air Force |
| AGM-154B Joint Standoff Weapon (JSOW) | Raytheon | glide weapon | uncooled imaging infrared autonomous terminal seeker and tracker | Air Force, Navy |
| AGM-154C | Raytheon | air-to-surface standoff from point defense (SOPD) | uncooled, terminal-guidance infrared seeker | Navy |
| AGM-158 Joint Air-to-Surface Standoff Missile (JASSM) | Lockheed Martin | precision standoff missile | passive infrared sensor on JASSM is a medium wavelength sensor using a 256 X 256 focal plane array with an IFOV of 12 degrees | Air Force |
| AGM-65 Maverick | Raytheon | air-to-surface guided missile | option of electo-optical, imaging infrared, or a laser guidance package. Maverick D and G models have an imaging infrared guidance package and Maverick F models have an infrared homing guidance package | Air Force, Marines, Navy |
| AH-64 Apache | Boeing | combat helicopter | FLIR's Target Acquisition Designation Sight | Army |
| AIM-9 Sidewinder | Raytheon and Loral Martin | air-to-air missile | infrared heat-seeking guidance system | Air Force, Marines, Navy |
| Airborne Laser Infrared Surveillance Subsystem (ABL/IRSS) | Boeing, Northrop Grumman, and Lockheed Martin | laser detector | Infrared Search and Track (IRST) and Active Ranging Sensor (ARS) technologies to perform the real-time detection and precise target tracking functions | Air Force |
| Airborne Standoff Minesfield Detection System (ASTAMIDS) | Northrop Grumman | sensor detector | Airborne Payload (AP) subsystem of the ASTAMIDS has multi-spectral electro-optical sensors covering visible, near infrared, and mid-wave infrared portions of the spectrum | Army |
| AN/AAQ-16 Infrared Imaging System | Raytheon | imaging system for low level navigation, long range targeting, and surveillance applications | second-generation, long-wavelength infrared imaging system | Air Force, Army, Navy, Marines |

| Weapons Program | Manufacturer | Description | Imaging/Sensor Capability | Use |
|---|---|---|---|---|
| AN/AAQ-24(V) Nemesis | Northrop Grumman | missile detector used in the AC-130 and MC-130 | infrared energy to defeat missile attacks | Air Force, Army, Navy, Marines |
| AN/AAQ-26 Infrared Detecting Set | Raytheon | multi-purpose thermal imaging sensor deployed on the AC-130H and the AC-130U gunships | second-generation focal plane array | Air Force |
| AN/AAQ-27 | Raytheon | starring sensor on the V-22 Osprey and MH-47G | third-generation, mid-wave length infrared imaging system | Marines |
| AN/AAQ-28(V) Litening Targeting Pod | Northrop Grumman | targeting pod used with the AV-8B and F-16 | 256x256 resolution third-generation FLIR | Air Force, Marines |
| AN/AAR-47 Missile Warning System (MWS) | ATK | missile detector employed on helicopters and transport aircrafts | four infrared sensors located in four quadrants on the aircraft | Navy |
| AN/AAS-38B Nite Hawk Targeting Pod | Lockheed Martin | targeting pod employed on the F/A-18 Hornet aircraft | real-time FLIR thermal imaging displayed on one of the cockpit CRTs and HUD | Air Force |
| AN/AAS-42 Infrared Search and Track (IRST) | Lockheed Martin | sensor system for the F-14D Tomcat | passive long-wave infrared sensor system that searches for and detects heat sources within its field of view | Navy |
| AN/AAS-44(V) Infrared Laser Detecting-Ranging-Tracking Set | Raytheon | long-range tracking, surveillance, designation,a nd range-finding for the SH-60B | infrared imager with an adaptable interface, six-axess of stabilization, dual-mode tracker, a laser rangefinder/designator, 1553 data bus and/or descrete controls | Navy |
| AN/AAS-52 Multi-Spectral Targeting System (MTS) | Raytheon | multi-spectral targeting system used in the RQ/MQ-1 | electro-optical, infrared, laser designation capabilities | Air Force |
| AN/ALQ-212 Advanced Threat Infrared Countermeasure/Common Missile Warning System (ATIRCM/CMWS) | BAE Systems | countermeasure warning system for rotary and fixed wing aircraft. | infrared laser to detect infrared-guided air-to-air and surface-to-air missiles | Army |

| Weapons Program | Manufacturer | Description | Imaging/Sensor Capability | Use |
|---|---|---|---|---|
| AN/ASQ-228 Advanced Targeting Forward Looking Infrared (ATFLIR) System | Raytheon | pod-mounted infrared system for the F/A-18 aircraft | third-generation targeting FLIR with mid-wave infrared targeting and navigation FLIRs and an electro-optical sensor | Marines, Navy |
| AN/AVS-6 Aviator's Night Vision Imaging System (ANVIS) | ITT and Northrop Grumman | helmet-mounted light weight binocular | third-generation image intensification device | Army |
| AN/BVS-1 Photonics Mast System | Kollmorgen | photonics mast system | infrared camera | Navy |
| AN/PAQ-4A/4C Infrared Aiming Light | Insight Technology | light weight, battery powered, pulsating infrared-emitting target marking beam. | Class I laser to generate the aiming point to be used with the AN/PVS-7B Night Vision Goggles | Marines |
| AN/PAS-13 Thermal Weapon Sight (TWS) | Raytheon | viewer for use on rifles, surveillance missions, and shoulder-launched missiles | second-generation FLIR | Army |
| AN/PVS-4 Individual Weapon Night Sight | Northrop Grumman | night vision device for passive night vision and aiming fire of individual weapons using ambient light for illumination. | second-generation image intensification device | Marines |
| AN/PVS-5 Night Vision Goggles | ITT and Northrop Grumman | self-contained, passive, image intensifying, night vision viewing system. | second-generation binocular system with a built-in infrared light source | Marines |
| AN/PVS-7B Night Vision Goggles | ITT and Northrop Grumman | image intensifying, passive binoculars | third-generation image intensifier which uses prisms and lenses to provide the user with simulated binocular vision | Marines |
| AV-8B Harrier II | McDonnell Douglas Corp. | attack and destroy surface targets under day and night visual conditions | night vision goggle-compatible cockpit controls and displays, a wide-field-of-view HUD and a Navigation Forward Looking Infrared (NAVFLIR) system | Marines |
| Avenger | Boeing | light weight, day/night limited adverse weather fire unit | FLIR system for target acquisition and fire-and-forget infrared/ultraviolet guided missiles | Army, Marines |
| B-52 Stratofortress | Boeing | heavy bomber aircraft | electro-optical viewing system that uses platinum silicide forward-looking infrared and high resolution low-light-level television sensors and pilots use night vision goggles | Air Force |

| Weapons Program | Manufacturer | Description | Imaging/Sensor Capability | Use |
|---|---|---|---|---|
| CH-46E Sea Knight Helicopter | Boeing | medium-lift assault helicopter | all-weather, day/night, night vision goggles | Marines |
| Enhanced Guided Bomb Unit-15 (EGBU-15) | Raytheon | air-to-ground guided glide weapon | video feed is generated by electro-optical/infrared sensors placed in the weapon's nose | Air Force |
| F/A-18 Hornet | Boeing, with Sniper XR targeting pod manufactured by Lockheed Martin, SHARP is manufactured by Raytheon | multi-role attack and fighter aircraft | FLIR capabilities (AN/AAS-38 for the F/A-18A/C/CN) for passive detection and ranging; F/A-18 A-Ds have the Sniper XR, which contains a high-resolution, mid-wave third-generation FLIR; F/A-18F has a shared reconnaissance pod (SHARP) with eletro-optical and infrared sensors | Air Force, Marines, Navy |
| F-14 Tomcat Fighter | Northrop Grumman | aircraft with precision strike against ground targets, air superiority, and fleet air defense. | AN/AAD-5 infrared reconnaissance line scanner and the LANTIRN targeting system | Navy |
| F-15 Eagle | Beoing, with Lockheed Martin's LANTIRN pod | air-to-ground attack aircraft | Low Altitude Navigation and Targeting Infrared for Night (LANTIRN) pod, containing AN/AAQ-13 and AN/AAQ-14 airborne infrared multipurpose/special equipment | Air Force |
| F-22A Raptor | Lockheed Martin and Boeing | air dominance and multi-role fighter aircraft | mast-mounted sight (MMS) has a thermal imaging system, low-light television, laser rangefinder/designator, and an optical boresight system | Air Force, Army |
| F-35 Joint Strike Fighter | BAE Systems, Lockheed Martin, Northrop Grumman, and the helmet is designed by Vision Systems International | air-to-ground strike aircraft | electro-optical Distributed Aperture System (DAS) with FLIR capabilities and the Electro-Optical Targeting System (EOTS), which has a third-generation FLIR. The helmet-mounted display system has day/night capabilities | Air Force, Marines, Navy |
| Fused Multi-Spectral Weapon Sight (FMWS) | Northrop Grumman | night vision device for dismounted soldiers | infrared detection of targets, and imaging and detection capabilities of near-infrared lasers | Army, Marines |
| Global Hawk | Northrop Grumman (Raytheon manufactures the sensors) | unmanned aerial vehicle (UAV) | integrated sensor suite with electro-optical infrared high-resolution imaging capability and a synthetic aperture radar (SAR) in a single integrated sensor system | Air Force |
| Hawkeye Extended Range Target Sight System (XR TSS) | Lockheed Martin | targeting system | third-generation, large-aperture, mid-wave FLIR | Marines |
| HC-130P/N | Lockheed Martin | air refueling for combat search and rescue helicopters | night vision googles, FLIR systems and the AN/AAM-78 maintenance and test set for airborne infrared equipment | Air Force |

| Weapons Program | Manufacturer | Description | Imaging/Sensor Capability | Use |
|---|---|---|---|---|
| Infrared Acquisition Designation System (IRADS) | Raytheon | targeting system for the F-117A Nighthawk | downward-looking infrared system | Air Force |
| Javelin | Raytheon and Lockheed Martin | fire-and-forget antitank missile | command launch unit (CLU) with an infrared imaging system | Army |
| LITENING II/ER/AT | Northrop Grumman and Rafael Corporation | navigation and infrared/electro-optical targeting for the A-10, B-52H, F-15E, and F-16 | targeting pod with a high-resolution FLIR sensor | Air Force |
| Long Range Advnaced Scout Surveilance System (LRAS3) | Raytheon | surveillance system | second-generation FLIR | Army |
| Low Altitude Navigation and Targeting Infrared for Night (LANTIRN) | Lockheed Martin | low altitude navigation and targeting infrared for night flying | navigation pod with a fixed infrared sensor and a targeting pod that contains a high-resolution, forward-looking infrared sensor | Air Force |
| M1A2 Abrams | General Dynamics | tracked vehicle | commander's independent thermal viewer (CITV) and the system enhancement program (SEP) adds second-generation thermal sensors and at thermal management system to the M1A2 | Army |
| M2/M3A3 Bradley | United Defense, CIV manufactured by Raytheon, IBAS manufactured by DRS Technologies | tracked vehicle | two second-generation FLIR sensors: the commander independent viewer (CIV) and the Improved Bradley Acquisition System (IBAS) | Army |
| Multispectral Adaptive Networked Tactical Imaging System (MANTIS) | Rockwell Collins | develops and integrates a soldier-worn visualization system | digitally fused, multi-spectral video imagery in real time from the helmet-mounted sensors, fusing imagery in the visible/near infrared, short wave infrared, and long wave infrared frequency bands | Army |
| Mark VII Eye-Safe Laser Range Finder | Northrop Grumman | laser target locator system | Uses light intensification technology for night operation | Air Force |
| MH53J/M Pave Low | Sikorsky | long-range infiltration, exfiltration and resupply of special operations forces in day, night or marginal weather conditions | AN/AAQ-18 FLIR system | Air Force |

| Weapons Program | Manufacturer | Description | Imaging/Sensor Capability | Use |
|---|---|---|---|---|
| OH-58D Kiowa Warrior | Bell Helicopter Textron and Boeing manufactures the mast mounted sight. | rotary-wing reconnaissance aircraft | AIM-1 laser is a IIIb infrared laser and the mast-mounted sight contains a thermal imaging sensor | Army, Navy |
| P-8A Multi-mission Maritime Aircraft (MMA) | Boeing, CFM International Northrop Grumman, Raytheon, and Smiths Aerospace | maritime surveillance aircraft | electro-optical/infrared sensor and a directional infrared countermeasures system | Navy |
| Predator RQ-1, MQ-1, and MQ-9 | General Atomics Aeronautical Systems Incorporated | UAV for armed reconnaissance, airborne surveillance, and target acquisition | variable-aperture infrared camera | Air Force |
| RIM-116A/B Rolling Airframe Missile (RAM) | Raytheon | surface-to-air or surface-to-surface missile | RIM-116A has a radio frequency that transitions to infrared guidance for terminal engagement; RIM-116B has the added capability of autonomous infrared-all-the-way guidance | Navy |
| S-3B Viking | Lockheed Martin | force protection and organic overhead/mission tanking aircraft | infrared targeting sensor system | Navy |
| SLAM-ER Missile | Boeing | long-range, air-launched precision land and sea attack cruise missile | imaging infrared seeker for terminal guidance | Navy |
| Space-Based Infrared System (SBIRS) High | Lockheed Martin and Northrop Grumman | space-based surveillance systems for missile warning | two payloads in highly elliptical orbit, four satellites in geosynchronous orbit, with infrared capabilties, as well as fixed and mobile ground-based assets to receive and process the infrared data | Air Force |
| Space Tracking and Surveillance System (STSS) | Northrop Grumman | low-orbiting infrared satellites | infrared surveillance capable of tracking ballistic missiles in all flight stages | Air Force |
| Stinger Missile System | Raytheon | guided missile system for short-range air defense | passive infrared and ultraviolet tracking seeker | Army |
| TOW | Hughes, Hughs and Kollsman, and Electro Design Mfg. | anti-armor weapon | thermal sight capability | Army |
| U-2S/TU-2S | Lockheed Martin | high-altitude reconnaissance | AN/AAD-3 high-altitude infrared set for airborne infrared reconnaissance and surveillance | Air Force |

[1] Information for defense programs were taken from the manufacturer's website, Federation of American Scientists (www.fas.org), Global Security (www.globalsecurity.org), and from U.S. military websites (www.af.mil, www.army.mil, www.marines.mil, and www.navy.mil). Please direct any updates to the Office of Strategic Industries and Economic Security at 202-482-4060.

# Appendix D: Selected Major U.S. Civilian Programs Utilizing Image and Sensor Technology

## SELECTED MAJOR U.S. CIVILIAN PROGRAMS UTILIZING IMAGE AND SENSOR TECHNOLOGY[1]

| Civilian Program | Manufacturer[2] | Description | Imaging/Sensor Capability | Use[2] |
|---|---|---|---|---|
| Altair Unmanned Aerial Vehicle (UAV) | General Atomics Aeronautical Systems, Inc | high-altitude civilian UAV | EO/IR sensors for habitat mapping and ecosystem monitoring | NASA, NOAA |
| Altus UAV | General Atomics Aeronautical Systems, Inc | wildfire monitoring | infrared scanning imager | USFS, LACoFD, NIFC, CARA |
| ASTROCAM | Mauna Kea Infrared, Inc. | Used to measure the annual parallax of objects classified as brown dwarfs and the supernova rate in dusty starburst galaxies. | infrared cameras with large format sensitive arrays | Navy |
| Cassini Spacecraft | NASA's JPL | interplanetary spacecraft | composite infrared spectrometer (CIRS) and a visible and infrared mapping spectrometer (VIMS) | NASA |
| Chandra Spacecraft | TRW Space and Electronics Group | observes x-rays and high energy regions of the universe | advanced CCD imaging sepctrometer (ACIS) and high resolution spectrometers | NASA |
| Counter-Man Portable Air Defense System (MANPADS) | Northrop Grumman | technology to counter the threat to commercial airliners | infrared seekers | DHS |
| Far-Infrared Spectroscopy of the Troposhere (FIRST) | Utah State University, Space Dynamics Laboratory | measures the infrared spectrum | long-wave imaging spectrometer | NASA, SAO |
| Galileo's Near Infrared Mapping Spectrometer (NIMS) | NASA's JPL | measures both reflected sunlight and emitted thermal radiation | diffraction grating spectrometer which disperses the radiation onto the focal plane assembly and a focal plane assembly consisting of multiple detectors, optical filters, and preamplifier circuitry | NASA's JPL |
| Gemini Observatory telescopes | partnership between Argentina, Australia, Brazil, Canada, Chile, the United Kingdom, and the United States | optical/infrared telescopes to observe the universe | multi-object spectrographs (GMOS), a near-infrared integral field spectrometer (NIFS), and a near-infrared imager (NIRIR) | NSF |
| Geostationary Operational Environmental Satellites (GOES) | | monitors storm development and tracks its movements | imaging radiometer | NOAA |
| Hubble Space Telescope (HST) | NASA and an extensive list of industry partners | space telescope | near-infrared camera and multi-object spectrometer (NICMOS) | NASA, ESA |

| Civilian Program | Manufacturer | Description | Imaging/Sensor Capability | Use |
|---|---|---|---|---|
| James Webb Space Telescope (JSWT) | Northrop Grumman | space telescope | near-infrared camera, near-infrared spectrograph, and mid-infrared instrument | Canadian Space Agency, ESA, NASA |
| Kepler Photometer | e2v Technologies | astronomical telescope | 42 - 2200x1024 CCDs | NASA |
| Large Synoptic Survey Telescope (LSST) | LSST Corp. | astronomical telescope | thermal imaging capabilities | LSST Corp. |
| Maui Space Surveillance System | Boeing and Textron and Trex are subcontractors | Used to collect data on both near-Earth and deep-space objects. | Uses large-aperture tracking optics with visible and infrared sensors. The telescopes accommodate imaging systems, infrared radiometers, and low light level video systems. | Air Force |
| Multispectral Thermal Imager (MTI) satellite | Sandia National Laboratories and Savannah River Technology Center | satellite | remote chemical detection infrared sensing capabilities | DOE |
| National Polar-orbiting Operational Environmental Satellite System (NPOESS) | Northrop Grumman and Raytheon | satellite system used to monitor global environmental conditions | Cross-Track Infrared Sounder (CrIS) and an Visible/Infrared Imager Radiometer Suite | DOC, DOD, and NASA |
| Origins Billion Star Survey (OBSS) satellite | United States Naval Observatory | astrometic satellite | 58 spectroscopy CCDs | USNO |
| Panoramic Survey Telescope and Rapid Response System (Pan-STARRS) | University of Hawaii, Institute of Astronomy | 4 telescopes | CCD digital camera | Air Force |
| Portable Infrared Video Camera | Indigo Systems (FLIR) and NASA's JPL Infrared Focal Plane Array Technology Group | infrared camera | highly sensitive quantum-well infrared photodetectors | aviation, environmental research, law enforcement, medicine |
| Remote Ultra-Low-Light Imager (RULLI) | Los Alamos National Laboratory | visible imager | single-photon detection system | DOE |
| Sloan Digital Sky Survey (SDSS) telescope | 200 PH.D. scientists from various institutions | survey telescope | 30 CCDs and a spectrograph | SDSS |

| Civilian Program | Manufacturer | Description | Imaging/Sensor Capability | Use |
|---|---|---|---|---|
| Space Infrared Interferometic Telescope (SPIRIT) | various universities and research facilities, in addition to Ball Aerospace, Boeing, Lockheed Martin, and Northrop Grumman | 2 space telescopes | infrared interferometer | NASA |
| Spitzer Space Telescope | Caltech, Ball Aerospace, and Lockheed Martin | space telescope | cryogenically-cooled instruments with infrared detector arrays | NASA's JPL |
| Supernova/Acceleration Probe (SNAP) telescope | international collaberation | space telescope | billion-pixel CCD camera and spectrometer system | DOE |
| Terrestrial Planet Finder (TPF) interferometer | NASA's JPL and various universities | mid-infrared formation-flying interferometer | mid-infrared spatial filter tech, common path phase sensing testbed, | NASA |
| Thermal Infrared Multispectral Scanner (TIMS) | NASA JPL and Stennis Space Center | six-channel aircraft scanner | operates in the thermal infrared (8 to 12 /m) region of the electromagnetic spectrum. | DOE |
| Thirty-Meter Telescope (TMT) | ACURA, AURA, CIT, UC | telescope for ground-based observations | various types on infrared spectrometers and a wide-field infrared camera | TMT |
| TopHat | international collaberation | spinning telescope and a detector system | monolithic silicon bolometers | NASA |
| Tropical Rain Measuring Mission (TRMM) | NASA's Global Hydrology Center, Kaiser Electro Optics, and Lockheed Martin | scanner and imaging sensor | visible and infrared scanner and lightning imaging sensor | NASA, JAXA |

[1] Information for civilian programs were taken from the manufacturer's website and the websites of the organizations that use the program. Please direct any updates to the Office of Strategic Industries and Economic Security at 202-482-4060.

[2] Acronyms and their meanings:

ACURA - Association of Canadian Universities for Research in Astronomy
AURA - Associated Universities for Research in Astronomy
CARA - California Resource Agency
CIT - California Institute of Technology
DHS - Department of Homeland Security
DOC - Department of Commerce
DOD - Department of Defense
DOE - Department of Energy
ESA - European Space Agency
JAXA - Japan Aerospace Exploration Agency
JPL - Jet Propulsion Laboratory
LACoFD - Los Angeles County Fire Department
LSST - Large Synoptic Survey Telescope
NASA - National Aeronautics and Space Administration
NIFC - National Interagency Fire Center
NOAA - National Oceanic and Atmospheric Administration
NSF - National Science Foundation
SAO - Smithsonian Astrophysical Observatory
SDSS - Sloan Digital Sky Survey
TMT - Thirty-Meter Telescope
UC - University of California
USFS - United States Forest Service
USNO - United States Naval Observatory

# Appendix E: Selected Federal Laboratories and Research Centers Related to Imaging and Sensors Technology

| Federal Laboratories and Research Centers<br>Directly or Indirectly Related to the Image and Sensor Industry[1] | | |
|---|---|---|
| **Facility** | **Location** | **Description** |
| Air Force Research Laboratory - Human Effectiveness Directorate | Wright Patterson AFB, Ohio | The only Air Force organization dedicated by charter to advancing night vision technology. Its efforts address all aspects of night vision device research, engineering, and application. |
| Air Force Research Laboratory – Sensors Directorate | Hanscom AFB, Massachusetts | Conducts basic research and exploratory and advanced development programs to advance electro-optical science and technology for multi-function EO/IR components and multi-function EO/IR systems. |
| Ames Research Center | Moffett Field, California | The Human-Centered Systems Lab research programs investigate human performance issues related to night vision devices, sensor imagery devices, and infrared technologies. |
| Army Aviation & Missile Research, Development, and Engineering Center | Redstone Arsenal, Alabama | The Applied Sensors, Guidance, and Electronics Directorate is a government team of scientists and engineers that provide the Army unsurpassed sensor and guidance, navigation, and control (GNC) technologies. |
| Army Communications Electronics Research Development and Engineering Center | Ft. Monmouth, New Jersey | CERDEC develops and integrates Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) technologies. |
| Army Edgewood Chemical, Biological Center | Aberdeen Proving Ground, Maryland | The Electro-Optics Research Laboratory's imaging and optical analysis laboratories scientists and technicians develop tactical sensors as a first line of defense against chemical and biological attacks. |
| Army Engineer Research and Development Center | Alexandria, Virginia | ERDC designs develops contracts integrates tests and sustains imagery systems. |
| Army Research Laboratory - Night Vision and Electronic Sensors Directorate | Ft. Belvoir, Virginia | This directorate engages in R&D to provide advanced sensor technology to target enemy forces, detect and neutralize mines, minefields and unexploded ordnances, deny enemy surveillance and acquisition through electro-optics, camouflage, concealment, and deception techniques, provide for night driving and piloting of aircraft, and protect troops and fixed installations from enemy intrusion. |
| Army Research Laboratory - U.S. Army Materiel Systems Analysis Activity | Aberdeen Proving Ground, Maryland | Research to improve the capability to detect, identify, and engage targets through the integration of electro-optic components, including passive multi- and hyper-spectral IR target and background phenomenology; low-cost, compact, staring, high-resolution laser radars; and low-cost, lightweight, compact, rugged, flexible displays for in-the-field image display. |
| Army Research Laboratory – Vehicle Technology | Cleveland, Ohio | The directorate conducts R&D on gas turbine engines and advanced power transmission systems for air and ground vehicle systems. |
| Army Space & Missile Defense Command | Huntsville, Alabama | The program is to develop a Ladar sensor technology that will augment passive sensors to perform enhanced discrimination of advanced threat targets, such as re-entry vehicles. |

| Facility | Location | Description |
|---|---|---|
| Army Tank Automotive Research, Development, and Engineering Center | Warren, Michigan | TARDEC's mission is to research, develop, engineer, leverage and integrate advanced technology into ground systems and support equipment throughout the life cycle. |
| Defense Advanced Research Projects Agency | Arlington, Virginia | DARPA's Coherent Communications, Imaging, and Targeting (CCIT) program addresses the critical need for high-data-rate communications and imaging from land, sea and airborne platforms to space. |
| Defense Microelectronics Activity | North Highlands, California | DMA designs and develops analog, digital, and mixed signal integrated circuits and hybrid and multi-chip module products. |
| DOE Research Labs | | These multi-program national labs run by the National Nuclear Security Administration (NNSA) conduct the DOE's nuclear stockpile stewardship mission. Research falls into the broad categories of basic science, energy resources, environmental management, and national security. They also provide DoD, the Intelligence Community, and other government agencies with analysis and advanced technologies to meet national security needs. |
| Ames Laboratory | Ames, Iowa | |
| Argonne National Laboratory | Argonne, Illinois | |
| Idaho National Laboratory | Idaho Falls, Idaho | |
| Kansas City Plant | Kansas City, Missouri | |
| Lawrence Berkeley National Laboratory | Berkely, California | |
| Lawrence Livermore National Laboratory | Livermore, California | |
| Los Alamos National Laboratory | Los Alamos, New Mexico | |
| Oak Ridge National Laboratory | Oak Ridge, Tennessee | |
| Pacific Northwest National Laboratory | Richland, Washington | |
| Sandia National Laboratories | Albuquerque, New Mexico | |
| Sandia National Laboratories - CA | Livermore, California | |
| DOT-John A. Volpe National Transportation Systems Center | Cambridge, Massachusetts | The center work primarily for DOT and other federal agencies and state, local, and international entities in support of DOT's safety, mobility, and security goals. |
| FAA – William J. Hughes Technical Center | Atlantic City International Airport, New Jersey | Aviation R&D and test and evaluation facility whose activities involve testing and evaluation in air traffic control, communications, navigation, airports, aircraft safety, and security. |
| NASA Research Labs | | While science, aeronautics, and space exploration-focused, NASA's various research labs frequently develop devices whose spin-offs support military and commercial applications, such as night vision surveillance. |
| Glenn Research Center | Cleveland, Ohio | |
| Goddard Space Flight Center | Greenbelt, Maryland | |
| Jet Propulsion Laboratory | Pasadena, California | |
| Johnson Space Center | Houston, Texas | |
| Kennedy Space Center | Kennedy Space Center, Florida | |
| Langley Research Center | Hampton, Virginia | |
| Marshall Space Flight Center | Huntsville, Alabama | |
| Stennis Space Center | Stennis Space Center, Mississippi | |

| Facility | Location | Description |
|---|---|---|
| Missile Defense Agency - Advanced Systems | Washington, DC | Develops an integrated ballistic missile defense system and associated technologies. |
| National Institute of Standards and Technology | Gaithersburg, Maryland | The Electron and Optical Physics Division develops measurement capabilities needed by emerging electronic and optical technologies. |
| Naval Air Warfare Center - Weapons Division | China Lake, California | This facility conducts research, development, test, and evaluation on optical materials, optical components, laser and optical systems, and laser and optical subsystems. |
| Naval Research Lab | Washington, DC | The corporate research laboratory for the Navy and Marine Corps and conducts a broad program of scientific research, technology and advanced development. |
| Naval Surface Warfare Center-Indian Head Division | Indian Head, Maryland | The center's capabilities include R&D, testing, and engineering as well as weapons product development. |
| NAVSEA Carderock Division | West Bethesda, Maryland | Ship Design and Integration Technology efforts at Carderock focus on integrating mulitdisciplinary technologies and systems into total ship designs and support analyses for surface ships, submarines, combatant craft, and Marine Corps vehicles. |
| Office of Naval Research | Arlington, Virginia | ONR coordinates, executes, and promotes the science and technology programs of the US Navy and Marine Corps through schools, universities, government laboratories, and nonprofit and for-profit organizations. It provides technical advice to the CNO and the secretary of the Navy and works with industry to improve technology manufacturing processes. |
| Space and Naval Warfare Systems Center | San Diego, California | SSC San Diego is responsible for development of the technology to collect, transmit, process, display and, manage information. It conducts research on intelligence, surveillance, and reconnaissance sensors. |

[1] Descriptions for individual facilities were taken from the organization's website. Please direct any updates to the Office of Strategic Industries and Economic Security at 202-482-4060.

# Appendix F:
# U.S. Department of Defense EO/IR Budgets, FY 2001-2007

## Appendix F: U.S. Department of Defense EO/IR Budgets, FY 2001-2007 (in $millions)

| U.S. DOD Budget Procurement Programs (P-1) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Product** | **FY01** | **FY02** | **FY03** | **FY04** | **FY05** | **FY06** | **FY07** |
| Integrated Meteorological System Sensors (IMETS) | 7.0 | 2.5 | 7.0 | 11.3 | 0.3 | 3.7 | 3.5 |
| Enhanced Sensor & Monitoring System | n/a | n/a | n/a | n/a | 1.4 | 2.0 | n/a |
| Tactical Remote Sensor System | n/a | n/a | n/a | 9.4 | 8.5 | n/a | n/a |
| Sensor Fuzed Weapon | 112.0 | 108.5 | 124.1 | 117.0 | 116.5 | 118.8 | 118.9 |
| Space Based IR Sensor Program Space | n/a | n/a | n/a | 94.7 | n/a | 3.6 | 4.2 |
| Night Vision Goggles | 2.9 | 3.7 | 9.8 | 11.6 | 20.9 | 11.8 | 19.3 |
| Night Vision System Devices and Components (Night Vision Devices) | 89.3 | 40.1 | 99.9 | 159.8 | 258.7 | 393.1 | 321.0 |
| Image Intensifier ($I^2$) Devices (Common Imagery Ground Surface Systems) | 46.0 | 56.9 | 51.2 | 40.3 | 49.6 | 20.2 | 78.3 |
| Night Vision Scopes and Monocular Devices (Night Vision, Thermal Weapon Sight) | 36.0 | 36.3 | 73.9 | 128.5 | 73.5 | 145.7 | 209.5 |
| Infrared Target Detection Systems (Air Defense Targets) | 2.4 | 3.3 | 3.3 | 3.4 | 5.8 | 6.1 | 3.9 |
| Aerial Targets | 57.8 | 57.8 | 66.6 | 77.7 | 69.1 | 91.5 | 83.3 |
| Target Drones (Aircraft) | 22.9 | 33.2 | 29.6 | 55.2 | 72.6 | 81.8 | 82.0 |
| Other (Night Vision Equipment) | 21.2 | 30.2 | 24.4 | 30.0 | 605.5 | 103.0 | 13.7 |
| ASE Infrared CM | n/a | 3.6 | n/a | 75.2 | 322.6 | 209.2 | 305.6 |
| Lightweight Laser Designator/Rangefinder | 7.0 | 11.2 | 9.7 | 12.2 | 43.1 | 12.6 | 50.1 |
| Tactical Unmanned Aerial Systems | n/a | n/a | n/a | n/a | 305.6 | 202.6 | 100.3 |
| Tactical Unmanned Aerial Vehicle | 37.8 | n/a | n/a | n/a | n/a | 19.8 | 10.2 |
| Small Unmanned Aerial System | n/a | n/a | n/a | n/a | n/a | n/a | 15.2 |
| Weaponization of Unmanned Aerial System | n/a | n/a | n/a | n/a | n/a | n/a | 20.7 |
| Unmanned Vehicles | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Combat Identification Aiming Light | 10.9 | 10.0 | n/a | n/a | n/a | n/a | n/a |
| **Totals** | **453.2** | **397.3** | **499.5** | **826.3** | **1,953.7** | **1,425.5** | **1,439.7** |
| Sources: U.S. Department of Defense, Defense Budget Materials, Summary Justification Materials: FY 2001 Budget, FY 2002 Budget, FY 2003 Budget, FY 2004 Budget, FY 2005 Budget, FY 2007 Budget. | | | | | | | |

## Appendix F: U.S. Department of Defense EO/IR Budgets, FY 2001-2007 (in $millions)

| U.S. DOD Budget Procurement Programs (P-1R) National Guard and Military Reserve Components (yearly figures equal national guard + military reserve budget figures) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Product** | **FY01** | **FY02** | **FY03** | **FY04** | **FY05** | **FY06** | **FY07** |
| Night Vision Goggles | 0.3 | 0.9 | 0.6 | 0.4 | 0.4 | 0.6 | 1.5 |
| Night Vision System Devices and Components (Night Vision Devices) | n/a | n/a | n/a | n/a | n/a | 119.6 | 102.7 |
| Night Vision Scopes and Monocular Devices (Night Vision, Thermal Weapon Sight) | n/a | n/a | n/a | n/a | n/a | n/a | 50.0 |
| Lightweight Laser Designator/Rangefinder | n/a | n/a | n/a | n/a | n/a | n/a | 23.3 |
| Tactical Unmanned Aerial Systems | n/a | n/a | n/a | n/a | 17.1 | n/a | n/a |
| **Totals** | **0.3** | **0.9** | **0.6** | **0.4** | **17.5** | **120.2** | **177.5** |
| Sources: U.S. Department of Defense, Defense Budget Materials, Summary Justification Materials: FY 2001 Budget, FY 2002 Budget, FY 2003 Budget, FY 2004 Budget, FY 2005 Budget, FY 2007 Budget. | | | | | | | |

## Appendix F: U.S. Department of Defense EO/IR Budgets, FY 2001-2007 (in $millions)

| U.S. DOD Budget Research, Development, Testing & Evaluation (RDT&E) Programs (R-1) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Product** | **FY01** | **FY02** | **FY03** | **FY04** | **FY05** | **FY06** | **FY07** |
| Sensors and Electronic Survivability | 22.7 | 31.6 | 21.7 | 25.2 | 56.3 | 51.3 | 38.4 |
| Advanced Tactical Computer Science and Sensor Technology | 16.5 | 15.9 | 26.9 | 24.7 | 51.7 | 45.0 | 64.6 |
| Aerial Common Sensor | n/a | n/a | n/a | n/a | 26.6 | 35.0 | 17.2 |
| Aerospace Sensors | 65.4 | 79.4 | 77.1 | 86.4 | 92.6 | 115.7 | 117.6 |
| Advanced Aerospace Sensors | 44.8 | 57.6 | 50.9 | 41.1 | 41.6 | 39.8 | 55.1 |
| Sensor Technology | n/a | n/a | n/a | n/a | 196.6 | 186.7 | 205.5 |
| Guidance Technology (Sensor and Guidance Technology) | 138.5 | 190.1 | 216.1 | 336.7 | 111.1 | 101.8 | 157.4 |
| Advanced Sensor Applications Program | 38.0 | 21.2 | 16.9 | 33.0 | 26.1 | 24.7 | 18.8 |
| Ballistic Missile Defense Sensors | n/a | 313.0 | 327.0 | 425.4 | 567.2 | 278.2 | 514.5 |
| Night Vision Advanced Technology | 41.6 | 54.9 | 77.1 | 84.1 | 102.0 | 101.7 | 44.3 |
| Night Vision Technology | 24.9 | 22.2 | 18.7 | 21.5 | 26.4 | 31.7 | 24.0 |
| Night Vision Systems Advanced Development | 14.8 | 10.7 | 11.0 | 7.0 | 17.0 | 6.8 | 5.3 |
| Night Vision Systems – Engineering Development | 28.7 | n/a | n/a | n/a | n/a | n/a | n/a |
| Night Vision Systems – Systems Development and Demonstration | n/a | 24.8 | 31.7 | 38.8 | 34.1 | 29.0 | 38.8 |
| Navy Meteorological and Ocean Sensors – Space | 22.1 | 20.9 | 21.8 | 7.9 | n/a | n/a | n/a |
| **Totals** | **458.0** | **842.3** | **896.9** | **1,131.8** | **1,349.3** | **1,047.4** | **1,301.5** |

Sources: U.S. Department of Defense, Defense Budget Materials, Summary Justification Materials: FY 2001 Budget, FY 2002 Budget, FY 2003 Budget, FY 2004 Budget, FY 2005 Budget, FY 2007 Budget.

# Appendix G:
# U.S. Department of Commerce, BIS/SIES Publication List

# OFFICE OF TECHNOLOGY EVALUATION (OTE)
# PUBLICATIONS LIST

**October 12, 2006**

The U.S. Department of Commerce's Office of Technology Evaluation is the focal point within the Department for conducting assessments of defense-related industries and technologies. The studies are based on detailed industry-specific surveys used to collect information from U.S. companies and are conducted on behalf of the U.S. Congress, the military services, industry associations, or other interested parties.

| PUBLICATION TITLE | *_Italics_ indicate forthcoming studies |
|---|---|
| ***Global Availability of State-of-the-Art Semiconductor Manufacturing Equipment – December 2007*** | |
| ***Domestic Industrial Base Capabilities for Defense Mission-Critical Microchips – September 2007*** | |
| ***Defense Industrial Base Assessment of the U.S. Satellite Industry – September 2007*** | |
| ***11th Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 – December 2006*** | |
| Defense Industrial Base Assessment: U.S. Imaging and Sensors Industry – September 2006 | |
| National Security Assessment of the Cartridge and Propellant Actuated Device Industry: Third Review – July 2006 | |
| 10th Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 – December 2005 | |
| Economic Impact Assessment - Air Force C-17 Program – December 2005 | |
| 9th Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 – March 2005 | |
| National Security Assessment of the Munitions Power Sources Industry – December 2004 | |
| Offsets in Defense Trade and the U.S. Subcontractor Base – August 2004 | |
| 8th Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 – July 2004 | |
| National Security Assessment of the Air Delivery (Parachute) Industry – May 2004 | |
| Industry Attitudes on Collaborating with DoD in R&D – Air Force – January 2004 | |
| Army Theater Support Vessel Procurement: Industrial Base/Economic Impact Assessment – December 2003 | |
| A Survey of the Use of Biotechnology in U.S. Industry – October 2003 | |
| U.S. Textile and Apparel Industries: An Industrial Base Assessment – October 2003 | |
| 7th Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 - July 2003 | |
| Technology Assessment: U.S. Assistive Technology Industry – February 2003 | |
| 6th Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 - February 2003 | |
| Heavy Manufacturing Industries: Economic Impact and Productivity of Welding – Navy – June 2002 | |
| The Effect of Imports of Iron Ore and Semi-Finished Steel on the National Security – October 2001 | |
| National Security Assessment of the U.S. High-Performance Explosives & Components Sector –June 2001 | |
| National Security Assessment of the U.S. Shipbuilding and Repair Industry - May 2001 | |
| Statistical Handbook of the Ball and Roller Bearing Industry (Update) - June 2001 | |
| 5th Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 - May 2001 | |
| National Security Assessment of the Cartridge and Propellant Actuated Device Industry: Update - December 2000 | |

| |
|---|
| The Effect on the National Security of Imports of Crude Oil and Refined Petroleum Products - November 1999 |
| 4th Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 - October 1999 |
| U.S. Commercial Technology Transfers to The People's Republic of China – January 1999 |
| Critical Technology Assessment: Optoelectronics - October 1998 |
| 3rd Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 - August 1998 |
| National Security Assessment of the Emergency Aircraft Ejection Seat Sector - November 1997 |
| 2nd Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 – August1997 |
| Critical Technology Assessment of the U.S. Semiconductor Materials Industry - April 1997 |
| 1st Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 - May 1996 |
| National Security Assessment of the Cartridge and Propellant Actuated Device Industry - October 1995 |
| A Study of the International Market for Computer Software with Encryption – NSA -1995 |
| The Effect of Imports of Crude Oil and Petroleum Products on the National Security - December 1994 |
| Critical Technology Assessment of U.S. Artificial Intelligence - August 1994 |
| Critical Technology Assessment of U.S. Superconductivity - April 1994 |
| Critical Technology Assessment of U.S. Optoelectronics - February 1994 |
| Critical Technology Assessment of U.S. Advanced Ceramics - December 1993 |
| Critical Technology Assessment of U.S. Advanced Composites - December 1993 |
| The Effect of Imports of Ceramic Semiconductor Packages on the National Security - August 1993 |
| National Security Assessment of the U.S. Beryllium Industry - July 1993 |
| National Security Assessment of the Antifriction Bearings Industry - February 1993 |
| National Security Assessment of the U.S. Forging Industry - December 1992 |
| The Effect of Imports of Gears and Gearing Products on the National Security - July 1992 |
| Natl. Sec. Assessment of the Dom. and For. Subcontractor Base~3 US Navy Systems - March 1992 |
| Natl. Security Assessment of the U.S. Semiconductor Wafer Processing Equipment Industry - April 1991 |
| National Security Assessment of the U.S. Robotics Industry - March 1991 |
| National Security Assessment of the U.S. Gear Industry - January 1991 |

| **Archived Studies** | |
|---|---|
| The Effect of Imports of Uranium on the National Security – Sept. 1989 | Investment Castings: A Natl. Security Assessment – Dec. 1987 |
| The Effect of Imports of Crude Oil and Refined Petroleum on Natl. Security – Jan. 1989 | Joint Logistics Commanders/DOC Precision Optics Study - June 1987 |
| The Effect of Imports of Plastic Injection Molding Machines on Natl. Security – Jan. 1989 | An Economic Assessment of the U.S. Industrial Fastener Industry – Mar. 1987 |
| The Effect of Imports of Anti-Friction Bearings on the Natl. Security - July 1988 | Joint Logistics Commanders/DOC Bearing Study - June 1986 |

**For further information about OTE's programs or for additional copies of reports, please visit us at:**
**http://www.bis.doc.gov/ and select "Defense Industrial Base Programs," or contact:**
**Brad Botwin, Supervisory Industrial Specialist, OTE**
**Phone: 202-482-4060 Fax: 202-482-5650 E-mail: bbotwin@bis.doc.gov**