From: "Goodrich, John (SA-1)" <JGoodrich@drs-rsta.com>
To: PublicComments@bis.doc.gov
Date: Tue, Feb 8, 2011 7:54 AM
Subject: RIN 0694-AF03 for the STA notice

Attached is the SITAC response to the subject matter above. Two of the enclosures are electronically attached. The signature page is also attached.

Chris, I trust it is appropriate to cc the TAC members? If yes, can Yvette please do that? Thank you.

John Goodrich

952-334-3454

Jgoodrich@drs-rsta.com

CC: CCOSTANZ@bis.doc.gov

February 7, 2011

Sent via email to: publiccomments@bis.doc.gov

Regulatory Policy Division
Bureau of Industry and Security
Room 2705
U.S. Department of Commerce
Washington, DC 20230

RE: Federal Register: December 9, 2010 (Volume 75, Number 236)
RIN 0694-AF03

Export Control Modernization: Strategic Trade Authorization License Exception

Dear Sir or Madam:

The Sensors and Instrumentation Technical Advisory Committee (SITAC) would like to thank the Department of Commerce and the interagency task force for the tremendous amount of work that has been done so far in support of the Administration's Export Control Reform Initiative.

SITAC appreciates the opportunity to comment on this and forthcoming proposed regulations. The involvement of the TACs in the reform effort will ensure the resulting export control system is streamlined in a way that more effectively addresses national security concerns in an era of globalization, while making the system more transparent and efficient for the government and regulated community.

Please accept our comments below which include policy principles, criteria for controlling end items, and technology and software, as well as the proposed rule which would add a new license exception to the Export Administration Regulations (EAR). This Strategic Trade Authorization (STA) exception would allow exports, reexports and transfers (in-country) of specified items to destinations that pose little risk of unauthorized use of those items. Additionally, we have provided significant information related to foreign availability of items controlled under Category 6 of the EAR.

Policy Principles

1) Consistent with the Administration's goal of avoiding an overly broad and complex export control system, the Administration should adopt positive lists that consist only of sensitive items that are susceptible to effective control. The

positive list should apply only to end items, allowing controls on associated sensitive parts/components, software and technology to be applied as specified below.

2) To this end, products, equipment, systems, parts, components, software and technology that are or will become widely available or accessible, or are otherwise not susceptible to effective control, should be classified under EAR99 except under very narrow and justifiable circumstances. Similarly, items should not be subject to Tiers 1-3 controls where broad foreign availability or capability exists.

3) Restructure the CCL to align with the format of the revised USML. In particular, a CCL category should focus primarily on identification of end items that produce a significant, substantial or military or intelligence advantage. Parts, components, technology or software would only be subject to control as a subcategory of a listing for an end item, but only if they are peculiarly responsible for the specific features of the end item that produce a military or intelligence advantage (see specific criteria below).

4) Considerations that should inform the Administration's proposed criteria for placing items within the 3-tier control structure should include:

- An application of foreign availability that considers the existence of equivalent foreign items and capabilities, as well as other relevant factors, including but not limited to the degree to which an item is available or accessible through commercial channels outside the U.S. The attached appendix provides specific data related to SIMILAR TECHNOLOGY AVAILABLE FROM NON-U.S. SOURCES.
- Tier 1 and 2 controls should apply to items that have an inherent military or intelligence capability. In particular, the controls should apply to items with functions/capabilities that are peculiarly responsible for critical or substantial military/intelligence applications.
- All other items subject to control under the 3-tiered structure should fall under Tier 3.
- Items where companies hold CCATs or other rulings indicating products are EAR99 should continue to stand since items don't fall under any of the Tier's on the new control list.
- Ensure that positive control list parameters for sensitive end items are predicated upon precise, clear, objective and positive criteria. If control metrics for an item cannot be articulated in objective, unambiguous and positive standards, the items should not be subject to Tier 1-3 controls.

5) Technical export control parameters should be continuously reviewed with a view toward swiftly updating those parameters that are overtaken by technological advances, wide availability and foreign availability. Although there has been some discussion about how the tiered list will evolve in the future, it remains of

great concern that the export control reform initiative needs to establish a clear and effective process for future changes to the tiered list in light of changing foreign availability, for example. A stagnant list that is a snapshot of a period of time in the past will not serve the US industrial base well and US exporters will be no better off than with the previous export control system. US suppliers will effectively lag foreign suppliers undermining technology leadership in the US.

6) The new 3-tier list structure should contain descriptions and criteria that avoid subjecting items to export controls that are more stringent than they are today. In addition, the removal of terms like "specifically designed" should not result in the broadening of controls.

7) While there has been mention about the need for transparency in the new export control regime, we see no specific guidelines where a level playing field is established amongst US suppliers. Certainly, there will be gray areas between tiers and it remains possible that some exporters will have products considered part of one tier while others may have products in a different tier – and for products that are essentially identical. Manufacturers need to be able to review tier decisions made on all products in order to have the expectation that similar products will have the same tier classification. This will better assure that product development investments are appropriately expended.

8) The new export control system should align with multilateral agreements and disciplines.

Criteria for Controlling End Items

1) An end item should fall under EAR99 if it is not directly related or essential to the creation of a military/intelligence advantage. For example, cameras controlled under 6A003.b.4.b and 6A993, or other 6A003 cameras whose performance falls under specific figures of merit (FOM). To properly tier products having significant application in both military and commercial areas, FOMs will need to be established and published. For imaging technologies (visible, SWIR, thermal) that have night vision applicability, **the fundamental FOMs for these imaging systems should be based on: resolution (array size), sensitivity, spectral range, frame rate.** Other factors such as pixel pitch or thermal time constant have no impact on a products ability to provide a significant, substantial or military or intelligence advantage.
2) The terminologies and FOMs should be aligned. For example, DARPA's Low Cost Thermal Imager-Manufacturing (LCTI-M) program # DARPA-BAA-11-27, is seeking innovative research proposals to provide very low cost, low SWaP (Size, Weight and Power). That solicitation identifies 640x480 UFPAs as "small format" and 1280x768 UPFAs as "large format". Yet, other DOD organizations such as DTSA, identifies 640x480 as "large format". The inconsistent use of these terms results in serious misinterpretations of DOD policy during the Tri-Service reviews related to commodity jurisdictions.

3) An end item should also fall under EAR99 if it meets the wide availability, controllability and broad foreign availability guidelines stated in the second policy principle above.

Criteria for Controlling Technology and Software

1) Software and technology should only be controlled within Tiers 1-3 to the extent they are peculiarly responsible for enabling a feature of an end item that provides a critical, substantial or significant military- or intelligence advantage.

2) Software and technology that are general purpose or generally commercially applied should be classified as EAR99. General purpose software and technology by themselves have no inherent military or intelligence capability; in addition, software and technology that are generally commercially applied are civilian in character and, hence, cannot by definition be peculiar to military or intelligence applications.

3) Software and technology that meet the wide availability, controllability and broad foreign availability guidelines stated in the second policy principle above should fall under EAR99. This includes technology or software in the public domain, to basic scientific research, or to the minimum necessary information for patent applications.

4) Tier 1-3 controls should not apply to "use" technology, including technology that is the minimum necessary for the installation, operation, maintenance (checking) and repair of those items which are not controlled or whose export has been authorized.

License Exception STA

SITAC would like to thank the Department of Commerce for evaluating and proposing new approaches to exporting low risk items to low risk countries by utilizing license exceptions versus individual licenses. We would also like to encourage the Department of Commerce to consider additional non-licensing mechanisms such as the validated end-user program, intracompany licensing and "open licenses" that are used in the United Kingdom.

From the perspective of exporters of items controlled under Category 6, the benefits of license exception STA are not readily distinguished from existing EAR license exceptions such as the UTIC rule. Unless it is clear to the exporter that using STA has benefits over using existing, familiar license exceptions that do not require incremental statements or procedures, then it is doubtful that the new exception will be used.

SITAC has a concern regarding the STA exception of 6A001, 6A002 and 6A003. While there are very sensitive portions of 6A001, 6A002 and 6A003, there are other parts of these ECCNs that have significant foreign availability in both regime partner and non-

regime partner nations. Commercial Marine Seismic Equipment in 6A001 is available from companies located in Europe and China. Equivalent non-space qualified focal plane arrays in 6A002a2 and 6A002a3 are available from several European manufacturers. The cameras containing those focal plane arrays, 6A003b, are currently available world-wide from vendors in Europe, the Middle-East, the Pacific, and most notably China.

STA would be much more interesting and worth the investment to implement if 740.20(c)(2) destinations were allowed for Category 6 items. It isn't clear why items such as commercial focal plane arrays, cameras, and optical systems which are widely available from non-US sources would be restricted to the narrow list of countries in 740.20(c)(1).On another note, creating a unique Destination Control Statement for this license exception will likely create costly export system change requirements, and create confusion for the overseas customer. The overseas customer, sales representative, and distributors who are re-exporting may realize he/she can use alternate US re-export license exceptions and thus be confused by the additional language and decide that **using US-sourced product is not worth the uncertainty and potential liabilities**. It is better to have fewer and distinctive license processes rather than a multitude of similar choices in order to avoid the need to analyze the subtleties of each situation.

The SITAC would like to thank the Department of Commerce for the opportunity to provide comments on Export Control Modernization and proposed license exception STA. This letter, enclosures, and references are made on behalf of the Sensors and Instrumentation Technical Advisory Committee.

Sincerely,

John Goodrich
SITAC Chairman

ENCLOSURE 1

FOREIGN AVAILABILITY DATA

The SITAC is presenting foreign availability data in several categories.

1) Uncooled Focal Plane Array (UFPA) Camera Cores
2) Commercial Cameras incorporating 640x480 UFPAs
3) Uncooled and cooled Packaged Focal Plane Arrays
4) Enclosure 2 (electronically attached) is the Foreign Availability Report certified by the SITAC and submitted to BIS 13 August 2008. This report was submitted in accordance with the requirements described in Part 768.1 of the EAR and addresses the availability of UFPA based cameras manufactured in the Peoples Republic of China
5) Enclosure 3 (electronically attached) is a study conducted by the Bureau of Industry and Security on the Thermal Imaging Industry. This study concluded 1) there is a growing commercial market, 2) Heavy R&D investment is being made by US companies and there is strong employment by the thermal imaging industry, 3) International competition is increasing, 4) there is a sharp decline in the export of UFPA cameras, and 5) the majority of US exports of thermal imaging cameras are made to NATO Allies.
6) Reference material not enclosed due to DOD controls. Report entitled "Comparison of Foreign and US Infrared Detector Technology". Presented to Military Sensing Symposium (MSS) February 2006. The report was authored by Paul Norton, Stuart Horn, and James Campbell, Night Vision and Electronics Sensors Directorate, US Army, Fort Belvoire, VA. This report provides a thorough assessment of the availability of UFPA and Cooled Focal Plane Arrays from Non-US sources.

UFPA Camera Cores

There are many Non-US manufacturers of Camera Cores that incorporate 640x480 Uncooled Focal Plane Arrays (UFPA). The UFPAs incorporated into these camera cores are manufactured in France and Japan (Wassenaar Partners) and also in Israel (Neither Wassenaar nor NATO...see below for International sensor fabricators). These camera cores are produced by well-established manufacturers who have made significant investments into the development of the UFPA technology. The performance of these camera cores are all very similar.

- Camera Cores are incorporated into both military and commercial products.
- The Camera Core by itself is not military and only obtains a "personality" by incorporation into a higher level assembly.
- Commercial utility of uncooled FPAs has been irreversibly proven

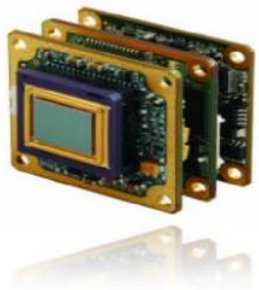
– Several applications have been enabled by the technology
    - Analytics, Energy Saving, Building Inspection, Power Monitoring – 2009 Addressable Market for Uncooled Dual Use Systems: $1.9B
    - 2009 Addressable Market for Uncooled FPAs/Modules: $442M
    - Estimated to grow at 13% CAGR
- World Wide sources are competing for market share
- Commercial demand for UFPA cameras is growing faster than military demand
- These growing markets will be satisfied with either US technology or non-US technology

Thermoteknix Microcam

Specification	
Sensitivity (f1.0 no lens)	384˙M˙ Model = <80mK 384˙H˙ Model = <50mK
Power consumption	<0.6 Watts
Supply	1.8V to 5.5V
Detector Material	ASi
Array Size	384x288 (Optional 320x240)
Pixel Count	110,592
Pixel Pitch	25µ
TEC-Less operation	Yes
NUC operation	Shutterless - No Shutter Present nor required
Spectral response	8-12um
Frame Rate	60 FPS
Video Output	Composite PAL / NTSC
Digital Zoom	x2 x4
Polarity invert	Yes
Image flip / rotate	Yes
Discrete Button inputs	4
Text overlay	Yes
Operating temperature	-20°C to +60°C
Weight (Excluding optics)	35g / 1.2oz
Typical Weight (Including 14.95mm F/1.3 lens)	74g / 2.6oz

Opgal **EYE R640 ™ Ver4**

(17µm pitch detector)™



17µ, 640x480, AmSi microbolometer 8-12µm, 70 mK NETD (25° F#1)
Input Voltage 8-28 VDC. Power consumption Max <2.7W @ room temp.
41mm X 54mm x 48.5mm (HxWxL), weight < 160gr.
Tecless
Opgal/PelcoD protocol over RS232/RS422
Analog CCIR or RS-170.
NUC, BPR, time domain filter, edge enhancement, Local DRC, Auto Focus, Digital Zoom Continuous X0.9 – X12
Easy embedding of Customer Application
Customizable menus, logo, colors. Customizable Graphic overlay & reticules Upgradable computing power (Optional)
Temp -40° - 60° C
MIL-STD 810F
MIL-STD 461D

Jenoptik – OEM 640x480 Camera Module

	IR-TCM 640 compact
Detector type	Uncooled microbolometer (Focal Plane Array)
Image format	640 × 480 pixel
Spectral range	7.5 µm ... 14 µm
Range for measuring / visualization[2]	-40 °C ... +300 °C | Option: up to +2000 °C
Temperature resolution	NETD < 70 mK | With filtering: NETD < 30 mK
Measurement accuracy[3]	± 1.5 K (0 °C ... 100 °C) | otherwise ± 2 K, ± 2%
Dynamic range	16 bit
Image rate	50 Hz (PAL) or 60 Hz (NTSC)
Interfaces	Gigabit-Ethernet, CameraLink, IEEE-1394 (FireWire), S-/C-Video, VGA, RS-232, Trigger
Power supply	9 VDC ... 24 VDC
Operating temperature	-15 °C ... +45 °C
Storing temperature	-40 °C ... +70 °C
Humidity	Relative humidity 10 % ... 95 %, non-condensing
Shock	Operational: 25G, IEC 68-2-29
Vibration	Operational: 2G, IEC 68-2-6
Dimensions (without lens)	109 mm × 100 mm × 100 mm
Weight (without lens)	675 g
Options	+ Radiometric calibration -40 °C ... +300 °C

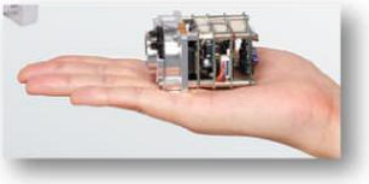
SCD 640x480 25 um Camera

Main Features:
Compact size
Low power
State of the art performance
Flexible video interface: Analog and Digital with glue-less connection to an OLED display
Flexible system interface options including R232, Ethernet and USB2.0
Linux/DSP-BIOS™ based Open software environment for customers easy customization
Supports TEC-LESS and SCD's PowerSave© mode

BIRD 640-VE / BIRD 640-VE HS
Bird 640 Video Engine

NEC 640 Camera Module

Item	HX3100
Detector	Uncooled focal plane array
Number of Pixels	640(H) × 480(V)
Pixel Size	23.5μm
Spectral range	8 to 14μm
NETD(with F/1 lens)	L range: <75mk/H range: <300mk
Sensor frame rate	30Hz
Range	LH (2range)
Dynamic Range(with F/1 lens)	L range: -40℃ to 150℃ / H range: 0℃ to 540℃
Power supply	DC 11 to 13V
Power Consumption(at 25℃)	7W Approx.
Video Output	NTSC (30Hz) or PAL (25Hz) composite video
Digital Output	ITU-R, BT656 video data / 16bit raw data
Control Interface	RS-232C
Size (mm)(without lens)	82(W) × 89(H) × 75(D)
Weight (without lens)	370g
Operating Temperature	-30℃ to +60℃
Functions	Contrast / Brightness/ Polarity (Hot white/Hot black) / Digital Zoom (×2,×4) /Range change / FPN correction / Save Configuration



Commercial Cameras Incorporating 640x480 (small format) Uncooled Focal Plane Array

There are numerous cameras that have been developed specifically for commercial markets such as Building Diagnostics, Electrical/Mechanical Analysis, Automation, Science/Research and Development. The incorporation of Uncooled Focal Plane Arrays (UFPA) utilizing a 640x480 (307,000 pixels) is the commercial standard and considered small format by the DOD. Several camera manufacturers are incorporating large format UFPAs (1280x768) into the commercial cameras shown below. The UFPAs are from the sources shown above in the Camera Core section. None of the cameras below incorporate UFPAs manufactured in the United States. The current U.S. export regulations do not support the incorporation of 640x480 small format UFPAs into commercial markets. The cameras shown below represent a sampling of cameras that are currently in the market place and sold world-wide.

All of the cameras identified below are manufactured by well-established manufacturers that have been in the business of producing commercial thermal imaging cameras for years, and some decades. The 640x480 UFPAs incorporated into these cameras all have similar performance distinguishable only in a laboratory environment. The most significant differences between the various cameras are usability features such as report generation, voice annotation, ergonomics, and other features specific to commercial markets.

Japan

NEC H2640 k$ 22-25

Germany

Jenoptic Variocam
k$ 25-28

United Kingdom

Thermoteknix
VisIR640 k$ 30k

China

SAT HR600 for
Research $k ?

Sweden

FLIR B620 for Building Inspection

Uncooled and Cooled Packaged Focal Plane Arrays

Below are International IR sensor fabricators. Within the industry they are well know. Quality and capacity continue to improve.

Additionally, there is evidence that UFPAs, based on Vanadium Oxide (VOX) are in a mature development and in pre-production in China. The Chinese Government has invested significant funding into the research and development of uncooled focal plane arrays as well cooled focal plane arrays. It has been very difficult to obtain specific data on the Chinese product however; it is very likely that a Chinese UFPA product will enter the market within the next couple of years.

SCD SemiConductor Devices (Israel)

www.scd.co.il

MWIR (cooled, InSb; 15, 20 and 25 micron pitch)

320x256
384x288
480x384
640x512
1280x1024
2048x16

LWIR (cooled, HgCdTe; 25 and 28 micron pitch)

288x4 480x6
384x288 (QWIP)

LWIR (uncooled, Vanadium Oxide; 17 and 25 micron pitch)

384x288
640x480

Dual band (MWIR and LWIR uncooled; Vanadium Oxide, 25 micron)

384x288
640x480

Reference

https://www.scd.co.il/dynamic-web.aspx?page id=15&parent id=0&pgnm=Detectors

ULIS (France)

www.ulis-ir.com

LWIR (uncooled, amorphous silicon; 17, 25 and 35 micron)

160x120

384x288
640x480
1024x768

Reference http://www.ulis-ir.com/index.php?infrared-detector=products

Sofradir (France)

www.sofradir.com

MWIR and LWIR HgCdTe (Pixel pitches: 15 – 30 microns)

* EPSILON MW 384 x 288
* JUPITER MW 1280 x 1024
* MARS LW 320 x 256
* MARS MW 320 x 256
* MARS SW 320 x 256
* MERCURY LW 480 x 6
* NEPTUNE SW 500 x 256
* PLUTON LW 288 x 4
* SATURN SW 1000 x 256
* SCORPIO MW 640 x 512
* URANUS MW 640 x 512
* VENUS LW 384 x 288

QWIP (25 micron)

* SIRIUS LW 640 x 512
* VEGA LW 384 x 288

Reference

http://www.sofradir.com/products/epsilon mw.htm

NEC (Japan)

Uncooled VOx 23.5 micron pixel pitch

Array Formats:
320x240
640x480

Reference

http://www.nec.co.jp/geo/en/products/hx0830.html
http://www.nec.co.jp/geo/en/products/hx3100.html

regime partner nations. Commercial Marine Seismic Equipment in 6A001 is avaible from companies located in Europe and China. Equivalent non-space qualified focal plane arrays in 6A002a2 and 6A002a3 are available from several European manufacturers. The cameras containing those focal plane arrays, 6A003b, are currently available world-wide from vendors in Europe, the Middle-East, the Pacific, and most notably China.

SITAC is concerned that STA may replace RPL. This will impede aftermarket service and support of restricted ECCN goods.

The enclosures and references related to foreign availability is information that the thermal imaging industry and SITAC have presented to BIS, DOD, and DDTC many times over the years. This data is real and relevant to the discussion of how to classify products in the Tier 1-3 process.

STA would be much more interesting and worth the investment to implement if 740.20(c)(2) destinations were allowed for Category 6 items. It isn't clear why items such as commercial focal plane arrays, cameras, and optical systems which are widely available from non-US sources would be restricted to the narrow list of countries in 740.20(c)(1).On another note,, creating a unique Destination Control Statement for this license exception will likely create costly export system change requirements, and create confusion for the overseas customer. The overseas customer, sales representative, and distributors who are re-exporting may realize he/she can use alternate US re-export license exceptions and thus be confused by the additional language and decide that **using US-sourced product is not worth the uncertainty and potential liabilities**. It is better to have fewer and distinctive license processes rather than a multitude of similar choices in order to avoid the need to analyze the subtleties of each situation.

The SITAC would like to thank the Department of Commerce for the opportunity to provide comments on Export Control Modernization and proposed license exception STA. This letter, enclosures, and references are made on behalf of the Sensors and Instrumentation Technical Advisory Committee.

Sincerely,

John Goodrich
SITAC Chairman

AVAILABILITY OF UNCOOLED THERMAL IMAGING CAMERAS IN CONTROLLED COUNTRIES

A Foreign Availability Report Certified by the Sensors and Instrumentation Technical Advisory Committee (SITAC)

Submitted to:
The Bureau of Industry and Security (BIS)

13 August 2008

TABLE OF CONTENTS

TABLE OF CONTENTS ii
1.0 INTRODUCTION 1
2.0 COMPANY PROFILE – Zhejiang Dali Technology Co., Ltd (DALI) 3
2.1 Overview 3
2.2 Camera Products – Availability in Fact From a Non-US Source 3
2.3 DALI Internal FPA Development Efforts 5
2.4 Market Availability – Sufficient Quantity 6
2.5 Key Data Points for Broader Export Efforts 6
2.6 DALI Camera Specifications and Capabilities – Comparable Quality 10
3.0 COMPANY PROFILE – Guangzhou SAT 11
3.1 Overview 11
3.2 Camera Products – Availability in Fact from a Non-US Source 11
3.3 Market Availability – Sufficient Quantity 13
3.4 Camera Specifications and Capabilities – Comparable Quality 15
4.0 COMPANY PROFILE – Wuhan Guide 17
4.1 Overview 17
4.2 Camera Products 18
4.3 Market Availability – Sufficient Quantity 19
4.4 Camera Specifications and Capabilities – Comparable Quality 19
5.0 COMPANY PROFILE – Wuhan Huazhong Numerical Control Co. Ltd. (HCNC) 21
5.1 Camera Products 22
5.2 Market Availability – Sufficient Quantity 23
5.3 Camera Specifications and Capabilities – Comparable Quality 23
6.0 COMPANY PROFILE – Nanjing Kuyee Tech 24
6.1 Camera Products 24
6.2 Market Availability – Sufficient Quantity 26
6.3 Camera Specifications and Capabilities – Comparable Quality 26
7.0 ANALYSIS OF CHINESE CAMERAS IN LIGHT OF CCL CONTROLS 27
7.1 Further Comment On Comparable Quality 32
8.0 SUMMARY AND CONCLUSION 34

APPENDIX A Zhejiang Dali Technology Co., Ltd (DALI)
APPENDIX B Guangzhou SAT
APPENDIX C Wuhan Guide
APPENDIX D Wuhan Huazhong Numerical Control Co. Ltd. (HCNC)
APPENDIX E Nanjing Kuyee Tech

AVAILABILITY OF UNCOOLED THERMAL IMAGING CAMERAS IN CONTROLLED COUNTRIES

A Foreign Availability Report Certified by the Sensors and Instrumentation Technical Advisory Committee (SITAC) Presented to the Bureau of Industry and Security (BIS)

1.0 INTRODUCTION

Over the past decade, US Government policy makers and American companies supplying commercial and dual-use thermal imaging products have become increasingly concerned and challenged by the rapid growth of foreign competition. An October 2006 report from the Office of Strategic Industries and Economic Security documented the decline in export sales by the US industry. In addition to the obvious negative effect on the economic health of an industry founded in the US, many have understood the critical link between the health of this industry and the national security. The Sensors and Instrumentation Technical Advisory Committee (SITAC) has considered this situation in many deliberations. Via this report, the SITAC will demonstrate the existence of foreign availability of similar technology as defined by and in accordance with Part 768 of the Export Administration Regulations and the Supplement thereto. This report is submitted to the Bureau of Industry and Security (BIS), with the certification of the SITAC, to assist BIS in and request a formal Decontrol Assessment of Commerce Control List 6A003.b.4.b as provided in Part 768.4

By way of this report the SITAC will demonstrate that uncooled, dual-use thermal imaging cameras, such as those controlled for National Security reasons by 6A003 of the Commerce Control List, are available-in-fact in a controlled country, from a non-US source and are of comparable quality to controlled US products. Further the SITAC will demonstrate that these products are available in sufficient quantity to render US National Security controls ineffective.

While it is very likely that products can flow freely from producing countries to essentially all of the controlled countries listed in Part 768.1, there are relatively few of the controlled countries that have the level of economic development and growth to consume large numbers of thermal cameras. Of this list Russia and China are, by far, the most significant economies. Russia, as a party to the Wassenaar Arrangement, is ambiguous in its applicability to the definition of "available-in-fact" cited in Part 768.1.d. Therefore the SITAC has elected to focus this study on foreign availability within the People's Republic of China.

With this scope defined the report will proceed to profile several Chinese thermal imaging companies and their products. By doing so the report will demonstrate that the four criteria of foreign availability as defined in Part 768.1 are met. The four criteria are listed below with commentary as to how the report seeks to demonstrate that the criteria are, in fact, met.

Available-in-fact. Evidence of indigenous production and active marketing within China will be shown. The evidence includes company marketing information as well as independently obtained photographic evidence showing that the products are quite real and readily available in the Chinese market.

Non-US source. The legitimacy of the Chinese companies profiled will be shown drawing information from independent sources such as credit rating agencies and securities analysts that supports the information provided by the companies themselves.

Sufficient quantity. The standard presented by Part 768 is that the products must be available from non-US sources in quantities that meet the needs of the Chinese military. Thus US exports to China would not make a significant contribution to the military potential of China. Stated more directly, the question to be addresses is 'can the Chinese military get an adequate supply of the subject products from its Chinese producers?' The SITAC does not have access to information on the purchases and needs of the Chinese military. However, the report will show that Chinese camera makers are actively selling their products in non-military markets. Further, it will show that these companies are marketing outside of China on an aggressive basis. With these facts the SITAC concludes that these products could not be so freely available on the commercial and international market if the Chinese military's funded need for similar products was not already met.

The presence of French focal plane array supplier ULIS in the Chinese market is a major factor in the quantity expansion there. Recent announcement by GE of an equity investment in ULIS included some market information declaring very dramatic growth and a large export contribution. Members of the SITAC have provided BIS with some analysis of likely ULIS export numbers to China under separate cover.

Comparable quality. The report will describe products marketed by the Chinese suppliers and provide specifications and attributes that compare them to US products within the context of characteristics specified in the Commerce Control List under 6A003. The characteristics of 6A003 cast a broad net for thermal imaging cameras and include relatively little distinction of performance thresholds. BIS is presently proposing adoption of new performance thresholds pertaining to pixel count and frame rate on 6A003 cameras. Where appropriate, comment may be made on how the Chinese cameras compare to the proposed control criteria.

2.0 COMPANY PROFILE – Zhejiang Dali Technology Co., Ltd (DALI)

639 Binkang Road, Hangzhou
P.R.CHINA, 310053
www.dali-tech.com

Chairman and CEO: Mr. Huimin Pang
B.S. in Physics, East China University
Former Managing Director of Jiangsu T&M Technology Institute

2.1 Overview

Developed from Zhejiang Testing Technology Institute affiliated to the Science and Technology Department of Chinese Government, Zhejiang Dali Technology Co., Ltd is an enterprise that specializes in scientific research, production and sales. They were the first company in Zhejiang Province to successfully re-organize from state control to a limited liability company. The company was listed on the China stock exchange in 2007. Among objectives for the capital infusion is funding of internal focal plane development. The Chairman and CEO, Mr. Pang owns 32% of the company's shares.

The company has two R&D centers in Shanghai and Hangzhou, with 30,000 square meters (323,000 ft^2) of manufacturing. **Figure 2-1** pictures Dali's Headquarters.

Figure 2-1. Dali's headquarters facility is one of two major facilities.

The company manufactures and sells complete uncooled FPA thermal imaging cameras as well as engines/modules to other manufacturers. DALI camera products are similar in design and characteristics with those offered by US manufacturers and specifications are competitive. Dali cameras clearly would fall under current EAR controls if exported from the US to foreign destinations.

Of particular note is DALI's very public development of their own FPA to vertically integrate and move away from sourcing from ULIS. This work was a key point of their positioning for a successful public stock offering.

2.2 Camera Products – Availability in Fact From a Non-US Source

DALI produces a range of products from camera cores to full-featured portable cameras that combine thermal cameras with visible cameras and lasers. **Table 1-1** shows photos of some of DALI's products and provides the model number and features of each as described by the company's product literature. Cameras are built in one of DALI's two locations using imported FPAs sourced from ULIS (France).

Table 1-1. Model listing, photos, and features of representative products. Descriptions come directly from DALI's English language website.

MODEL	*PHOTO*	*COMPANY DESCRIPTION*
TE		The TE IR camera is an extremely affordable hot spot finder thermograph camera. With unbelievable precise thermal image and high price & performance ratio, TE meets a wide variety of application requirement including electrical industry and field of metallurgy.
T6-S/P		T6 ultra portable thermal infrared camera, built-in world's most powerful infrared detector with 384x288 pixel array, offers unmatched temperature measurement accuracy and the best image quality. The particular 90 degree rotated 2.8" LCD enhance the image displaying functions. It is the ideal option to maintenance detection and other control applications.
DL700E/E+		DL700E/DL700E+ offers outstanding image quality and temperature measurement performance in an affordable, rugged and easy to use infrared camera. It works as a professional tool for engineer or thermographer adaptable to every situation.
DL700C/C+		DL700C/DL700C+ is a rugged, economical and practical IR camera, which allows to capture infrared and visual images in the field. Comb(in)ing with the intelligent DALI Report software, the camera is perfect solution for all infrared inspections especially in filed of Electrical industry and Metallurgy equipment detecting.

MODEL	PHOTO	COMPANY DESCRIPTION
DM60		DM60 thermal imaging camera is idea for condition monitoring with accurate temperature available. This system is perfect for process control and analysis, as well as security and surveillance applications which are difficult or impossible to capture the record by using conventional means such as normal infrared or visible light cameras. It also meets and exceeds needs in many applications including: research & development, electronic R&D, industrial process control, public safety, etc.
DL780		DL780 is an uncooled FPA thermal imaging module, applying in its design the (FPA) of ULIS France and real-time image processing circuits independently developed by DALI. It helps to reduce the hardness of independent development of thermal infrared system, shortening the developing period. This module meets a wide variety of IR imaging needs in many applications including medical research, electronic R&D, public safety and surveillance, etc.

2.3 DALI Internal FPA Development Efforts

DALI intends to use part of IPO proceeds (i.e. RMB 50.65 M) to continue to fund its Un-cooled Infrared Focal Plane Array Detector (UIFPAD) localization project. Dali started developing its UIFPAD in 2001 with the full intention of manufacturing in China and eliminating the need to purchase FPAs other sources. Dali has already developed a prototype of it's UIFPAD with 160X120 resolution (**Figure 2-2**). Pictures and production projections below in **Figures 2-3 and 2-4** are derived from the prospectus for Dali's initial public offering.

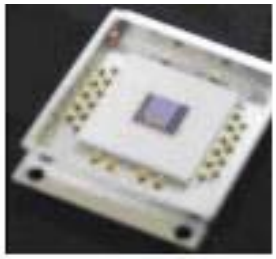
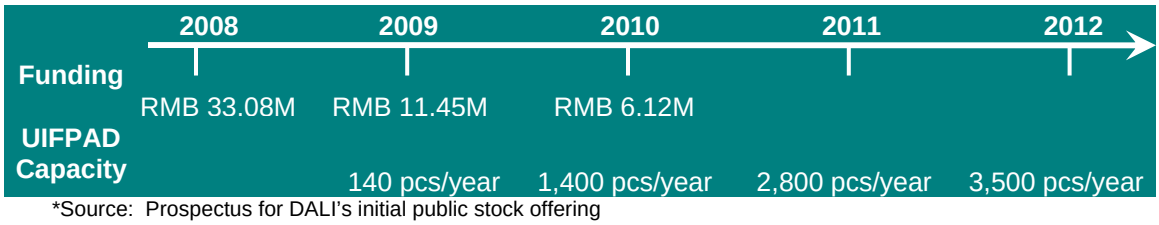


Figure 2-2. Prototype DALI FPA.

Figure 2-5 presents excerpts from a Dali sales presentation to an affiliate of a US company.



*Source: Prospectus for DALI's initial public stock offering

Figure 2-3. Expected UIFPAD yearly funding and production capacity.

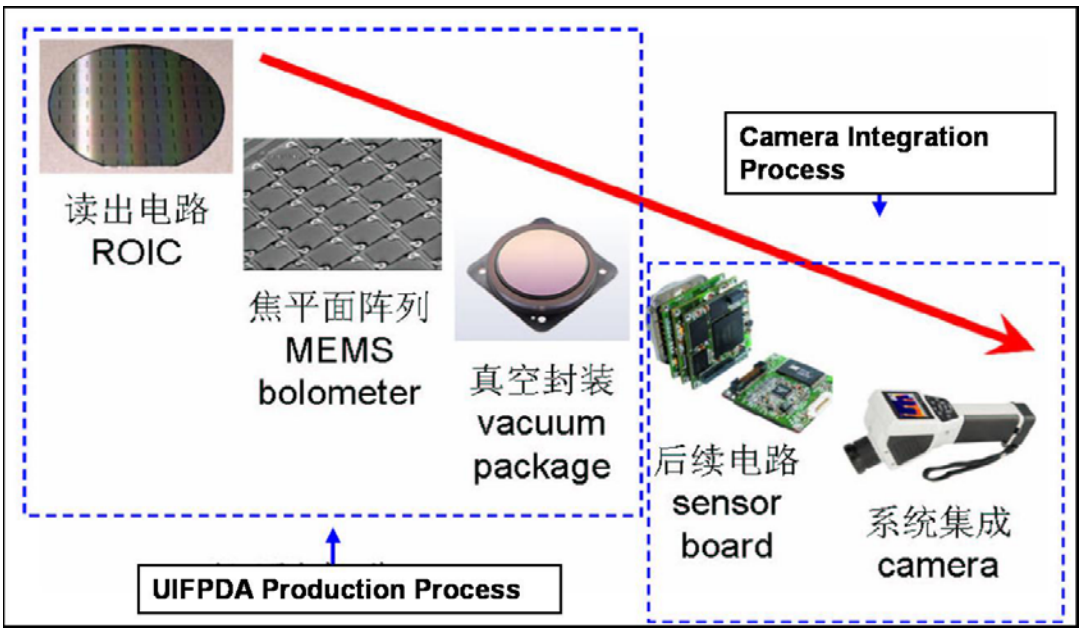


Figure 2-4. DALI's UIFPAD consists of ROIC, MEMS Bolometer & vacuum package.

Future Product R&D
In addition to the FPA development effort, stated product R&D efforts are:
- Real-time on-line thermal imager for process control. Prototype has been developed for electronics MFG and food processing
- Security monitoring thermal imager with high movement tracking capability. Application in border control, environmental monitoring and national security
- High capacity thermal imagers
  - High resolution, i.e. higher than 640X480. Design is already completed
  - Microscanning thermal imager
  - High-speed thermal imager, 100Hz has been developed and 200Hz is under-development
- Second-generation Firefighting thermal imager

Figure 2-5. Excerpts from a Dali sales presentation to an affiliate of a US company.

2.4 Market Availability – Sufficient Quantity

DALI markets its products in the US and other areas outside China and in multiple commercial markets indicating that DALI's production capability exceeds that needed to supply the Chinese military. Other aspects of the overall marketing presentation and product portfolio verify that a broad export market is being sought. Three specific distributors were located with a simple web search, two in the UK and one in Singapore.

2.5 Key Data Points for Broader Export Efforts

2.5.1 DALI Exhibits

DALI has exhibited at recent tradeshows in Orlando, FL, Birmingham, UK, and Las Vegas, NV (**Figure 2-6**).

Figure 2-6. Photos of displays at SPIE Show in Orlando.

2.5.2 DALI Website

DALI has an English language website to address the English-speaking world. **Figures 2-7 and 2-8** show examples of the website display.

Figure 2-7. Example of Dali website postings in English.

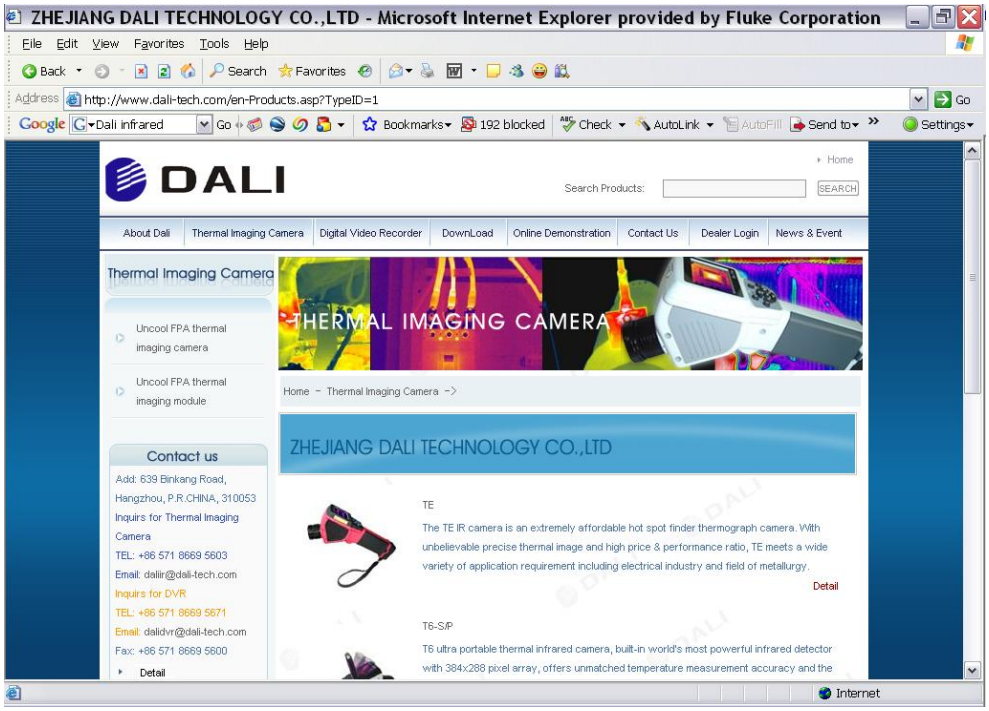


Figure 2-8. Another example of a DALI website posting.

*2.5.3 DALI "CE" Mark

Most DALI products carry the "CE" mark meaning they are targeted for European sales. DALI also proudly displays FCC compliance credentials (**Figure 2-9**) to support it sales in the US market.

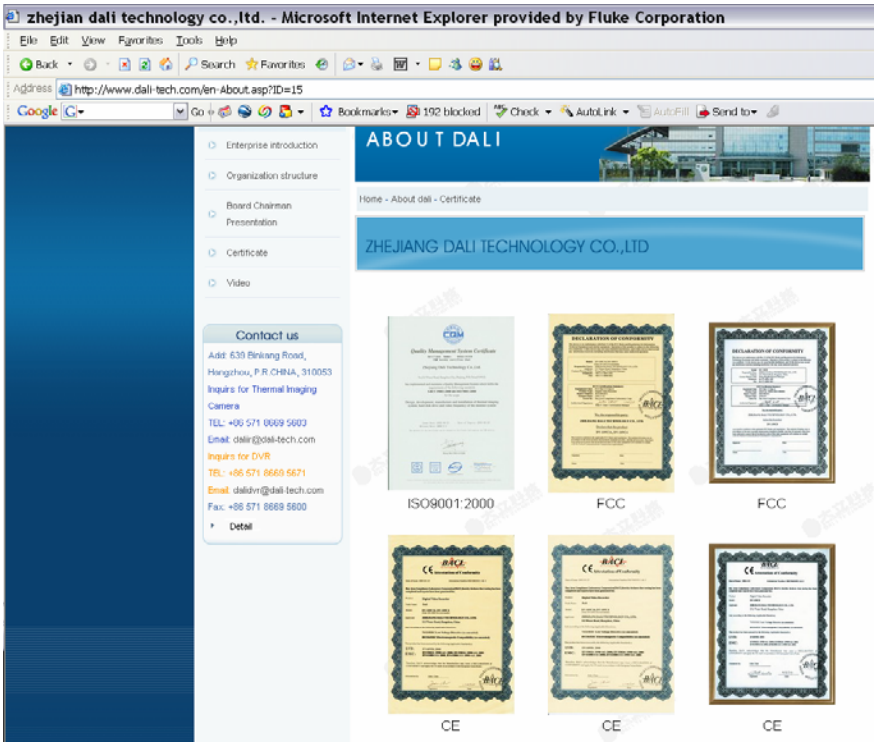


Figure 2-9. DALI proudly displays "CE" and "FCC"marks.

2.5.4 Export of DALI Products

DALI products are made available outside of China as illustrated in the examples below.

UK distributor – Barber Insys UK. From website (Figures 2-10and 2-11):
http://www.barber-insys.co.uk/themo/themog1.html

> A range of portable hand held thermal imaging cameras depending on the application requirements. The low cost TE unit suitable for plumbers/electricians, through to the T6 with enhanced detector size for building surveys or engineering applications requiring high image resolution at a reasonable cost. All the cameras are real time, therefore suitable for rotating machinery applications. **The cameras are fitted with European detectors and therefore not subject to US license regulations.**

Figure 2-10. Information from Barber Insys UK Website.

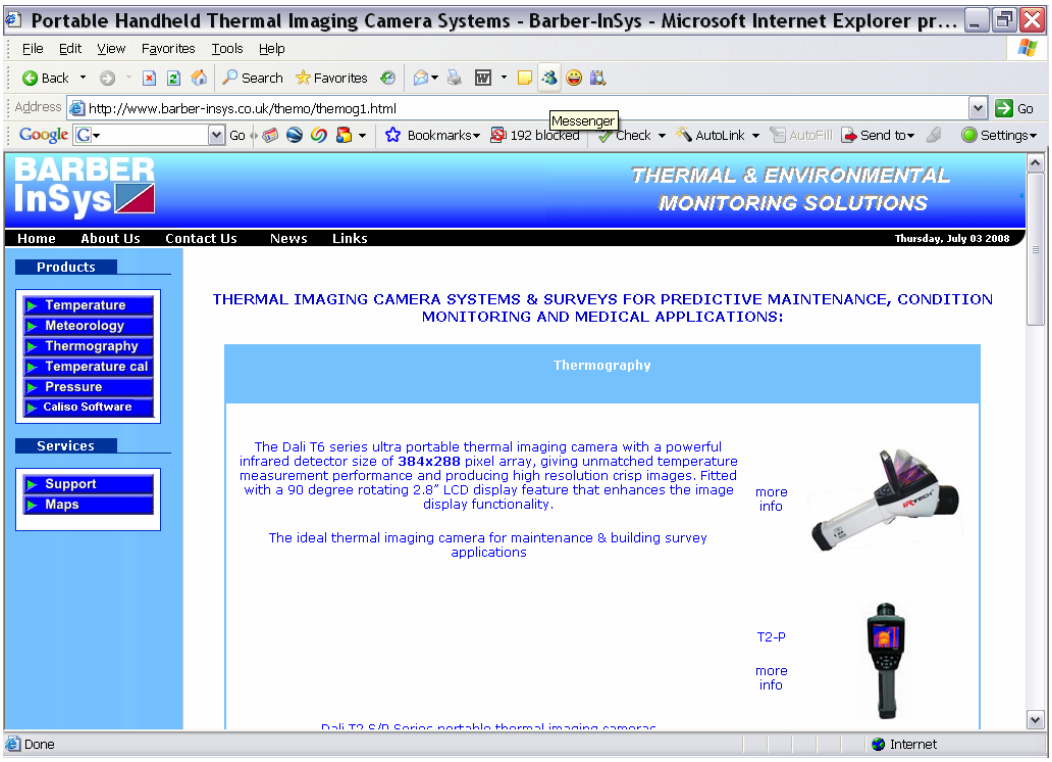


Figure 2-11. Example of display on Barber Insys UK website.

UK Distributor Metrum
http://www.metrum.co.uk/Dali_TE_Thermal_imaging_camera.htm

Figure 2-12 is an example of a UK Distributor Metrum website display.

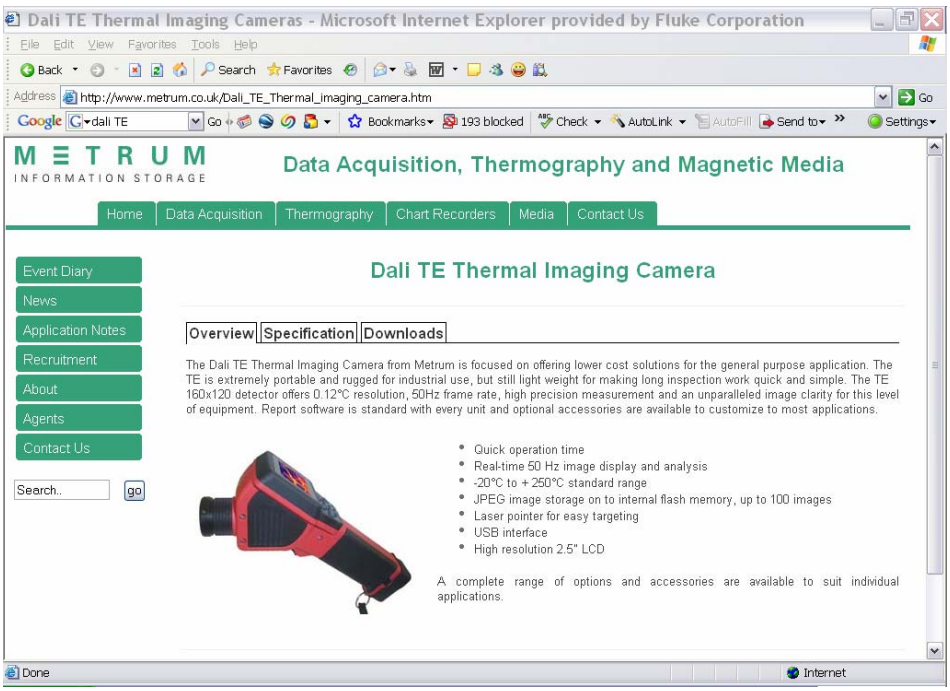


Figure 2-12. Website display from UK DISTRIBUTOR METRUM

2.6 DALI Camera Specifications and Capabilities – Comparable Quality

Appendix A includes English-language specification sheets on several products representative of the DALI line. A quick survey of the specifications will show these products to be of comparable quality to those currently controlled by the CCL. The characteristics of wavelength sensitivity and/or frame rate dictate that most of these products would be controlled under 6A003 of the CCL to all destinations except Canada if exported from the US. These products and those listed for other manufacturers all have sensitivity in the long wavelength infrared band around 8-12µm, a key parameter for control under the CCL. The final section of this report includes a table summarizing how these items would be controlled by current and pending US regulations if produced in the US or imported into the US for resale abroad.

3.0 COMPANY PROFILE – Guangzhou SAT

Guangzhou SAT Infrared Technology Co., Ltd.
No. 10 Dongjiang Avenue
Guangzhou Economic & Technological Development District
Guangzhou
China
510730
http://www.sat.com.cn/english
Jiping Wu, CEO

3.1 Overview

Guangzhou SAT Infrared Technology Co., Ltd. (SAT) claims 15 years experience in the thermal camera market and has grown to become a leading Chinese supplier of uncooled thermal cameras. SAT presents a market story through its website and literature that offers IR cameras, software and solutions in a variety of market areas including predictive maintenance, process and control monitoring, firefighting, border security and driving. The SAT marketing message is aimed largely at industrial and other civilian users. Products are marketed inside China and broadly outside of China. **Figure 3-1** shows portions of a SAT display during a China Electo-Optics Exposition. SAT aims to provide its customers with cameras, software and complete solutions. Camera products are similar in design and characteristics with those offered by US manufacturers and specifications are competitive. SAT cameras clearly would fall under current EAR controls if exported from the US to foreign destinations.

A recent Dunn & Bradstreet (D&B) Report cites seven domestic branch offices in addition to the headquarters operation. The same report grants SAT the lowest credit risk rating, a rating enjoyed by only 10% of industry peers.

SAT proudly touts its in-house design and development capabilities and associated achievements in securing intellectual property rights in China and abroad.

Figure 3-1. Scenes from the SAT display at the China Electro Optics Exposition in November 2007.

3.2 Camera Products – Availability in Fact from a Non-US Source

SAT IR produces a range of products from camera cores to full-featured portable cameras that combine thermal cameras with visible cameras and lasers. **Table 3-1** shows photos of representative SAT IR products and provides the model number and features of each. SAT provides cameras with some unique features including an explosion-proof version targeted for mining applications. SAT cameras have been demonstrated to DoD personnel at an industry meeting held in February 2002 and, more recently, shown as

exemplary of foreign production by Assistant Secretary Chris Padilla during testimony before Congress. Cameras are built in SAT's Guanzhou facility using imported FPAs. The relative value of the FPAs vs. camera market price is relatively large for the simplest cameras like the HY600 below but on the order of 10% - 15% of total value for the more full-featured products like the G90 that include multiple cameras as well as sophisticated electronic features.

Table 3-1 Model listing, photos, and features of representative SAT IR products.

MODEL	*PHOTO*	*FEATURES*
HY600		➢ IR camera core ➢ Serial digital communications ➢ 320 X 240 FPA ➢ Analog NTSC / PAL video out ➢ Digital video via USB 2.0
S160		➢ Small portable, rugged predictive maintenance camera ➢ 160 X 120 FPA ➢ Built-in display ➢ Thermographic / radiometric ➢ Laser pointer
GF3000A		➢ Portable IR camera for firefighting ➢ 160 X 120 FPA ➢ Submersible ➢ Large display
S280		➢ Full feature predictive maintenance camera ➢ 320 X 240 FPA ➢ Visible camera ➢ Flip out display plus viewfinder ➢ NTSC / PAL compatible ➢ Image capture and storage ➢ Integrated laser pointer

MODEL	PHOTO	FEATURES
G90		➢ Full feature predictive maintenance camera ➢ 320 X 240 FPA ➢ Visible camera, integrated laser pointer ➢ Flip out display plus viewfinder ➢ NTSC / PAL compatible ➢ Image capture and storage
SAT 618		➢ Quick installation automotive driving aid ➢ 384 X 288 resolution ➢ Full kit including display
MC602R		➢ Scientific camera ➢ 320 X 240 ➢ Variable frame rate

3.3 Market Availability – Sufficient Quantity

SAT markets its products in multiple areas outside China and in multiple commercial market segments indicating that SAT's production capability exceeds that needed to supply the Chinese military. For example, **Figure 3-2** shows a product display setup and personnel during a tradeshow in Birmingham, UK. SAT maintains a sales office for Southeast Asia and the Pacific located at the Guangzhou base. The above cited D&B Report claims export sales during 2003 to Europe, Latin America, Japan, Australia, and the US. The website also lists a sales office in India and a technical support operation in France. In the recent past, SAT products have been marketed in the US by ISG Thermal Systems with offices in Georgia, and Monroe Infrared with offices in Michigan and Maine. Other aspects of the overall marketing presentation and product portfolio verify that a broad export market is being sought.

Figure 3-2. SAT Display at a 2007 Tradeshow in Birmingham, UK

- SAT has an English language website to address the English-speaking world.

- Some SAT products carry the "CE" mark meaning they are targeted for European sales.
- Some SAT products have NTSC and PAL video output formats. The NTSC analog video standard is used in a relatively short list of countries, notably the US, Canada, Taiwan, Japan and South Korea.
- SAT's listing of recent tradeshow appearances includes events in Japan, the UK, France and Germany.

A notice on the SAT website regarding opening of a European Technical Center is shown in **Figure 3-3.**

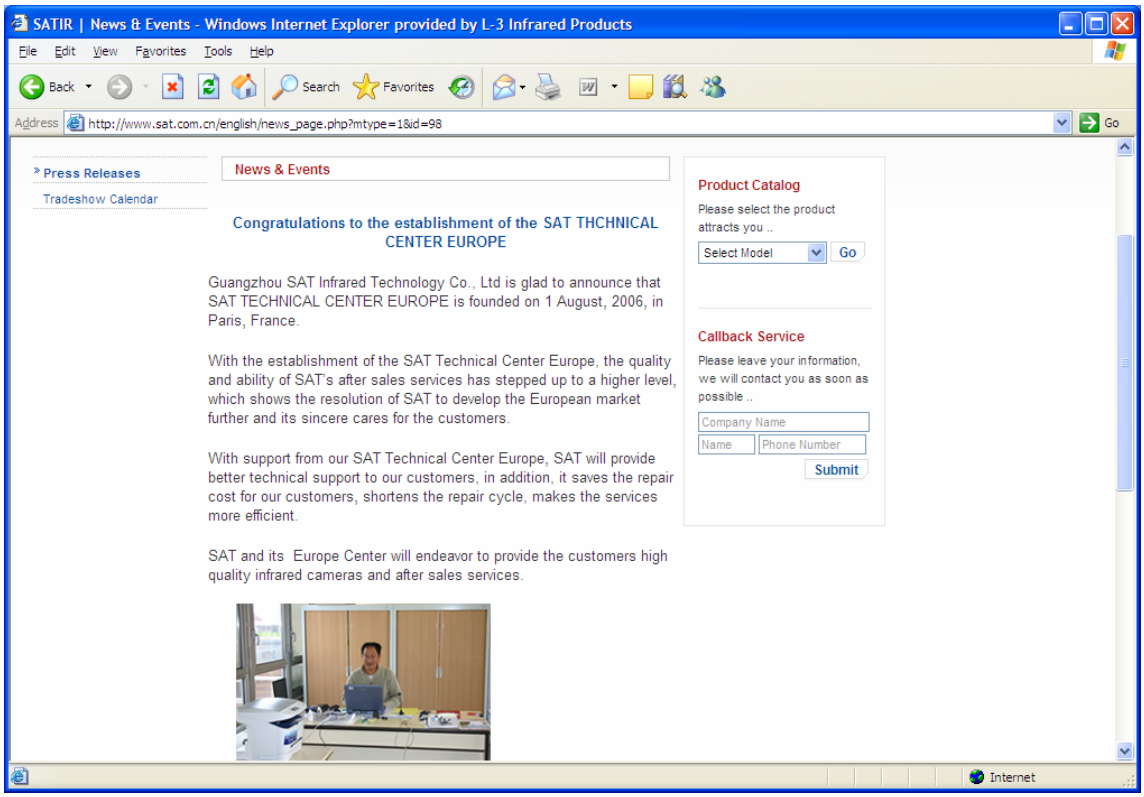


Figure 3-3. A notice on the SAT website regarding opening of a European Technical Center

Figure 3-4 is taken from a website for a company selling SAT products in Scandinavia.

Figure 3-4. Website Notice of a Scandinavian Distributor of SAT Products.

3.4 Camera Specifications and Capabilities – Comparable Quality

Appendix B includes English-language specification sheets on several products representative of the SAT line. A quick survey of the specifications will show these products to be of comparable quality to those currently controlled by the CCL. The characteristics of wavelength sensitivity and frame rate dictate that most of these products would be controlled under 6A003 of the CCL to all destinations except Canada if exported from the US. SATIR appears to be the first of the Chinese manufacturers to introduce a high resolution uncooled thermal camera using a 640X480 pixel FPA. This resolution is comparable to the state of the art in US military systems. To date, the US government has controlled products with comparable resolution as munitions items. **Figure 3.5** is a screenshot from the same Scandinavian distributor's web site touting the high resolution product. It should be noted that this product does not appear in this fashion on the SAT web site at this writing.

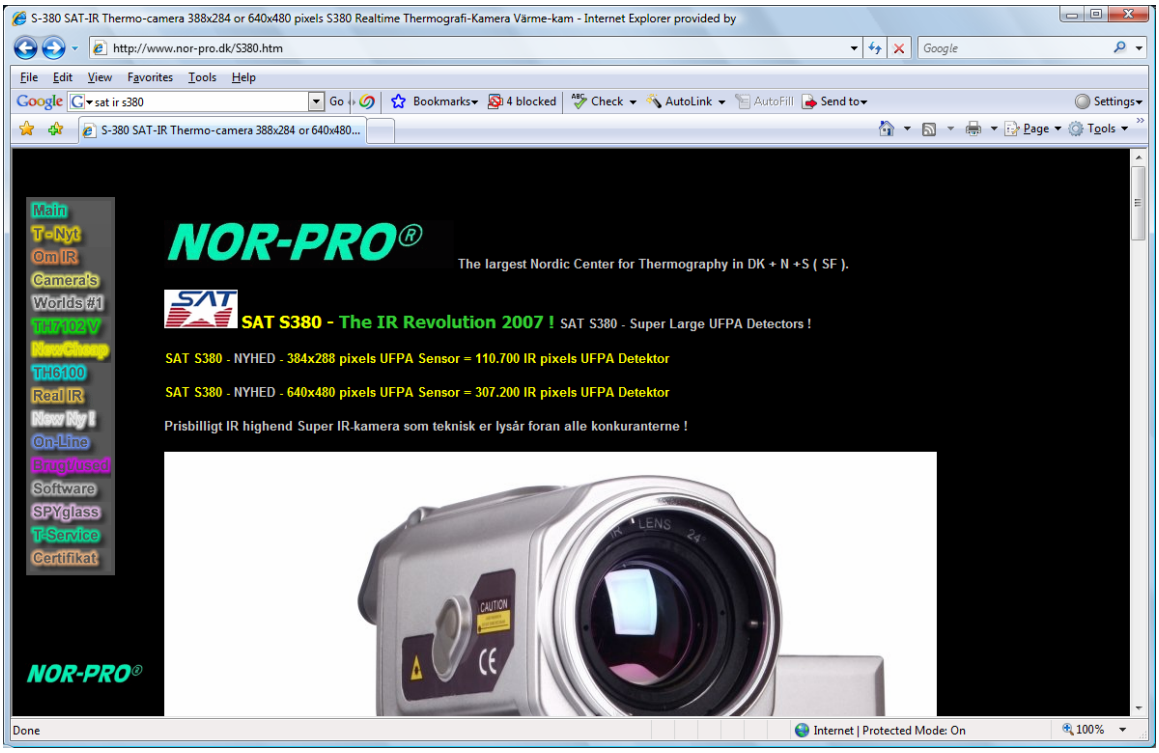


Figure 3-5. SAT's Scandinavian Distributor Announces S380 using a 640X480 FPA.

4.0 COMPANY PROFILE – Wuhan Guide

Wuhan Guide Infrared Company, Ltd
No.26 Shucheng RD.HongShan District
Wuhan 430070
P.R.China
http://www.guide-infrared.com/en/index_en.asp

4.1 Overview

Guide Group, located in the Wuhan-China Optics Valley, is a high-tech company specialized in the design, development, manufacturing, and sales of Infrared Thermal Imaging cameras, optics, accessories and test equipment. Wuhan Guide claims to be a pioneering enterprise in China independently developing infrared thermal imagers. Its newly developed products, Uncooled and Cooled Focal Plane Array infrared thermal imager IR series, with advanced technology and internally developed Intellectual Property, filled a void in China. Guide IR series have been listed under the National Torch Program and have been honored among National New Products in China. Guide products and manufacturing processes have received multiple certifications including ISO9001, CE Certificate, CMC Certificate, and Medical Equipment Manufacturing License and have been recognized as a result of the National Infrared Products Quality Examination. The first three of these are internationally recognized indications of a mature and capable product and/or business.

Guide products have been widely used for various end-uses such as electric power generation plants, firefighting, public security, metallurgy, medical, and petrochemical industry applications. Wuhan Guide is rapidly expanding its international marketing network and claims to cover more than 50 countries. Wuhan further claims to have developed strategic alliances with companies in the European Union, Asia, and the United States. Wuhan Guide has doubled its sales volume every year, becoming an important profit source of Guide Group. Wuhan Guide claims to be the leader in infrared technology application development and market share among its Chinese counterparts.

Many progressive Chinese companies have established business processes and company cultures modeled after US companies found in high tech business areas such as the Silicon Valley. Wuhan Guide counts itself among these and feels that it stands out from the typical Western impression of a Chinese manufacturing company. A high priority on quality, satisfaction and innovation are central to Guide's message. The company's profile on its web page includes the following company culture ideals and values (Guide's translation):

- *Create and maintain an environment that encourages new thinking on the part of all employees.*
- *Provide customers with products and services of consistently superior quality.*
- *Assure that all orders are delivered to customers complete and on time.*
- *Grasp latest trend of the industry by active learning and smooth communication with competitors and partners.*
- *Keep a positive, open-minded and patient culture that inspires individual employees to willingly contribute to the achievement of team goals while growing professionally and personally.*

4.2 Camera Products

Guide produces a wide range of products including camera cores and full-featured portable and hand-held cameras with visible cameras and lasers. Guide's product portfolio is broad and includes several models that have features common to military products. An example of the latter is the IR513 detailed below.

Guide created a stir in the thermal imaging world when it introduced a thermal camera in cell phone form factor around 2006. This demonstrated the ability of Chinese manufacturers with ready access to high-tech electronics to put together attractive and very competitive products given access to the basic thermal imaging technology. A sampling of some their products is provided in **Table 4-1**.

Table 4-1. Model listing, photos, and features of representative WUHAN GUIDE products.

MODEL	PHOTO	FEATURES
MobIR M3		➢ High performance, low price radiometric camera ➢ Ultra-compact ➢ Integrated alarming, hot-spot tracing & laser locating ➢ Digital image storage with voice recording ➢ USB connectivity
TP8S		➢ Radiometric camera ➢ 384X288 pixel, 35µm uncooled FPA ➢ Detachable touch screen ➢ Intelligent auto speech control of the camera ➢ Bluetooth voice recording technology ➢ High-resolution 640×480 OLED viewfinder & 1280×1024 visual camera
IR112		➢ 384X288 uncooled FPA OEM module ➢ Rugged, compact and lightweight ➢ High resolution, high sensitivity and high accuracy ➢ Mass produced

MODEL	PHOTO	FEATURES
Thermal Goggle GUIDIR ®IR528		➢ Helmet-mounted or handheld ➢ 160X120 FPA ➢ <300 g ➢ Instant on imaging ➢ Spot temperature measurement
GUIDIR IR513		➢ Long range handheld ➢ IR, GPS, Laser range finder, day optics, compass ➢ 384X288 uncooled FPA ➢ 5.5º HFOV IR lens

4.3 Market Availability – Sufficient Quantity

Wuhan Guide markets its products in 50 countries outside of China in multiple market segments indicating that Wuhan's production capacity exceeds that needed to supply the Chinese military. The images in **Figure 4-1** below show Wuhan Guide's tradeshow booth from an Electro-Optics Exposition held in Beijing in November 2007. The display featured the range of Guide products including an array of military-like products in helmet-mounted and weapon-mountable configurations. Guide's product descriptions on the website such as for the MobIR M3 proudly proclaim "license free & rapid delivery".

4.4 Camera Specifications and Capabilities – Comparable Quality

Appendix C includes English-language specification sheets on several products representative of the Guide line. The characteristics of wavelength sensitivity and/or frame rate dictate that most of these products would be controlled under 6A003 of the CCL to all destinations except Canada if exported from the US. The final section of this report includes a table summarizing how these items would be controlled by current and pending US regulations if produced in the US.

A quick survey of the specifications in Appendix C will show these products to be of comparable quality to those currently controlled by the CCL

The MobIR product is sold in the US by Sierra Pacific Innovations as the RazIR. The website below promotes these sales and features a video product testimonial from a satisfied user.

http://raz-ir.com/news/models/raz-ir-pro.html

Guide uncooled long-range handheld imager with 388X244 ULIS FPA

Guide IR595, 384X288 ULIS FPA with 150mm lens, military packaging

Array of Guide IR thermal weapon sights using 25um ULIS FPAs

Figure 4-1. Views of Wuhan Guide's tradeshow booth from an Electro-Optics Exposition held in Beijing in November 2007

.

5.0 COMPANY PROFILE – Wuhan Huazhong Numerical Control Co. Ltd. (HCNC)

H.U.S.T Park,Miaoshan Region,
East-lake Development Zone,
Wuhan, Hubei, P.R.China 430223
+86-27-87180051
+86-27-87180306 fax
http://www.huazhongcnc.com/
http://english.huazhongcnc.com.cn/
Chairman: Chen Jihong, born 1965

Wuhan Huazhong Numerical Control Co. Ltd. (HCNC) is located in Wuhan, about 300 miles to the east of Shanghai. Wuhan is also the location for Wuhan Guide Infrared, another well-known infrared thermography company and camera manufacturer. As its name implies, HCNC was founded in 1994 as a company to manufacture high-precision CNC machining instruments. It works closely with the Huazhong University of Science and Technology (HUST) which setup the CNC National Engineering Research Center with support from the Ministry of Science and Technology (MOST). HCNC has been selling their CNC machines on the worldwide market, including the US, Latin America, and southeast Asia. HCNC touts its highly educated staff citing "30-odd professors and 60-odd employees with master's degrees or doctorate".

Over the years, HCNC has received $24 million worth of contracts from the Chinese government and developed an extensive network of sales and training centers within China. Their modern headquarter buildings in Wuhan cover 11,600 square meters of space **(Figure 5-1)** and are located in the Science and Technology park of HUST. The company counts a staff of 260 skilled engineers and technicians and prides itself on innovation and research spending. It is one of the portfolio companies of HUST VC, a venture-capital firm located in Wuhan with focus on optics and 1.1B RMB ($134M) in funds.

More recently, the company decided to expand into infrared products. Its proximity to the Wuhan Optical Valley and funding from HUST VC were likely contributors to that expansion. Wuhan Optical Valley is well-known for its established optoelectronics and fiber-optic industries. The company now offers a series of infrared imaging products spanning the full size spectrum of handheld to desktop.

Figure 5-1. Photographs of the headquarter building of HCNC and one of their manufacturing lines.

5.1 Camera Products

The company offers on their website five families of infrared cameras (**Table 5-1**) focused on industrial thermography, medical thermography, remote monitoring, night vision, and surveillance. A few of HCNC's product specifications make reference to FPAs sourced from the US. During the investigation for this report, a third party inquiry with the company resulted in similar claims by HCNC. With all other companies' products profiled here, the FPA source is either claimed to be ULIS, determined through inquiry to be ULIS, or is gleaned to be ULIS by virtue of the specifications and descriptions cited.

Table 5-1. HCNC offers five families of infrared cameras focused on industrial thermography, medical thermography, remote monitoring, night vision, and surveillance

MODEL	PHOTO	FEATURES
HY-1088		➢ 160x120 pixels microbolometer UFPA ➢ Portable, rugged, 400 grams. ➢ Night vision (8 to 14 micrometer) ➢ Built-in display, 2.5 in LCD ➢ NTSC/PAL ➢ Battery life > 10 hours
HY-3088G		➢ 320x240 pixels, microbolometer UFPA ➢ States that UFPA sourced from USA ➢ 25 Hz ➢ 8 to 14 micrometer wavelength range ➢ Thermographic/radiometric ➢ Build-in display, 3.5 in LCD ➢ 17 x 14 degree field of view
HY-2005		➢ Same specs as HY-3088B but adapted for medical and clinical purposes.
HY-5800		➢ Dual visible and infrared surveillance camera. ➢ 320x240 UFPA ➢ 50/60 Hz.
HY-5000		➢ Scientific infrared camera with similar specs to the 3088B series but with USB connectivity to a PC.

5.2 Market Availability – Sufficient Quantity

HCNC has no obvious presence in the US or Europe. It markets and sells its cameras in China and, possibly, other portions of Asia. However, they have an English-language website that details their products and specifications indicating aspirations to pursue other geographic markets. Provision of both NTSC and PAL video formats also indicates aspirations to sell to markets outside China. Finally the HY-3088G camera includes both Chinese and English control menus. The products advertised on the HCNC website are largely commercial in nature, further demonstrating that there is ample capacity in Chinese industry to serve needs outside those of the Chinese military.

A description of the company by HUST VC on their website (**Figure 5-2**) indicates that the company has a well established sales, marketing and post-sales operations (see below). The large manufacturing floor of the company and the size of its employee population suggests that its only limiting factor on camera production is the availability of the UFPA from the US or Europe. It is unknown whether the company is engaged with UFPA development efforts within the Wuhan Optical Valley.

Infrared thermography system: independent IP focal plane thermography systems. They are widely used in industries of electricity power, chemicals, metallurgy, and army supplies.

HCNC has a sales, marketing and post-sale service team with technical background, among which 80% are holding bachelor's degree or above. Dozens of employees with bachelor and doctor degrees are serving for R&D of the company.

In 2005, HCNC was awarded as the Innovative Enterprise, and Software Enterprise of Excellence of Hubei province. In August 2006, HCNC was listed in 103 Innovative Example and Test Enterprises by the Ministry of Science & Technology, State-owned Assets Supervision and Administration Commission of the State Council, and All China Federation of Trade Unions.

Figure 5-2. HUST VC website posting with a description of HCNC.

5.3 Camera Specifications and Capabilities – Comparable Quality

Appendix D includes English-language specification sheets on several products representative of the HCNC line. A quick survey of the specifications will show these products to be of comparable quality to those currently controlled by the CCL. The characteristics of wavelength sensitivity and/or frame rate dictate that most of these products would be controlled under 6A003 of the CCL to all destinations except Canada if exported from the US. The final section of this report includes a table summarizing how these items would be controlled by current and pending US regulations if produced in the US.

6.0 COMPANY PROFILE – Nanjing Kuyee Tech

No 301 Room, 168 Longpan Road,
Jiangsu Software Park 53,
Nanjing, China
+ 86-25-84660588
+ 86-25-84660599 Fax
http://www.kuyee.cn

Nanjing Kuyee Technology Co., Ltd. (Kuyee) is an optoelectronics company located in Nanjing, about 100 miles east of Shanghai. It lists itself as a company that focuses upon the development, manufacturing and marketing of infrared cameras for medical diagnostics, security, fire fighting, electrical utilities, petrochemical, aviation, defense and scientific applications. It numbers 50 to 100 employees, making it the smallest of the companies profiled here. It claims it was founded in 2006, and has about 100,000 square meters (nearly a million sq. ft.) of manufacturing and R&D space. In a survey published by the European Commission external cooperation office, the company lists its interest in finding sales and marketing channels for its products (**Table 6-1**).

Table 6-1. Survey highlighting the types of cooperation priorities for Nanjing Kuyee. (*1* is highest, and *4* is lowest).

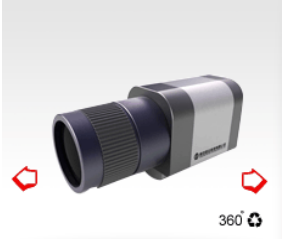
	Priority Ranking			
	1	*2*	*3*	*4*
Joint Venture				X
Investment				X
Export	X			
Import		X		
Distribution in China	X			
Distribution in Europe			X	
Technology Transfer				X
Transfer of Know How				X
Manufacturing	X			
Sell Components		X		
Buy Components		X		

The company has been exhibiting in tradeshows in China. The next exhibit for the company will be ILOPE (International Lasers, Optoelectronics and Photonics Exhibition) in Beijing, China, 25-27 November 2008.

6.1 Camera Products

The company offers multiple uncooled thermal cameras on their website, as depicted **Table 6-2**. All appear pointed to commercial applications. Resolutions range from 160x120 to 384X288 with frame rates of up to 50 Hz or better, varying primarily by the packaging and software. The core specifications are very similar indicating that they derive from the same camera engines. Kuyee also sells what it calls camera cores under part numbers C20 and C30.

Table 6-2. Nanjing Kuyee Technology Co., Ltd. (Kuyee) uncooled thermal cameras offered on their website.

MODEL	PHOTO	FEATURES
Checker K10		➢ 160x120 pixels microbolometer FPA ➢ Portable, rugged, water-proof design ➢ Thermographic/radiometric ➢ Built-in display ➢ 50 Hz
Checker K20		➢ 320x240 pixels, microbolometer FPA ➢ Dual-vision visible CCD ➢ Portable, rugged, water-proof design ➢ Thermographic/radiometric ➢ Built-in display ➢ 50 Hz operation ➢ 21 x 15.5 degree field of view
Inspector K26		➢ 320x240 uncooled FPA ➢ Suitable for fixed operation ➢ PAL video output
Groper A20		➢ 320X240 uncooled FPA ➢ Mountable on a tripod. ➢ Conceived for automotive application
Core C30		➢ 384X288 uncooled FPA ➢ 16-bit digital video interface ➢ Temperature measurement ➢ PAL output
Firefinder F20		➢ 320X240 firefighting camera ➢ 5” display

MODEL	PHOTO	FEATURES
Monitor N20		➢ 320X240 uncooled FPA ➢ Packaging adapted to fixed applications
Gy601		➢ 320X240 uncooled FPA ➢ Medical imaging software ➢ Temperature measurement

6.2 Market Availability – Sufficient Quantity

In the past few months, Kuyee went from no presence on the website, to a cryptic presence to a good website in Chinese and English that highlights products, contact and other relevant commercial information. Without a doubt, they are increasing their marketing activities reaching out to a broader audience. They are visible on the European Commission ASIA Invest website as well as the Made-In-China.com website that promotes products manufactured in China. The company is increasing their presence at tradeshows with initial emphasis on China and an eye on export to other geographies. Having said this, Kuyee remains the least sophisticated in its marketing message to non-Chinese markets of the companies profiled here. The company's sales channels appear to be limited at this time to the Chinese market.

In researching this report, the company was contacted by telephone through a third party fluent in Chinese. Kuyee indicated that the products are available immediately and provided an asking price of $15,000 to $20,000 for their Checker K20 product. The imported FPA content is estimated to be no more than 10% of that value.

6.3 Camera Specifications and Capabilities – Comparable Quality

Appendix E includes English-language specification sheets on several products representative of the Kuyee line. A quick survey of the specifications will show these products to be of comparable quality to those currently controlled by the CCL. The characteristics of wavelength sensitivity and/or frame rate dictate that most of these products would be controlled under 6A003 of the CCL to all destinations except Canada if exported from the US. The final section of this report includes a table summarizing how these items would be controlled by current and pending US regulations if produced in the US.

7.0 ANALYSIS OF CHINESE CAMERAS IN LIGHT OF CCL CONTROLS

The primary reasoning in the Commerce Control List (CCL) for control of similar products is the wavelength at which the FPAs are sensitive or have their peak response. Specific parameters called out in 6A002.a.3.c and 6A002.a.3.f capture all cameras in this report on this basis. Some exception is made for certain automotive system cameras or for cameras with relatively slow frame rates. Thus, frame rate is established as a distinguishing control factor in the CCL. A proposed change to the CCL, first published BIS in April of 2006 and still pending at this writing, mirrors some past Wassenaar Expert Group discussions by introducing resolution or pixel count as a basis for graduated controls. These parameters are commonly used to compare camera performance.

The table that forms the bulk of this section (**Table 7-1**) is a highly representative if not comprehensive listing of products offered by the companies profiled earlier in the report. It lists key technical specifications of each product as they relate to parameters that have been either adopted or considered for adoption as threshold criteria in the Wassenaar Dual-use Control List and, thus, the CCL. These parameters and associated values are then used to suggest how these products would be controlled for export from the US by the current CCL.

In the right-most column, it is suggested how these products would be controlled for export from the US if a proposed change to the CCL were to be published. This proposed ruling is sometimes known as the "RS Proposal". In the two right-most columns, the control criterion from the CCL that would be most restrictive, that is to say, require a license to the most destinations, is listed as the "dominant control".

As Table 7-1 shows, were these products manufactured by US companies and proposed for export markets, all would be tightly controlled under US export regulations. Further all will remain under fairly restrictive control, even if the pending BIS proposal is implemented. In effect, the table demonstrates in summary form that the test of comparable quality is met time and time again.

Table 7-1. Analysis of Chinese Cameras in Light of CCL Language

Manufacturer	Product		Key Control Attributes	Dominant Control Under CCL as of 7/1/08	Dominant Control Under Proposed "RS" Revision
Zhejiang Dali	DL700E		384X288, 50/60 Hz	RS1	RS2
	DL700C		384X288, 50/60 Hz	RS1	RS2
	T6-S/P		384X288, 50/60 Hz	RS1	RS2
	TE		160X120, 50 Hz	RS1	NS2
	DL780		384X288, 50/60 Hz	RS1	RS2
	F2		160X120, 50 Hz	RS1	NS2
	S730		384X288, 50 Hz	RS1	RS2

Manufacturer	Product		Key Control Attributes	Dominant Control Under CCL as of 7/1/08	Dominant Control Under Proposed "RS" Revision
	DM60		384X288, 50/60 Hz	RS1	RS2
SAT IR	HY600		320X240, 50/60 Hz	RS1	RS2
	S160		160X120	RS1	NS2
	GF3000A		160X120	RS1	NS2
	S280		320X240, 50/60 Hz	RS1	RS2
	S380		640X480 50/60 Hz	*ITAR*	*ITAR*
	G80		320X240, 50/60 Hz	RS1	RS2

Manufacturer	Product		Key Control Attributes	Dominant Control Under CCL as of 7/1/08	Dominant Control Under Proposed "RS" Revision
	SAT618		384X288	RS1	RS2
	MC602R		320X240, 50/60 Hz	RS1	RS2
	HY6800		320X240, 50/60 Hz	RS1	RS2
Wuhan Guide	MobIR M Series		160X120, 50/60 Hz	RS1	NS2
	TP8S		384X288	RS1	RS2
	IR112		384X288	RS1	RS2
	IR210		320X240	RS1	RS2
	IR510		320X240, 50/60 Hz	RS1	RS2
	IR513		384X288	RS1	RS2

Manufacturer	Product		Key Control Attributes	Dominant Control Under CCL as of 7/1/08	Dominant Control Under Proposed "RS" Revision
	IR516		320X240, 50/60Hz	RS1	RS2
	IR519		348X288	RS1	RS2
	IR528		160X120, 50/60 Hz	RS1	NS2
Wuhan Huazhong Numerical Control Co. Ltd.	HY-3088G		320X240, 25 Hz	RS1	RS2
	HY-1088A		160X120	RS1	NS2
	HY-1088B		320X240	RS1	RS2
	HY-5800		320X240. 50/60 Hz	RS1	RS2
Nanjing Kuyee Tech	A20		320X240, 50 Hz	RS1	RS2
	C20		320X240, 50Hz	RS1	RS2

Manufacturer	Product		Key Control Attributes	Dominant Control Under CCL as of 7/1/08	Dominant Control Under Proposed "RS" Revision
	C30		384X288	RS1	RS2
	F20		320X240, 50 Hz	RS1	RS2
	Gy603		320X240, 50 Hz	RS1	RS2
	K10		160X120, 50 Hz	RS1	NS2
	K20		320X240, 50 Hz	RS1	RS2
	K26		320X240, 50 Hz	RS1	RS2
	N20		320X240, 50 Hz	RS1	RS2

7.1 Further Comment On Comparable Quality

As outlined earlier in this section, frame rate and pixel count are often used as comparisons of quality and performance. They were used in the table above because of their relationship to control language and because they are widely published parameters on specification sheets. Resolution of the Chinese cameras studied is comparable to cameras from US manufacturers that are controlled on the CCL with one notable exception shown in the table above. The SATIR S380 has a 640X480 sensor. To date, the US has taken the position that all cameras using sensors of this resolution are munitions (ITAR) items.

Another frequently published performance parameter is thermal sensitivity, often specified as Noise Equivalent Temperature Difference (NETD). There are variations among products in this parameter. Most commercially available products will be listed as

0.1ºC or better. The products described here are consistent with this. There are many US products with larger NETD numbers (lower sensitivity) that are exported and are tightly controlled. In short, the CCL does not distinguish based on this performance parameter and it appears that the Chinese cameras described herein are quite comparable to those of their US counterparts.

More recently, US Military programs have placed emphasis on the response time of thermal detectors. This is sometimes referred to as thermal time constant. While this is rarely specified for commercial products it is an area in which the FPAs from Ulis in France have a superior performance to US products. For example, the US Army is currently developing its next generation of uncooled FPAs and requiring time constants of <10msec. This represents an aggressive goal vs. current generation performance. Ulis FPAs are often specified to have <7msec time constants. This high performance specification is cited in at least one product shown in an appendix to this report, the Dali DL720.

8.0 SUMMARY AND CONCLUSION

This report provides compelling evidence to initiate a determination of foreign availability of thermal imaging cameras in China, a controlled country per Part 768.1 of the EAR. The information contained herein serves to compile and document information that should already be well known to concerned government regulators that have paid attention to the development of this technology and market in recent years. US regulators have seen and held cameras at meetings with industry. Those who have attended trade shows and conferences have seen these products and noted their proliferation. Repeatedly presentations and discussions in industry / government forums have stressed the growth of Chinese camera makers. In fact, it is expected that knowledgeable readers of this report will find nothing truly new here but may be assisted by its assemblage into one document that specifically addresses the construct of Part 768.

Thermal imaging cameras such as those controlled under the CCL have been shown to be readily available in China from Chinese manufacturers. The quantities of these cameras have been shown to be sufficient so as to be widely available for commercial uses and export indicating large excess beyond the needs of the Chinese military. Cameras have been shown to be of comparable or better technical capability and quality to those controlled by the CCL. There should be no doubt that the criteria of Part 768 are demonstrated time and time again.

By certifying this report, the SITAC urges BIS to pursue the process of foreign availability determination to its statutory conclusion.

APPENDICES TO:

AVAILABILITY OF UNCOOLED THERMAL IMAGING CAMERAS IN CONTROLLED COUNTRIES

A Foreign Availability Report Certified by the Sensors and Instrumentation Technical Advisory Committee (SITAC)

Presented to:
The Bureau of Industry and Security (BIS)

LIST OF APPENDICES

APPENDIX A **Zhejiang DALI Technology Co., Ltd (DALI)**

APPENDIX B **Guangzhou SAT**

APPENDIX C **Wuhan Guide**

APPENDIX D **Wuhan Huazhong Numerical Control Co. Ltd. (HCNC)**

APPENDIX E **Nanjing Kuyee Tech**

APPENDIX A

Zhejiang Dali Technology Co., Ltd (DALI)

ENGLISH-LANGUAGE SPECIFICATION SHEETS ON SEVERAL PRODUCTS REPRESENTATIVE OF THE DALI LINE

Contact us

Add: 639 Binkang Road

Hangzhou, P.R.CHINA,

310053

Inquirs for Thermal Imaging

Camera

TEL: +86 571 8669 5603

Email: daliir@dali-tech.com

Inquirs for DVR

TEL: +86 571 8669 5671

Email: dalidvr@dali-tech.com

Fax: +86 571 8669 5600

Detail

Home - Thermal Imaging Camera ->

ZHEJIANG DALI TECHNOLOGY CO.,LTD

DL720 Series

OVERVIEW

DL780 is an uncooled FPA infrared imaging module, applying in its design the of ULIS France and real-time image processing circuits independently developed by DALI. It helps to reduce the hardness of independent development of thermal infrared system, shortening the developing period. This module meets a wide variety of IR imaging needs in many applications including medical research, electronic R&D, public safety and surveillance, etc.

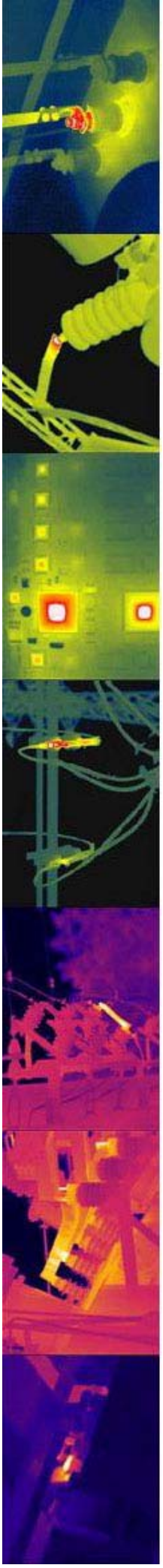
MAIN FEATURES

The auto temperature constancy ensures, under the different ambient temperature between -40□~60□, a constant operating temperature for detector, ensuring its working stability.
The function of real time noise reduction contributes to reducing the noise shown on the background, producing out an enhanced image of target.
Manual correction
Manual brightness/contract adjustment
Auto brightness adjustment
Numerical 2×
Color swap
Sight
Motor drive for lens adjust
Standard PAL video output
16bit digital video data output

TECHNICAL SPECIFICATIONS

Detector	
Material	Amorphous silicon
Thermal time constant	7 ms
Resolution	384×288
Pixel size	35μm×35μm
Spectral range	8 ~ 14μm
NETD	≤85mK
Module	
A/D	14bit
D/A	10bit
Start-up time	<45s（nearly 25s@-30□，25s@25□，40s@50□）
Power	7.5 ~ 9V
Video output	PAL
Focus drive	8V 10 mA
Power consumption	<2.2W(Normal)
Operating temperature	-20□ ~ +50□(Commercial) -40□ ~ +60□(industrial)
Storage temperature	-40□ ~ 70□

T2 Series
THERMAL IMAGING INFRARED CAMERA
Low Cost affordable solution



Features:

- ✓ State-of-art thermal imaging camera with all necessary functions for industrial use
- ✓ Ergonomic lightweight and portable
- ✓ Real-time 50Hz image display and analysis
- ✓ Three types of temperature units available (^{0}C, K, ^{0}F)
- ✓ 40 sec voice annotation with the image *(depending on models)*
- ✓ Built-in laser pointer for easy target locating
- ✓ Powerful and easy-to-use full function thermal image software to support analysis work and creating reports

T2-E

T2-P / T2-S

Detect hot spots, diagnose condition of electrical components to prevent failure due to heat built-up and increase product reliability.

Early detection of faulty and poor electrical connections, fuses, circuit breakers, wirings - enhances productivity and averts unscheduled system shutdowns.

For enquiry, please contact:

Hi-Tech Electronics Pte Ltd
60 Kaki Bukit Place, Unit 01-11 Eunos Techpark, Singapore 415979
Tel : (+65) 67472555 Fax : (+65) 6747 2511
Email: sales@hitech.com.sg Website: www.hitech.com.sg

T2 Series
THERMAL IMAGING INFRARED CAMERA
Low Cost affordable solution

Technical Specifications

Model:			T2-E	T2-S	T2-P
Detector characteristics	Detector type		Amorphous Silicon micro-bolometer		
	Array size/format, Pixel Pitch		160 x 120, 35um		
Imaging characteristics	Field of view/min focus distance		18°×13°/0.3m (std)	18°×13°/0.3m (std) 36°×26°/0.3m (3609)	18°×13°/0.3m (std) 36°×26°/0.3m (3609)
	Spatial resolution (IFOV)		1.9mrad		
	Thermal sensitivity		0.1^{0}C @30^{0}C		
	Frame rate		50/60Hz		
	Focus		Manual		
	Electronic Zoom		NO		2X
	Spectral range		8-14um		
Built-in Optic Lens			STD Lens	STD Lens	STD Lens or 3609 (2x) lens
Image display	LCD		Built-in high-resolution color 2.5" LCD		
Measurement	Temperature ranges		-20℃ to +250^{0}C	-20℃ to **+500^{0}C**	-20℃ to **+250^{0}C** **Extendable to +1000^{0}C**
	Accuracy		± 2 °C or ± 2% of reading, Whichever is greater		
	Measurement correction		Automatic / Manual		
	Measurement mode	Movable spots	1	1	4
		Movable areas	NO	1	3
		Area Max/Min temperature	NO	YES	YES
		Area average temp.	NO	YES	YES
		Line Profile	NO	NO	YES
		Isotherms	NO	YES	YES
		Temp. difference	NO	NO	YES
		Alarm (Voice, color)	NO	YES	YES
	Image Controls	Color palette	3	8	11
		Image adjustment	Auto gain and brightness	Auto / manual gain and brightness	
	Setup functions		Date / Time, temperature unit, language		
	Emissivity correction		Variable from 0.1 to 1.0		
	Ambient temperature correction		Automatic corrections according to user input		
	Atmospheric transmission correction		NO	Automatic correction according to user object distance, relative humidity, ambient temperature	
Image storage	Type	Storage card	Built-in flash memory, up to 100 images	Built-in flash memory, Up to 1000 images	
		Storage mode	Manual single image saving	Automatic/manual single image saving	
	File format-thermal		JPEG, 14 bit thermal image with measurement data		
	Voice annotation		NO	Input via built-in microphone up to 40 seconds of digital voice per image stored with image	
Laser pointer			Class 2, 1mw/635nm(red)		
Power supply	Battery type		Li-Ion, rechargeable, field-replaceable		
	Battery operating time		3 hours continuous operation		
	Charging system		Intelligent charger or power supply adaptor(optional), online charge		
	Power saving		Automatic shutdown and sleep mode (user-selectable)		
	External power		NO	10-15V DC	
Environment	Operating temperature		-15^{0}C to +50^{0}C		
	Humidity		≤90%non-condensing		
	Encapsulation		IP54		
Physical characteristics	Dimensions, Weight		250mm×100mm×72mm, 0.6Kg		
Interface	External DC input		NO	YES	
	Audio output		NO	YES	
	Video output		NO	PAL/NTSC	
	USB		YES		
Standard Accessories			Thermal Imaging camera, Carrying case, Lens cap, Li-Ion batteries (2), Charger, USB cable, Adumbral cover, Operator's manual, Dali Image Explorer, Dali Infrared Reporter	Thermal Imaging camera, Carrying case, Lens cap, Li-Ion batteries(2), Charger, Earphone, USB cable, Adumbral cover, Video cable, Audio adaptor cable, Operator's manual, Dali Image Explorer, Dali Infrared Reporter	Thermal Imaging camera, Carrying case, Lens cap, Li-Ion batteries(2), Charger, Earphone, USB cable, Adumbral cover, Video cable, Audio adaptor cable, Operator's manual, Dali Image Explorer, Dali Infrared Reporter
Optional Accessories				Power supply adaptor, 3X Lens, 0.5X Lens	Power supply adaptor, 3X Lens, 0.5X Lens, 1000^{0}C extendable lens

Hi-Tech Electronics Pte Ltd
60 Kaki Bukit Place, Unit 01-11 Eunos Techpark, Singapore 415979 Tel : (+65) 67472555 Fax : (+65) 6747 2511
Email: sales@hitech.com.sg Website: www.hitech.com.sg

DL700 Series
THERMAL IMAGING INFRARED CAMERA
High Performance – Auto Focus

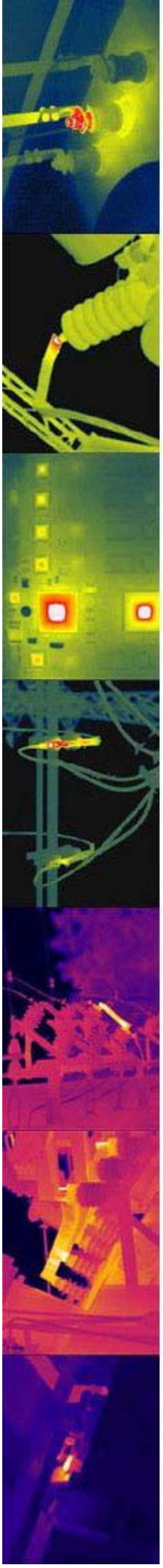
Features:

- ✓ High speed DSP real time image processing for a well defined and stable infrared thermal images
- ✓ Advanced world standard temperature measurement technology
- ✓ Auto-Focus, Full Screen LCD
- ✓ Continuous 8x digital zooming
- ✓ 300,000 pixels CCD picture display
- ✓ 640 x 480 pixels LCD screen
- ✓ NTSC / PAL Video or VGA output
- ✓ Up to 1200 degree C temperature sensing
- ✓ 40 sec voice annotation with the image
- ✓ Built-in laser pointer
- ✓ IP54 water and dust resistant
- ✓ Built-in 64MB Flash and extendable CF card memory slot
- ✓ Powerful and easy-to-use full function thermal image software to support analysis work and creating reports

DL700 Series

Detect hot spots, diagnose condition of electrical components to prevent failure due to heat built-up and increase product reliability.

Early detection of faulty and poor electrical connections, fuses, circuit breakers, wirings - enhances productivity and averts unscheduled system shutdowns.



For enquiry, please contact:

Hi-Tech Electronics Pte Ltd
60 Kaki Bukit Place, Unit 01-11 Eunos Techpark, Singapore 415979
Tel : (+65) 67472555 Fax : (+65) 6747 2511
Email: sales@hitech.com.sg Website: www.hitech.com.sg

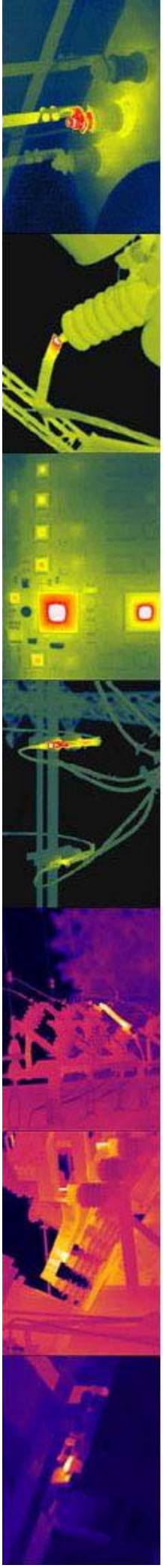
DL700 Series
THERMAL IMAGING INFRARED CAMERA
High Performance – Auto Focus

Technical Specifications

Model:			DL700C	DL700E	DL700C+	DL700E+
Detector characteristics	Detector type		Amorphous Silicon micro-bolometer, uncooled			
	Array size/format, Pixel Pitch		320 x 240, 45um		384 x 288, 35um	
Imaging characteristics	Field of view/min focus distance		20°×15°/0.5m		16°×12°/0.5m	
	Spatial resolution (IFOV)		1.13mrad		0.88mrad	
	Thermal sensitivity		0.08^{0}C @30^{0}C			
	Frame rate		50/60Hz			
	Focus		Manual	Manual / Automatic	Manual	Manual / Automatic
	Electronic zoom		1 – 8x continuous			
	Spectral range		8-14um			
	Built-in Visual camera		300,000 pixels, Pic in Pic or FULL			
Image display	LCD		High-resolution color LCD, 640 x 480			
Measurement	Temperature ranges		-20℃- +500^{0}C, Extendable to +1,200^{0}C *(optional)*			
	Accuracy		± 2 °C or ± 2% of reading, Whichever is greater			
	Measurement correction		Automatic / Manual			
	Measurement mode	Movable spots	4	10	10	10
		Movable areas	3	5	5	5
		Area Max/Min temperature	YES			
		Area average temperature	YES			
		Line Profile	YES			
		Isotherms	YES			
		Temp. difference	YES			
		Alarm (Voice, color)	YES			
	Color palette		11			
	Image adjustment		Auto / manual gain and brightness			
	Setup functions		Date / Time, temperature unit, language			
	Emissivity correction		Variable from 0.1 to 1.0 or select from listings in pre-defined material list			
	Ambient temperature correction		Automatic corrections according to user input			
	Atmospheric transmission correction		Automatic correction according to user object distance, relative humidity, ambient temperature			
Image storage	Type	Storage card	Built-in 64MB Flash memory, COMPACT FLASH memory slot, Up to 3000 images			
		Storage mode	Automatic/manual single image saving			
	File format-thermal		JPEG, 14 bit thermal image with measurement data			
	Voice annotation		Input via built-in microphone up to 40 seconds of digital voice per image stored with image			
	Image Improvement		Averaging (Σ2, Σ4, Σ8, Σ16) image spatial filter			
Laser pointer			Class 2, 1mw/635nm(red)			
Power supply	Battery type		Li-Ion, rechargeable			
	Battery operating time		2 hours continuous operation			
	Charging system		Intelligent charger or power supply adaptor(optional) online charge			
	Power saving		YES			
	External power		10-15V DC			
Environment	Operating temperature		-15^{0}C to +50^{0}C			
	Humidity		≤90％non-condensing			
	Encapsulation		IP54			
Physical characteristics	Dimensions		305mm×130mm×135mm			
	Weight		1.83Kg	1.69 kg	1.83Kg	1.69 kg
Interface	External DC input		Yes			
	Audio & Video output		Yes, PAL/NTSC			
	USB		Image (thermal and visual), measurement data and voice transfer to PC			
Standard Accessories			Thermal Imaging camera, Carrying case, Lens cap, Li-Ion batteries(2), Charger, LCD Bracket, LCD cable, Earphone, Audio cable, VGA cable, USB cable, 1G CF card, Shoulder strap, CD Card Reader, Operator's Manual, Dali Image Explorer, Dali Infrared Reporter			
Optional Accessories			Power supply adaptor, 2X Lens, 0.5X Lens			

Hi-Tech Electronics Pte Ltd
60 Kaki Bukit Place, Unit 01-11 Eunos Techpark, Singapore 415979 Tel : (+65) 67472555 Fax : (+65) 6747 2511
Email: sales@hitech.com.sg Website: www.hitech.com.sg

T6 Series
THERMAL IMAGING INFRARED CAMERA
High Resolution Razor-sharp thermal images



Features:

- ✓ Ergonomic lightweight and portable
- ✓ High resolution 384 x 288 pixels detector
- ✓ 2.8 inch LCD rotatable screen with brightness and gain adjustment
- ✓ Precise temperature measurement with thermal sensitivity of 0.1°C
- ✓ 40 sec voice annotation with the image
- ✓ Built-in laser pointer
- ✓ 1-GB Flash memory, store up to 3,000 thermal images along with voice annotation
- ✓ Powerful and easy-to-use full function thermal image software to support analysis work and creating reports

Detect hot spots, diagnose condition of electrical components to prevent failure due to heat built-up and increase product reliability.

Early detection of faulty and poor electrical connections, fuses, circuit breakers, wirings – enhances productivity and averts unscheduled system shutdowns.

For enquiry, please contact:

Hi-Tech Electronics Pte Ltd
60 Kaki Bukit Place, Unit 01-11 Eunos Techpark, Singapore 415979
Tel : (+65) 67472555 Fax : (+65) 6747 2511
Email: sales@hitech.com.sg Website: www.hitech.com.sg

T6 Series
THERMAL IMAGING INFRARED CAMERA
High Resolution Razor-sharp thermal images

Technical Specifications

Model:			T6-S	T6-P
Detector characteristics	Detector type		Amorphous Silicon micro-bolometer	
	Array size/format, Pixel Pitch		384×288, 35um	
Imaging characteristics	Field of view/min focus distance		16°×12°/0.5m	
	Spatial resolution (IFOV)		0.88mrad	
	Thermal sensitivity		0.1℃@30℃	
	Frame rate		50/60Hz	
	Focus		Manual	
	Electronic zoom		N/A	2x
	Spectral range		8-14um	
Image display	LCD		Built-in high-resolution color 2.8” LCD	
Measurement	Temperature ranges		-20℃- +500℃	
	Accuracy		± 2 °C or ± 2% of reading, Whichever is greater	
	Measurement correction		Automatic / Manual	
	Measurement mode	Movable spots	1	4
		Movable areas	1	3
		Area Max/Min temperature	YES	YES
		Area average temperature	YES	YES
		Line Profile	N/A	YES
		Isotherms	YES	YES
		Temp. difference	N/A	YES
		Alarm (Voice, color)	YES	YES
	Color palette		8	11
	Image adjustment		Auto / manual gain and brightness	
	Setup functions		Date / Time, temperature unit, language	
	Emissivity correction		Variable from 0.1 to 1.0	
	Ambient temperature correction		Automatic corrections according to user input	
	Atmospheric transmission correction		Automatic correction according to user object distance, relative humidity, ambient temperature	
Image storage	Type	Storage card	Built-in 1G flash memory, , Up to 3000 images	
		Storage mode	Manual single image saving	Automatic/manual single image saving
	File format-thermal		JPEG, 14 bit thermal image with measurement data	
	Voice annotation		Input via built-in microphone up to 40 seconds of digital voice per image stored with image	
Laser pointer			Class 2, 1mw/635nm(red)	
Power supply	Battery type		Li-Ion, rechargeable	
	Battery operating time		3 hours continuous operation	
	Charging system		Intelligent charger or power supply adaptor(optional) online charge	
	Power saving		YES	
	External power		10-15V DC	
Environment	Operating temperature		-15℃-+50℃	
	Humidity		≤90％non-condensing	
	Encapsulation		IP54	
Physical characteristics	Dimensions, Weight		310mm×127mm×90mm, 0.91Kg	
Interface	External DC input		Yes	
	Audio & Video output		Yes, PAL/NTSC	
	USB		Image, measurement data and voice transfer to PC	

Standard Accessories

Thermal Imaging camera, Carrying case, Lens cap, Li-Ion batteries(2), Charger, Earphone, Adumbral cover, USB cable, Video cable, Operator’s manual, Dali Image Explorer, Dali Infrared Reporter

Optional Accessories

Power supply adaptor, Car charge cable, Convertible lens 8.6°×6.4°/1.5m

Hi-Tech Electronics Pte Ltd
60 Kaki Bukit Place, Unit 01-11 Eunos Techpark, Singapore 415979 Tel : (+65) 67472555 Fax : (+65) 6747 2511
Email: sales@hitech.com.sg Website: www.hitech.com.sg

APPENDIX B

Guangzhou SAT

ENGLISH-LANGUAGE SPECIFICATION SHEETS ON SEVERAL PRODUCTS REPRESENTATIVE OF THE SAT LINE

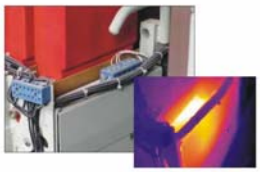
SAT-S160

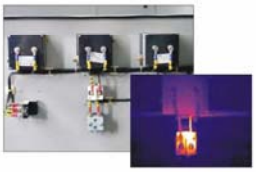
Based on the excellent 160x120 UFPA detector, the super compact IR camera SAT-S160 can meet your need with low-cost, precise measurement, easy-to-use, laser pointer, dual-screen display, and so on.

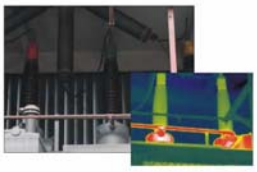
SAT INFRARED

The New Millennial Pioneer in Infrared Cameras

- **Rugged and Ergonomic Construction, Easy to Use**
- **Point & Shoot**
- **Precision Direct Temperature Measurement**
- **Dual Display**
- **Uncooled Focal Plane Array Technology**
- **Temperature Tracking**
- **Semitransparent Menu and Automatic Power-Off**
- **Laser Pointer**
- **USB Image Download**
- **Smart Power Management**







Description	Characteristics	Performance
Detector	Type	Microbolometer UFPA
	Spectral range	8 ~14 micron
	Resolution	160 x 120
Imaging Performance	NETD	0.1°C
	Lens / focusing	20°x 15°manual focusing
	Min focus distance	0.1m
Image presentation	Video output	Pal / NTSC
	Image display	2.5" color LCD, pseudocolor, multi-palettes
Features	Image freeze	Run or freeze
	Image function	Open and delete
Measurement	Temperature range	-20~250°C (standard); -40 ~ 1000°C (extendable)
	Accuracy	±2°C or ±2%
Analysis Functions	Spot	4 Spots：3 of them are Full-screened moveable
	Temperature tracking	Tracking the highest or lowest temperature spot automatically in the whole image
	Temperature Alarm	Preset the alarm temperature value and camera will show alarm when over or below it; Beep when alert.
	Adjustment	Level and span can be adjusted automatically or manually.
	Correction	Emissivity, distance, environmental temperature, relative humidity
Software	Analysis software	Report generation software
Laser	Power consumption	1 mw
	Wavelength	635 nm (red)
System	Settings	Time, date, °C or °F, Multi-language
	LCD power save	Automatically or User-Defined
	Power supply	SONY 7.2V Lithium battery, 8 ~ 11V DC supply
	Power-Off	Automatically or User-Defined
	BWT	About 2 hours
Environmental specification	Operational temperature	-20°C ~ 50°C
	Storage temperature	-40°C ~ 70°C
	Relative humidity	20 ~ 90%
Interfaces	Mechanism	Standard tripod mounting (Optional)
	Electric	USB, Video output
Physical Characteristics	Weight	< 700g (including the battery)

SAT INFRARED

GUANGZHOU SAT INFRARED TECHNOLOGY CO.,LTD.
No.10 Dongjiang Avenue,Guangzhou Economic &
Technological Development District ,Guangzhou,China.
Zip:510730
Tel:8620-82229925(MKT) 8620-82227955(Service)
Fax:8620-82227947
http://www.sat.com.cn
E-mail: sat@sat.com.cn

SAT-618

Vehicle-mount Thermal Imager

Survey shows that the distance or time spent on the driving during the night takes up only 28% of the total driving; however, the death rate caused by the accidents occurred during the night driving takes up 55% of the whole death rate.

With the concerns to the safety of lives, SATIR has lately launched a new night vision system for the night driving, which greatly enhanced the safety of the night driving, establishing another milestone for the night driving safety technology.

By simply turning on the power of the car-load thermal imager, the night vision system will be started up. With the attached LCD display, drivers can see the obstacle of 100 meters away, so that they can recognize the path, pedestrian, motorcycle, and other obstacle etc. This night vision system can also reduce the stress brought about to the drivers by the exhausted night journey, enabling them to keep alert and take proper action to respond to the emergency.

SAT-618

Mount

Click

Plug

Specification

Description	Parameter
Detector	UFPA
Resolution	384 x 288 Pixels
Wave	8 to 14 micron
FOV	40°X 30°
Image Settings	Brightness, Contrast, Digital zoom,
	Image noise reduction
Power Supply	Cigarette Lighter

The vehicle-mount thermal imager is encapsulated with metal housing, completely in line with the IP54 standard, and it is firmed and durable.

GUANGZHOU SAT INFRARED TECHNOLOGY CO.,LTD
Phone: +8620-82229925
Fax: +8620-82227947
Http://www.sat.com.cn
E-mail:sat@sat.com.cn

GF3000A

Based on the years of developing experience and technology of IR cameras of Guangzhou SAT Infrared Technology LTD, SAT introduces the new generation fire fighting uncooled IR camera SAT-GF3000A. It adopts the UFPA 160X120 detector and integrates advanced electronic technology, detector technology and IR image processing technology. It will play a great role in fire fighting and saving lives of human being.

SAT INFRARED

GF3000A

::Specification::

Physical Characteristics:

Weight	≤1.25Kg（with battery）
Dimensions	175x119x125mm
Color	Red or Yellow

Infrared Characteristics:

Detector	α-Silicon, UFPA Micro Bolometer
Pixel	160X120
Spectral range	8～14um
Focus	0.5m to infinity
NETD	≤120mk
FOV	38°
Spatial resolution	4.1mrad

Electrical Characteristics:

Video Standard	PAL/NTSC
Battery Technology	Rechargeable NiMH
RechargeCycles	1000+
Rechargetime	2.5 Hours (nominal)
Battery life	≥2 hours.

Environmental Characteristics:

Shock	30g
Vibration	3g
Drop	1.8m
Water resistance	IP67, 1.0m(3'3") depth
Burning arrestment	UL94-V0
Operating temperature	-20℃ ~ +55℃ long time working 55℃ ~ 430℃, short periods

1.Detector

High definition UFPA detector can provides excellent resolution, rapid refresh rate, and wide dynamic range. Even in widely varying temperature environments, the camera can make thermal images.

2.Mechanical

The camera is light and small which can be hold by one hand for a long time. The design of both sides handle allows firefighters can use the camera by each hand comfortably for the natural movements, such as crawling, standing, overhead, etc.

3.Features and configuration

1)The NiMh battery can provide over 2 hours uninterrupted operation;

2)With less than 15 seconds startup time, GF3000A can be available on time;

3)With the IP67 encapsulation, GF3000A can works properly after imersing in one meter deep water for about 30 minutes;

4.Display function

1)GF3000A is equipped selectable pseudo-color palettes to optimize the display image for different scenario.

2)With the large size TFT LCD screen, GF3000A can provides excellent infrared images for the operator.

SAT INFRARED

GUANGZHOU SAT INFRARED TECHNOLOGY CO.,LTD

Phone: +8620-82229925
Fax: +8620-82227947
Http://www.sat.com.an
E-mail:sat@sat.com.cn

SAT-HY6800

The SAT-HY6800 is a high performance infrared camera, embedded with the complete processing and analysis functions such as multi-spot measurement, temperature tracking and alarm, isothermal, line and area analysis. Firstly-introduced at SPIE2002, the SAT-HY6800 is now involved in the wide range of IR imaging applications all over the world.

SAT INFRARED

The New Millennial Pioneer in Infrared Cameras

Uncooled FPA detector and high definition image

Integration design and easy operation

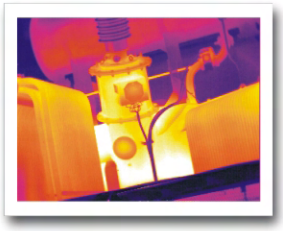
Record over 500 digital image in 128M PCMCIA card

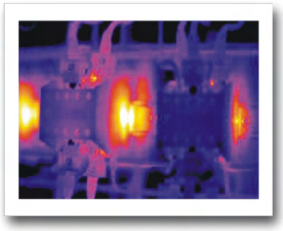
16-second testing voice annotation for each image

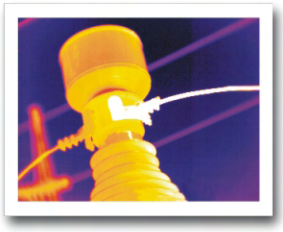
Powerful analysis and processing functions

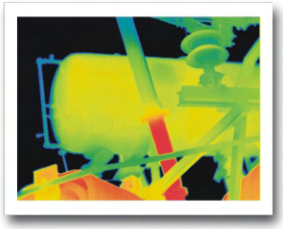
High reliability and solid structure

Smart battery system









SAT-HY6800 Technical Specifications

Description	Characteristics	Performance
Detector	Type	Microbolometer UFPA
	Spectral range	8-14μm
	Resolution	320 x 240
Imaging Performance	NETD	0.08℃ at 30℃
	Lens / focusing	24° x 18° ;motor focusing
	Spectral resolution	1.3 mrad(for24° lens)
	Min focusing distance	0.3m
	Frame rate	50Hz PAL/ 60Hz NTSC, non-interlaced
Image presentation	Video output	Pal / NTSC (optional)
	Image display	256 level, Black/White and pseudocolor
Features	Image freeze	Run or freeze
	Image storage	500 pcs /128M Flash card (Image and sound)
Measurement	Temperature range	-20-600°C, Standard; -40-2000°C, extendable
	Accuracy	±2°C or ±2%
Analysis Functions	Multi-Spot	Four spots analyzed in the meantime
	Temperature capture	highest or lowest temperature
	Line analysis	Analyze temperature distribution on the line
	Area analysis	Analyze temperature distribution in the area
	Parameter	Emissivity, ambience temperature, relative humidity and distance
	Isothermal	Display the same temperature area in sharp color
	Temperature Alarm	When the max or min temperature is highter or lower than the preset walue
	Voice annotation	16-seconds voice annotation can be saved within each image
	Adjustment	Level, gain and color span can be adjusted
	Quad-image display	Display four images in the meantime
	Image zooming	zoom in and zoom out (up to 8x)
Software	Analysis software	Report generation software
Environmental specification	Operational temperature	-20℃ ~ 50℃
	Storage temperature	-40℃ ~ 70℃
	Encapsulation	IP54
	Vibration	2.5G
	Shock	25G
Physical Characteristics	Weight	<1.7 Kg (including battery)
	Size (L x W x H)	200mm x 105mm x 110mm (camera only)

SAT INFRARED

GUANGZHOU SAT INFRARED TECHNOLOGY CO.,LTD.
No.10 Dongjiang Avenue,Guangzhou Economic &
Technological Development District ,Guangzhou,China.
Zip:510730
Tel:8620-82229925(MKT) 8620-82227955(Service)
Fax:8620-82227947
http://www.sat.com.cn
E-mail: sat@sat.com.cn

SAT-S280

Upright style infrared camera

UPRIGHT DUAL DISPLAY 4 IN 1

With over 10-year engineering experiences, SAT-IR introduces the innovative upright style infrared cameras (world patent pending). Design with the professional in mind, the S280 IR camera features powerful analysis tools, dual display, laser pointer, visual camera, and it is an ideal tool for predictive maintenance and various measurement and control applications.

Upright style
S series

Specifications (Preliminary Version)

Thermal	Field of view / min. focus distance	24° X18° /0.26m
	Spatial resolution (IFOV)	1.3mrad
	Thermal sensitivity	80mK@30℃
	Frame rate	50/60Hz non-interlaced
	Focus	Manual
	Digital zoom	1x-8x (0.1 increment)
	Detector type	Focal Plane Array (FPA), uncooled microbolometer 320x240 pixels
	Spectral range	8 to 14μm
Visual	Build-in digital camera	640x480 pixels, full color
	PIP	6 modes
LCD display	Viewfinder	Built-in, 640X480 color LCD (TFT)
	LCD display	320X240 color LCD (TFT)
	PIP	6 modes
Measurement	Measurement range	-20℃ to +500℃, (-4°F to +932°F),Up to 1500℃(2732°F) or +2000℃(3632°F), optional
	Accuracy	±2℃, ±2% of reading
Measurement mode	Spot	(up to 10 movable), manual or automatic placement
	Area	5 movable area, reading of max., min. and average temperature within area
	Isotherm	5 modes
	Line profile	Horizontal or vertical profile
	Emissivity correction	Variable from 0.01 to 1.00, automatic correction based on user input
	Measurement correction	Automatic, based on user input for ambient temperature, distance, relative humidity
Image storage	Memory	Built-in flash memory,128MB
Formats	Thermal image	SAT format, 14 bit measurement data included
	Visual image	CCD format
	Voice annotation	Input via headset up to 40 sec. of digital voice "clip" stored with thermal image
	Text annotation	Predefined by user and stored with image
Laser pointer	Classification	Class 2, red
Power source	Battery	Li-on, rechargeable, field replaceable
	Battery operating time	2.5 hours continuous operation
	External power operation	AC adapter
	Charging system	External intelligent charger
	Power saving	Automatic shutdown and sleep mode (user-selectable)
Environmental	Operation temperature range	-15℃ to +50℃ (5°F to +122°F)
	Storage temperature range	-40℃ to +70℃ (-40°F to +122°F)
	Humidity	Operating and storage 10% to 95%, non-condensing
	Encapsulation	IP 54 IEC 529
	Shock	Operational: 25g IEC 68-2-29
	Vibration	Operational: 2g IEC 68-2-6
Physical characteristic	Size	90mm X 160mm X 184mm
	Weight	1Kg
	Tripod mounting	1/4"-20
Interfaces	USB	Image (thermal and visual), measurement data, voice and text, real-time thermal video with measurement data (Optional) transfer to PC
	Video output	CCIR/PAL or RS170 EIA/NTSC composite video

SATIR

GUANGZHOU SAT INFRARED TECHNOLOGY CO.,LTD

Phone: +8620-82229925
Fax: +8620-82227947
Http://www.sat.com.an
E-mail:sat@sat.com.cn

APPENDIX C

Wuhan Guide

ENGLISH-LANGUAGE SPECIFICATION SHEETS ON SEVERAL PRODUCTS REPRESENTATIVE OF THE GUIDE LINE

Groundbreaking IR Thermal Radiometric Camera MobIR® M3

Imaging Performance	
Detector Type:	Focal plane array (FPA) uncooled microbolometer ; 160×120 pixels, 35μm
Spectral Range:	8 to 14μm
Thermal Sensitivity:	≤120mk at 30□
Image Frequency:	50Hz PAL/60 NTSC, non-interlaced
Field of View (FOV):	25°×19°
Electronic Zoom:	×2
Image Presentation	
External Display:	2.2″ TFT & 1.2″ CSTN high resolution color LCD
Display Colors:	256 level, 5 palettes
Video Output:	PAL/ NTSC, composite video
Measurement	
Temperature Range	-20□ to +250□
Accuracy	±2□ or ±2% of reading
Measurement Modes	Spot, area, isotherm, line profile, auto hot spot, auto alarm
Emissivity Correction	Variable from 0.01 to 1.00 (in 0.01 increment)
Measurement Features	Automatic correction based on user input for reflected ambient temperature, distance, relative humidity, atmospheric transmission and external optics
Image Storage	
Type	Built-in Flash Memory
Capacity	100 images
File Format	IRI (An individual file consists of infrared image and voice annotation if any)
Voice Annotation	Variant for different files, up to 30 seconds per file
System Status Indication	
LCD Display	Display of battery status, indication of power
Sound Alarm	Automatic alarm for power shortage
Laser Locator	
Classification Type	Class 2 semiconductor laser
Battery System	
Type	Li-ion battery, rechargeable, filed replaceable
Operating time	Over 2 hours continuous operation
Charging System	In camera via USB interface from AC adapter (96 – 250 VAC) or in battery charger
Power Dissipation	2W
Environmental Specification	
Operating Temperature	-10℃ to +50℃
Storage Temperature	-20℃ to +60℃
Humidity	Operating and storing 10% to 95%, non-condensing
Encapsulation	IP54
Shock	25G, IEC 68-2-29
Vibration	2G, IEC 68-2-6
Interfaces	
USB1.1	Image, measurement and digital video transfer to PC
Physical Characteristics	
Size	120mm×60mm×30mm
Weight	0.265kg (including battery)

IR Thermal Imaging Miracle MobIR® M4

Imaging Performance	
THERMAL	
Detector Type	Focal plane array (FPA) uncooled microbolometer ; 160×120 pixels, 35μm
Spectral Range	8 to 14μm
Field of View	25°×19°
Thermal Sensitivity	≤120mk at 30□
Image Frequency	50Hz PAL/60 NTSC, non-interlaced
Electronic Zoom	×2
VISUAL	
Built- in Digital Video colors	CMOS Sensor, 640 x 480 pixels, 2^{24} colors
Image Presentation	
External Display	2.2″ TFT & 1.2″ CSTN high resolution color LCD
Display Color	256 level, 8 palettes (Rainbow, iron, B&W, etc)
Video Output	PAL/ NTSC, composite video
Measurement	
Temperature Range	-20□ to +250□
Accuracy	±2□ or ±2% of reading
Measurement Modes	Spot / manual (up to 4 moveable), spot / automatic placement at max, area (up to 4 moveable) displaying either max, min, or average, isotherm, line profile, auto alarm
Emissivity Correction	Variable from 0.01 to 1.00 (in 0.01 increment)
Measurement Features	Automatic correction based on user input for reflected ambient temperature, distance, relative humidity, atmospheric transmission and external optics
Image Storage	
Type	Built-in Flash Memory
Capacity	600 images
File Format	IRI (An individual file consists of infrared image, visual image and voice annotation if any)
Voice Annotation	Variant for different files, up to 30 seconds per file
System Status Indication	
LCD Display	Shows status of battery, indication of power
Sound Alarm	Automatic alarm for power shortage
Laser Locator	
Classification Type	Class 2 semiconductor laser
Battery System	
Type	Li-ion battery, rechargeable, filed replaceable
Operating time	Over 2 hours continuous operation
Charging System	In camera via USB interface from AC adapter (96 – 250 VAC) or in battery charger
Power Dissipation	2W
Environmental Specification	
Operating Temperature	-10□ to +50□
Storage Temperature	-20□ to +60□
Humidity	Operating and storing 10% to 95%, non-condensing
Encapsulation	IP54
Shock	Operational: 25G, IEC 68-2-29
Vibration	Operational: 2G, IEC 68-2-6
Interfaces	
USB1.1	Image (thermal & visual), measurement, voice and digital video transfer to PC
Physical Characteristics	
Size	120mm×60mm×30mm (standard model)
Weight	0.265kg (including battery)
Color	2 colors alternative

Superb & Simpler IR Thermogrophic Camera ThermoPro™ TP8S

Imaging Performance	
THERMAL	
Detector type:	Uncooled FPA microbolometer (384× 288 pixels, 35μm)
Spectral Range:	8-14μm
Thermal Sensitivity:	0.08°C at 30°C (Frame averaging algorithm)
Field of View/ Focus:	22°× 16°/ 35mm
Focusing:	Automatic or motorized
Electronic Zoom:	×1 to ×10 continuous zoom
VISUAL	
Built- in Digital Video:	CMOS Sensor, 1280× 1024 pixels, 2^{15} colors
Image Presentation	
External Display:	3.5″ high resolution color VGA LCD, 640× 480 pixels
Viewfinder	0.6″ built-in high resolution color OLED, 640× 480 pixels
Video Output:	VGA/PAL/ NTSC switchable
Image Display:	Thermal image alone/ Visual image alone/ Picture in picture
Man-Machine Communication	
Remote Control Handle (optional) :	Respond as per operators' operation
Joystick & Buttons:	Respond as per operators' operation
Menu:	Microsoft® Windows style
Measurement	
Temperature Range:	-20 °C- +600°C (down to -40 °C, up to +2000°C optional)
Accuracy:	±1°C or ±1% of reading
Measurement Modes:	Auto hot/cold spot , auto alarm for temperature above or below ; 10 movable spots,10 movable & changeable areas displaying either max, min, or average, vertical & horizontal line profile, delta-t, histogram & isotherm in live/zoomed/frozen/saved image
Emissivity Correction:	Variable from 0.01 to 1.00 (in 0.01 increment)
Measurement Features:	Automatic correction based on distance, relative humidity, atmospheric transmission and external optics
Optics Transmission Correction:	Auto, based on signals from sensors
Image Storage	
Type:	Removable 2GB SD card or built-in flash memory
File Format:	JPEG (an individual file consists of infrared image, visual image, voice annotation and text annotation if any)

Voice Annotation:	Up to 60 seconds per file
Text Annotation:	Selected from preset texts
Optional Lenses	
Field of View/ Focus:	7.7°× 5.8°/ 100mm 45.6°× 35°/ 16mm
Laser Locator	
Classification Type:	Class 2 semiconductor laser
Power System	
Battery Type:	Rechargeable Li-ion Camcorder battery, field-replaceable
Charging System:	In camera or in battery charger
Battery Operating Time:	Over 2.5 hours continuous operation
External Power Operation:	AC adapter 110/ 220 VAC, 50/ 60Hz
Environmental Specification	
Operating Temperature:	-20°C~+60°C(extended range optional)
Storage Temperature:	-20°C~+60°C(extended range optional)
Humidity:	Operating and storing 10% to 95%, non- condensing
Encapsulation:	IP54 IEC 529 housing
Shock:	Operational: 30G, IEC 68-2-29
Vibration:	Operational: 3G, IEC 68-2-6
Interfaces	
USB 2.0:	Image (thermal and visual), measurement data and voice text transfer to PC
RS232 communication:	Control of camera on PC
Man-Machine Communication	
Touch Screen:	Present and receive operator's commands given by touch
Physical Characteristics	
Housing:	Magnalium
Weight:	0.85kg (excluding battery & LCD); 1.1kg (including battery & LCD)
Size:	186mm×106mm× 83mm (standard model)
Tripod Mounting:	1/4″- 20

Thermal Security Camera GUIDIR® IR210

Imaging Performance

Detector	Uncooled FPA Microbolometer 320x240 pixels
Pitch	45μm×45μm
Spectral range	8-14μm
Thermal sensitivity	0.08□@30□
Start-up time	<30 seconds
Gain control	Automatic / manual
Image Presentation	
Video output	PAL/NTSC
Display	White / black (pseudo color optional)
Contrast / brightness	Manual / Automatic
Electronic zoom	2X, 4X
Power System	
Voltage	DC9V
Power dissipation	4W
Environmental Specification	
Operating temperature	-20□-+50□(-40□-+60□ optional)
Storage temperature	-40□-+60□
Interface	
Remote control	RS232 serial communication
Physical Characteristics	
Size	120mm×60mm×60mm(camera body)
Weight	220g

Multifunctional Locating Handheld Thermal Viewer GUIDIR® IR513

Thermal Imager	
Detector:	384x288 pixels
Spectral range:	8-14 microns
Bad pixels:	<1%
NETD:	<85mk at 25℃
FOV:	5.50°x4.12°
Electronic zoom:	x2
Polarity:	White heat/ Black heat
Operating temperature range:	-25~+55℃
Storage temperature range:	-40~+60℃
Communication:	RS232
GPS	
Accuracy:	Single unit <3m (2DRMS)
Cold start:	<60 sec
Hot start:	<20 sec
Re-acquisition time:	<1 sec
Operating temperature range:	-25~+55℃
Storage temperature range:	-40~+85℃
Laser Range Finder	
Laser ranging performance:	50 ~ 5000 m
Ranging accuracy:	±3m
Wavelength:	1.06μm
Beam disperse angle:	≤1.0mrad
Repeat frequency:	10 times/ minute
Working voltage:	7~12V
Digital Compass	
Accuracy:	0.3°
Operating temperature range:	-25~+55℃
Storage temperature range:	-40~+125℃

Security Monitoring IR Thermal Camera GUIDIR® IR516

Image Performance	
Detector Type:	Microbolometer UFPA (320 x 240 pixels, 45μm)
Spectrum Range:	8-14μm
Field of View/ Min focus distance:	5.5°×4.1° /150mm
Spatial Resolution (IFOV):	0.3mrad (IFOV)
Thermal Sensitivity:	0.08℃ at 30℃
Image Frequency:	50Hz PAL/ 60Hz NTSC, non-interlaced
Focus:	Motorized
Electronic Zoom:	×2, ×4
Image Presentation	
Image display:	Black/ white (pseudo color optional)
Environmental Specification	
Operating Temperature:	-20 to 50℃ (-40 to 60℃ optional)
Storage Temperature:	-40 to 60℃
Encapsulation:	IP54
Interfaces	
Communication:	RS422
Video Output:	PAL/ NTSC composite video
AC power supply:	AC adapter,110/220V,50/60Hz

Handheld Thermal Viewer GUIDIR® IR510

Imaging Performance	
Detector Type	Uncooled FPA microbolometer 320×240 pixels, 45um
Spectral Range	8- 14 μm
Field of View:	9.1°×6.9°
Thermal Sensitivity	0.08℃Cat 30℃
Gain & Offset	Auto & manual control
Electronic Zoom	×2, ×4 interpolating
Image Presentation	
Video Output	PAL or NTSC, composite video
Integrated Display	CRT viewfinder
Image Color	B & W, B & W inverse (pseudo color optional)
Power System	
Battery Type	7.2V rechargeable Li-ion Battery
Battery Operating Time	2 hours continuous operation
External Power Operation	AC adapter 110/ 220VAC, 50/ 60 Hz
Environmental Specification	
Operating Temperature	-20 - +50 （-40 - +60 optional）
Storage Temperature	-40℃-+60℃
Humidity	Operating and storing 10% to 95%,non-condensing
Shock	GJB
Vibration	GJB
Physical Characteristics	
Weight	2.0 Kg
Size	143mm× 82mm× 83mm
Tripod Mounting	1/4″- 20

Portable Handheld Thermal Viewer GUIDIR® IR519

Imaging Performance	
Detector Type	Uncooled FPA microbolometer 384× 288 pixels, 35μm
Spectral Range	8- 14 μm
Field of View	8.5°× 6 .4°
NETD	≤80mK
Gain & Offset	Auto & manual control
Electronic Zoom	×2, ×4 by interpolating
Image Presentation	
Video Output	PAL or NTSC, composite video
Integrated Display	OLED viewfinder
Image Color	B& W, B& W inverse, (pseudo color optional)
Power System	
Battery Type	7.2V rechargeable Li-ion Battery
Battery Operating Time	2 hours continuous operation
External Power Operation	AC adapter 110/ 220VAC, 50/ 60 Hz
Environmental Specification	
Operating Temperature	-20□- +50□(-40□- +60□ optional)
Storage Temperature	-40□- +60□
Humidity	Operating and storing 10% to 95%, non-condensing
Shock	GJB
Vibration	GJB
Physical Characteristics	
Weight	2.0 Kg
Size	232mm× 103mm× 126mm
Tripod Mounting	1/4″-20

Smallest & Lightest Thermal Goggle GUIDIR®IR528

Imaging Performance	
Detector type	Uncooled FPA, 160×120 pixels
Spectral range	8 ~ 14μm
FOV	32.4°×24.6° (5.1°×3.8° optional)
Image frequency	50/ 60Hz
Image zoom	×2
Image Presentation	
Display	OLED viewfinder, 256 grey levels
Video output	PAL/NTSC
Gain & offset	Auto & manual control
Temperature Measurement	
Measurement mode	Single spot measurement
Accuracy	±2℃ or ±2% of reading
Power Supply	
Rechargeable battery	4.2V
Power dissipation	< 2.5W
Battery operating time	> 2.5h
Environmental Specifications	
Operating temperature	-25℃~+55℃
Storage temperature	-40℃~+60℃
Humidity	Operating and storing 10% to 95%, non-condensing
Interfaces	
Video/Power	Analog video output/power input
Physical Characteristics	
Weight	< 300g
Size	148mm×50mm×70.5mm

UFPA IR Module GUIDIR® IR112

Detector	
Type	Uncooled FPA Microbolometer (384× 288 pixels)
Pitch:	35μm
Spectral Response:	8-14μm
Fill Factor:	>80%
Response Rate:	> 5 MV/K @ 30℃
Response Time:	10mS
Bad Pixel:	<1%
NETD:	<80mK @30°C
Power	
Input Voltage:	9VDC- 12VDC
Power Dissipation:	<3.5W
Environmental	
Operating Temperature:	-20°C- +60°C (-40°C optional)
Storage Temperature:	-20°C- +60°C (-40°C optional)

APPENDIX D

Wuhan Huazhong Numerical Control Co. Ltd. (HCNC)

ENGLISH-LANGUAGE SPECIFICATION SHEETS ON SEVERAL PRODUCTS REPRESENTATIVE OF THE HCNC LINE

Specifications: HY-1088B

Infrared detector	Place of origin	USA
	Material	VO_x
	Pixel	320×240
	Range of wave-length	7~14μm
	Thermal sensitivity	≤35mK
Picture characteristics	Start-up time	3-second
	Brightness/contrast	automatic
	Body detecting range	1000m
Optics characteristics	Field angle	9°×7°
	Focal length	75mm
Video characteristics	Format	NTSC or PAL
	Display mode	3.5-inch, colors with 16-million
	Video-recording hours	>2-hour
Power	Battery	3.6V , 8800mAh lithium-battery
	Available hours	>10-hour
	Charging hours	5-hour
Environmental characteristics	Application temperature	-40□~ + 75□
	Storage temperature	-45□~ + 80□
Mechanical characteristics	Size	219 mm ×110 mm ×100 mm
	Weight	1600g
Interface	Video and USB	

Product Content

HY Infrared Thermography
>>HY-3088G series
>>HY-3000G series
HY Infrared Thermography for Human body
>>HY-2005A series
>>HY-2005B series
HY Infrared Image Remote Monitoring System
>>HY-5800 series
HY Night-vision Infrared Thermography Setting
>>HY-1088A series
>>HY-1088B series
HY Infrared Image Monitoring Setting
>>HY-5000 series

Product Content

HY-3088G series

Integrating advanced optoelectronic technology, thermal-imaging technology as well as image processing technology, HY series infrared thermography features as many advantages as high temperature sensitivity, wide range temperature measurement, non-interfering detected target and easy-to-use. Infrared thermography, as one of the state-of-the-art and effective means in foreseeing maintenance and condition surveillance, has been increasingly recognized and valued with bringing users remarkable economic benefits. HY series infrared thermography is an up-to-date and the third-generation product with lots of features such as advanced technologies, reliable system, perfect functions, easy to operate, bottommost pricing and so on. Even in very bad conditions, it works wonderfully and satisfies requirements for measurement as well.

Characteristics:
1. No cooling necessary, start-up rapidly.
2. Image distinction, perfect functions.
3. High temperature resolution.
4. Temperature measuring both swiftly and accurately.
5. Storage and replay of thermal image.
6. High integration and reliability.
7. Mighty dedicated analyzing software.
8. Lightweight, extremely portable.

Technical specifications of HY-3088G infrared thermography

Image specifications	
Type of detector	Uncooled FPA detector (USA)
Pixel	320×240
Range of wave-length	8～14μm
Temperature resolution	0.07℃（when 30℃）
Spatial resolution	1.3mrad
Frame frequency	25HZ
Field of view/Min.focal length	17°×14°/0.5m
Focusing	Manual
Image display	
Video output	PAL composite video
Display mode	3.5-inch color-LCD, color electronic view-finder(clearly visible under bright light)
Type of menu	Chinese/English menu

Wuhan Huazhong Nume rical Control Co.,Ltd (abbreviation HCNC), one of the backbones of Wuhan Optics Valley

News & Events

Wuhan Huazhong Nume rical Control Co.,Ltd (abbreviation HCNC), one of the backbones of Wuhan Optics Valley

Pseudo -color set-up	Users can set up 256 pseudo-color mode, 5 palette options
Adjusting function	Brightness and contrast adjustable.
Visible-light image	Picture-in-picture display
Temperature measurement	
Range of temperature measurement	-20℃～+450℃ expandable up to 2000℃
Accuracy of temperature	±2℃ or ±2% of readings
Measurement mode	1. Automatically measuring and catching max. temperature on entire screen. 2. Temperature measuring to any point. 3. An upper limitation of temperature alarm can be set up. 4. The system alarms automatically once temperature is higher than the upper limitation.
Correction of air penetrating-rate	Performing automatically based on input target distance, air temperature and relative humidity.
Emissivity correction	Calibrating in terms of given emissivity.
Image storage and replay	
Type of storage	Built-in, large capacity FLASH-memory, storage images≥1000.
Image replay	Replay simultaneously and analyze on a 4-picture basis.
Audio notes	10-second audio notes in each thermal picture.
Clock function	Real clock
Battery	Built-in, rechargeable lithium-battery, available hours: 2 hours, changeable on-site.
Environmental parameters	
Operation temperature	-10℃～+50℃
Storage temperature	-40℃～+70℃
Humidity	10%~95%
Physical Characteristics	
Size	160mm×105mm×80mm
Weight	2kg
Interface mode	USB

Back

Home | About us | Product Content | Application | Download Center | Contact us

Copyright 2000 Wuhan huazhong numerical control Co,.LTD.All rights reserved
Telephone：87180040 87180302 87180292
Postcode：430223

Product Content

HY Infrared Thermography
>>HY-3088G series
>>HY-3000G series
HY Infrared Thermography for Human body
>>HY-2005A series
>>HY-2005B series
HY Infrared Image Remote Monitoring System
>>HY-5800 series
HY Night-vision Infrared Thermography Setting
>>HY-1088A series
>>HY-1088B series
HY Infrared Image Monitoring Setting
>>HY-5000 series

Product Content

HY-3000G series

Integrating advanced optoelectronic technology, thermal-imaging technology as well as image processing technology, HY series infrared thermography features as many advantages as high temperature sensitivity, wide range temperature measurement, non-interfering detected target and easy-to-use. Infrared thermography, as one of the state-of-the-art and effective means in foreseeing maintenance and condition surveillance, has been increasingly recognized and valued with bringing users remarkable economic benefits. HY series infrared thermography is an up-to-date and the third-generation product with lots of features such as advanced technologies, reliable system, perfect functions, easy to operate, bottommost pricing and so on. Even in very bad conditions, it works wonderfully and satisfies requirements for measurement as well.

Characteristics:

1. No cooling necessary, start-up rapidly.
2. Image distinction, perfect functions.
3. High temperature resolution.
4. Temperature measuring both swiftly and accurately.
5. Storage and replay of thermal image.
6. High integration and reliability.
7. Mighty dedicated analyzing software.
8. Lightweight, extremely portable.

Technical specifications of HY-3000G infrared thermography:

Image specifications	
Type of detector	Uncooled focal plane array detector
Pixel	320×240
Range of wave-length	8～14μm
Temperature resolution	0.07℃（when 30℃）
Spatial resolution	1.3mrad
Frame frequency	9HZ

Wuhan Huazhong Nume
rical Control Co.,Ltd (abbreviation HCNC), one of the backbones of Wuhan Optics Valley

News & Events

Wuhan Huazhong Nume
rical Control Co.,Ltd (abbreviation HCNC),
one of the backbones
of Wuhan Optics Valley

Image enlargement	×2
Field of view/Min.focal length	17°×14°/0.5m
Focusing	manual
Image display	
Video output	NTSC composite video
Display mode	3.5-inch color-LCD, color electronic view-finder(clearly visible under bright light)
Type of menu	Chinese/English menu
Pseudo -color set-up	Users can set up 256 pseudo-color mode, 5 palette optional
Adjusting function	Brightness and contrast adjustable
Visible-light image	Picture-in-picture display
Temperature measurement	
Range of temperature measurement	-20℃~+350℃ expandable up to 2000℃
Accuracy of temperature measurement	±2℃ or ±2% of readings
Measurement mode	1. Automatically measuring and capturing max. temperature on entire screen. 2. Temperature measuring to any point. 3. An upper limitation of temperature alarm can be set up. 4. The system alarms automatically once temperature is higher than the upper limitation.
Correction of air penetrating-rate	Performing automatically, based on input target distance, air temperature and relative humidity.
Emissivity correction	Calibrating in terms of given emissivity.
Image storage and replay	
Type of storage	Built-in, large capacity FLASH-memory, storage images≥1000.
Image replay	Replay and analyze on a 4-picture basis.
Audio notes	There is 10-second audio notes in each thermal picture.
Clock function	Real clock
Battery	Built-in, rechargeable lithium-battery, available hours: 2 hours, changeable on-site.
Environmental parameters	
Operation temperature	-10℃~+50℃
Storage temperature	-40℃~+70℃
Humidity	10%~95%
Physical Characteristics	
Size	160mm×105mm×80mm
Weight	1.5kg
Interface mode	USB

Back

Copyright 2000 Wuhan huazhong numerical control Co,.LTD.All rights reserved
Telephone：87180040 87180302 87180292
Postcode：430223

Product Content

HY Infrared Thermography
>>HY-3088G series
>>HY-3000G series
HY Infrared Thermography for Human body
>>HY-2005A series
>>HY-2005B series
HY Infrared Image Remote Monitoring System
>>HY-5800 series
HY Night-vision Infrared Thermography Setting
>>HY-1088A series
>>HY-1088B series
HY Infrared Image Monitoring Setting
>>HY-5000 series

Product Content

HY-1088A series

HY-1088A series night-vision infrared thermography, a newly developed product, forms infrared images by detecting tiny differences of temperature. It may observe targets not only under completely lightless condition but in dark night, thick smoke, and dense fog as well, even including disguised and speedy moving targets. Currently it plays an important roles in locating and rescuing victims, search for criminals, maritime patrol and surveillance.

Characteristics
1. Real-time photographing, rapid start-up.
2. Body detecting range covering up to 450m.
3. Enhanced picture processor obtains ideal picture.
4. Lightweight, merely 400g.
5. Lithium-battery, long working hours.

Application areas
1. Target search
2. Compulsory protection
3. Daily patrol
4. Firefighting
5. Rescue
6. Surveillance
7. Capturing convicts on the lam

Technical specifications of HY-1088A series infrared thermograph:

FPA	Material	Micro bolometer
	Pixel	160×120
	Range of wave-length	7~14μm
	Thermal sensitivity	≤50mK
Picture characteristics	Start-up time	3-second
	Brightness/contrast	Entire automation
	Body detecting range	450m
Optics characteristics	Instantaneous field view	11°×8°
	Focal length	25mm
Video characteristics	Format	NTSC or PAL
	Display	2.5-inch LCD
Power	Battery	7.2V，4000mAh Lithium-battery
	Available hours	>10-hour
	Application temperature	-20℃～+60℃
	Storage temperature	-20℃～+80℃

Wuhan Huazhong Nume rical Control Co.,Ltd (abbreviation HCNC), one of the backbones of Wuhan Optics Valley

News & Events

Wuhan Huazhong Nume rical Control Co.,Ltd (abbreviation HCNC), one of the backbones of Wuhan Optics Valley

characteristics		
Mechanical characteristics	Size	135 mm ×93 mm ×57 mm
	Weight	400g

Back

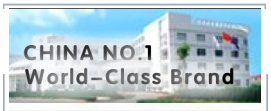
Home | About us | Product Content | Application | Download Center | Contact us

Copyright 2000 Wuhan huazhong numerical control Co,.LTD.All rights reserved
Telephone：87180040 87180302 87180292
Postcode：430223

`

Contact us

Address:science and technology Center of HuaZhong University of Science & Technology Miaoshan,Wuhan,Hubei, P.R.China
Postcode:430223
Telephone:027－87180302 027－87180040
Fax:027－87180302
E_mail:hwpub@163.com E_mail:mingliu2008@hotmail.com



Wuhan Huazhong Nume rical Control Co.,Ltd (abbreviation HCNC), one of the backbones of Wuhan Optics Valley

News & Events

Welcome to network information center of Infrared department in Wuhan Huazhong Numerical Control Co.,Ltd!

Copyright 2000 Wuhan huazhong numerical control Co,.LTD.All rights reserved
Telephone：87180040 87180302 87180292
Postcode：430223

Product Content

HY Infrared Thermography
>>HY-3088G series
>>HY-3000G series
HY Infrared Thermography for Human body
>>HY-2005A series
>>HY-2005B series
HY Infrared Image Remote Monitoring System
>>HY-5800 series
HY Night-vision Infrared Thermography Setting
>>HY-1088A series
>>HY-1088B series
HY Infrared Image Monitoring Setting
>>HY-5000 series

Product Content

HY-5000 series

It tends to be difficult to monitor temperature changing process of the detected target in scientific research and manufacturing.
Blending with advanced infrared thermal imaging technology, video gathering technolgy, measuring technlogy, the infrared thermography for process monitoring developed by HCNC performs well in on-line monitoring and real-time analysis for changes of temperature and its field of the detected target, obtaining many kinds of data in the process of rapid temperature changes of the detected target. Also it may analyze any single frame static picture.

Characteristics:
1. On-line monitoring temperature changes of target.
2. Dynamic capturing image with static analysis.
3. Analyzing recording data frame by frame.
4. Interface: USB
5. Two kinds of data deriving ways: function and text with allowing to insert other application programs in it.

System operation settings
Windows2000Pro or 2000Server/nt4.0 operation system P4-1.8G/256M/80G++ computer(or server) Server end software.

Wuhan Huazhong Nume
rical Control Co.,Ltd (abbreviation HCNC), one of the backbones of Wuhan Optics Valley

News & Events

Wuhan Huazhong Nume
rical Control Co.,Ltd (abbreviation HCNC),
one of the backbones
of Wuhan Optics Valley

		HY-5000 series	HY-5100 series
Infrared camera	Type of detector	The third-generation uncooled FPA(USA)	The third-generation uncooled FPA(USA)
	Pixel	320×240	160×120
	Output format	PAL	NTSC
	Response wave band	8～14μm	8～14μm
	Measurement range	-20℃～300℃ (expandable up to -20℃～300℃)	-20℃～300℃ (expandable up to -20℃～300℃)
	Temperature resolution	0.08℃(when 30℃)	0.08℃(when 30℃)
	Spatial resolution	1.3mrad	1.3mrad
	Range of focal distance	0.5m～∞	0.5m～∞
	Field frequency	50HZ	60HZ
	Focal length	Electrically operated/manual	Electrically operated/manual
	Operation setting	-20℃～+60℃	-20℃～+60℃
Video data interface	USB2.0		
PAN/TILT(optional)			
Software functions	1. Temperature measuring for any point of dynamic picture. 2. Automatically demarcating and monitoring of max.temperature. 3. Capturing dynamic images promptly and regularly, dividing object into single-frame picture for either in-depth static analysis or regional temperature contrast. 4. Thermal map can be enlarged (or lessened) with image filtering and adjusting to temperature range. 5. Automatic generation of corresponding technical report, or copied into WORD for self-definition editing. 6. The report is of universality, being unalterable, readable and transmissible. 7. The software may be installed in multi computers for normal use with early failure judgement, historic trend analysis by which aging information and its historic trend can be gripped properly. 8. Data deriving way is divided into two kinds: function & text that may be inserted into other application program.		

Back

Copyright 2000 Wuhan huazhong numerical control Co,.LTD.All rights reserved
Telephone：87180040 87180302 87180292
Postcode：430223

APPENDIX E

Nanjing Kuyee Tech

ENGLISH-LANGUAGE SPECIFICATION SHEETS ON SEVERAL PRODUCTS REPRESENTATIVE OF THE KUYEE LINE

Core C20

使用环境 Requirements on Operation environment

Operating Temperature	- 10□ ~ + 50□
Storage Temperature	- 40□ ~ + 70□
Humidity	≤95%

外型尺寸 Physical Characteristics

Weight	1Kg
Size	112mm×61mm×64mm
Tripod mounting	1/4〃 - 20

技术性能指标 Technic capability

Detector type	Uncooled microbolometer FPA
Spectral range	8 ~ 14μm
Thermal resolution	≤0.1□at 30□
Spatial resolution	3mrad
Pixel	320×240
Field of view	56.1°×43.6°
Focus distance	0.2m ~ ∞
Respond time	4ms
Video output	PAL
Startup	45 second
Focusing	Manual focus

电源 Power

Power	+8VDC
Power Dissipation	<3 W

测量功能 Measurement function

Operation	Drop-down menu
Adjustion	Auto adjust brightnesscontrast, Auto/manual mix colours
Dot temperature	Decussation dot temperature display,and sustain 10 dots contemporary most
Max/min temp capture	Max/mini temperature capture availabe

Simulation colour option	User can setup simulation option , sieve the background to emphasize high temperature target
Magnify of image	Real time magnifying of images
Temperature range	-20□ ~ 250 □ (Standard)
Temperature accuracy	±2% or ±2□

接口定义 Interfaces

Video	BNC Q9
Power source	ACadapter 85/260VAC,50/60HZ,8VDC,20W
Menu button	5 buttons

Core C30

Requirements on Operation environment

Operating Temperature	- 20□ ~ + 50□
Storage Temperature	- 40□ ~ + 70□
Humidity	≤95%

Physical Characteristics

Weight	1.1Kg
Size	175mm×64mm×70mm
Tripod mounting	1/4〃 - 20

Technic capability

Detector type	Uncooled microbolometer FPA
Spectral range	8 ~ 14μm
Thermal resolution	≤0.1□at 30□
Spatial resolution	0.7mrad
Pixel	384×288
Min focus distance	2m ~ ∞
Respond time	4ms
Video output	PAL
Startup	35 second
Focusing	Manual focus
Circular FOV/Focus	19.1°/50mm
Magnify of image	Real time magnifying of images
Image Color	B&W inverse
Adjustion	Auto/Manual Adjust Gain，Brightness contrast

Power

Power	+12VDC
Power Dissipation	<3 W

Interfaces

Video	BNC Q9
Power source	ACadapter 100/260VAC,50/60HZ,12VDC,20W
Menu button	5 buttons

Technical Datasheet

Model:	**GY603**
Detector:	UFPA micro bolometer
Field-of-View:	40mm
Frame Rate:	50HZ
Lens:	068.28 °
Temperature Resolution:	0.08℃
Spatial Resolution:	1.125mrad
Spectral:	8~14 micron
Detector Pixel:	320x240 pixels
Focus areas:	0.5m∞
Working Environmental Temperature:	0℃-- +40℃
Recommended Temperature:	16℃-- +32℃
Output data:	14bit
Data output:	USB2.0

Technical Datasheet Checker K10

Requirements on Opertation environment

Operating Temperature	- 10□ ~ + 50□
Humidity	≤95%
Storate Temperature	- 40□ ~ + 70□

Physical Characteristics

Weight	1.1Kg (include battery)
Size	200mm×85mm×130mm
Tripod mounting	1/4 〃 -20

Technic capability

Detector type	Uncooled microbolmoter FPA
Spectral range	8 ~ 14μm
Thermal resolution	≤0.1□at 30□
Spatial resolution	1.13mrad
Pixel	160×120
Image and measurement	Full screen simulant colour and measurement
Structure	Integrity design , one hand operation
Frame rate	50frame/sec ; PAL
Package	High strength plastic portable box
Fileld of view	20.6°×15.5°
Min focus distance	0.5m ~ ∞
Respond time	4ms
Video output	PAL
Startup	45 second
Focusing	Built-in focus motor

Power

Power	7.2V Li-Lon battery >3 hours
Power Dissipation	<3.5W

Measurement function

Operation	Drop-down menu
Adjustion	Auto adjust brightness/contrast, Auto/manual mix colours
Dot temperature	Decussation dot temperature display,and sustain 10 dots contemporary most

Max/min temp capture	Max/mini temperature capture availabe
Laser point	1mw/635nm(red)
Simulation colour option	User can setup simulation option , sieve the background to emphasize high temperature target
Magnify of image	Real time magnifying of images
Temperature range	-20□ ~ 250 □ (Standard)
Temperature accuracy	±2% or ±2□

Technical Datasheet Checker K20

Requirements on Opertation environment

Operating Temperature	- 10□ ~ + 50□
Humidity	≤95%
Storate Temperature	- 40□ ~ + 70□

Physical Characteristics

Weight	1.6Kg (include battery)
Size	200mm×85mm×130mm
Tripod mounting	1/4〃-20

Technic capability

Detector type	Uncooled microbolmoter FPA
Spectral range	8 ~ 14μm
Thermal resolution	≤0.1□at 30□
Spatial resolution	1.13mrad
Pixel	320×240
Image and measurement	Full screen simulant colour and measurement
Structure	Integrity design , one hand operation
Frame rate	50frame/sec ; PAL
Package	High strength plastic portable box
Fileld of view	20.6°×15.5°
Min focus distance	0.5m ~ ∞
Respond time	4ms
Video output	PAL
Startup	45 second
Focusing	Built-in focus motor

Power

Power	7.2V Li-Lon battery >3 hours
Power Dissipation	<3.5W

Measurement function

Operation	Drop-down menu
Adjustion	Auto adjust brightness/contrast, Auto/manual mix colours
Dot temperature	Decussation dot temperature display,and sustain 10 dots contemporary most

Max/min temp capture	Max/mini temperature capture availabe
Visible light image	CCD
Laser point	1mw/635nm(red)
Simulation colour option	User can setup simulation option , sieve the background to emphasize high temperature target
Magnify of image	Real time magnifying of images
Temperature range	-20□ ~ 250 □ (Standard)
Temperature accuracy	±2% or ±2□

Technical Datasheet Inspector K26

Requirements on Opertation environment

Operating Temperature	- 10□ ~ + 50□
Humidity	≤95%
Storate Temperature	- 40□ ~ + 70□

Physical Characteristics

Weight	1.6Kg (include battery)
Size	200mm×85mm×130mm
Tripod mounting	1/4〃-20

Technic capability

Detector type	Uncooled microbolmoter FPA
Spectral range	8 ~ 14μm
Thermal resolution	≤0.1□at 30□
Spatial resolution	1.13mrad
Pixel	320×240
Image and measurement	Full screen simulant colour and measurement
Structure	Integrity design , one hand operation
Frame rate	50frame/sec ; PAL
Package	High strength plastic portable box
Fileld of view	20.6°×15.5°
Min focus distance	0.5m ~ ∞
Respond time	4ms
Video output	PAL
Startup	45 second
Focusing	Built-in focus motor

Power

Power	7.2V Li-Lon battery >3 hours
Power Dissipation	<3.5W

Measurement function

Operation	Drop-down menu
Adjustion	Auto adjust brightness/contrast, Auto/manual mix colours
Dot temperature	Decussation dot temperature display,and sustain 10 dots

	contemporary most
Max/min temp capture	Max/mini temperature capture availabe
Visible light image	CCD
Laser point	1mw/635nm(red)
Simulation colour option	User can setup simulation option , sieve the background to emphasize high temperature target
Magnify of image	Real time magnifying of images
Temperature range	-20□ ~ 250 □ (Standard)
Temperature accuracy	±2% or ±2□

Technical Datasheet Groper A20

Requirements on Opertation environment

Operating Temperature	- 10□ ~ + 50□
Humidity	≤95%
Storate Temperature	- 40□ ~ + 70□

Physical Characteristics

Weight	1.6Kg (include battery)
Size	200mm×85mm×130mm
Tripod mounting	1/4 〃 -20

Technic capability

Detector type	Uncooled microbolmoter FPA
Spectral range	8 ~ 14μm
Thermal resolution	≤0.1□at 30□
Spatial resolution	1.13mrad
Pixel	320×240
Image and measurement	Full screen simulant colour and measurement
Structure	Integrity design , one hand operation
Frame rate	50frame/sec ; PAL
Package	High strength plastic portable box
Fileld of view	20.6°×15.5°
Min focus distance	0.5m ~ ∞
Respond time	4ms
Video output	PAL
Startup	45 second
Focusing	Built-in focus motor

Power

Power	7.2V Li-Lon battery >3 hours
Power Dissipation	<3.5W

Measurement function

Operation	Drop-down menu
Adjustion	Auto adjust brightness/contrast, Auto/manual mix colours
Dot temperature	Decussation dot temperature display,and sustain 10 dots contemporary most

Max/min temp capture	Max/mini temperature capture availabe
Visible light image	CCD
Laser point	1mw/635nm(red)
Simulation colour option	User can setup simulation option , sieve the background to emphasize high temperature target
Magnify of image	Real time magnifying of images
Temperature range	-20□ ~ 250 □ (Standard)
Temperature accuracy	±2% or ±2□

Technical Datasheet Firefinder F20

Requirements on Opertation environment

Operating Temperature	- 10□ ~ + 50□
Humidity	≤95%
Storate Temperature	- 40□ ~ + 70□

Physical Characteristics

Weight	1.6Kg (include battery)
Size	200mm×85mm×130mm
Tripod mounting	1/4〃-20

Technic capability

Detector type	Uncooled microbolmoter FPA
Spectral range	8 ~ 14μm
Thermal resolution	≤0.1□at 30□
Spatial resolution	1.13mrad
Pixel	320×240
Image and measurement	Full screen simulant colour and measurement
Structure	Integrity design , one hand operation
Frame rate	50frame/sec ; PAL
Package	High strength plastic portable box
Fileld of view	20.6°×15.5°
Min focus distance	0.5m ~ ∞
Respond time	4ms
Video output	PAL
Startup	45 second
Focusing	Built-in focus motor

Power

Power	7.2V Li-Lon battery >3 hours
Power Dissipation	<3.5W

Measurement function

Operation	Drop-down menu
Adjustion	Auto adjust brightness/contrast, Auto/manual mix colours
Dot temperature	Decussation dot temperature display,and sustain 10 dots contemporary most

Max/min temp capture	Max/mini temperature capture availabe
Visible light image	CCD
Laser point	1mw/635nm(red)
Simulation colour option	User can setup simulation option , sieve the background to emphasize high temperature target
Magnify of image	Real time magnifying of images
Temperature range	-20□ ~ 250 □ (Standard)
Temperature accuracy	±2% or ±2□

Technical Datasheet Monitor N20

Requirements on Opertation environment

Operating Temperature	- 10□ ~ + 50□
Humidity	≤95%
Storate Temperature	- 40□ ~ + 70□

Physical Characteristics

Weight	1.6Kg (include battery)
Size	200mm×85mm×130mm
Tripod mounting	1/4 〃 -20

Technic capability

Detector type	Uncooled microbolmoter FPA
Spectral range	8 ~ 14μm
Thermal resolution	≤0.1□at 30□
Spatial resolution	1.13mrad
Pixel	320×240
Image and measurement	Full screen simulant colour and measurement
Structure	Integrity design , one hand operation
Frame rate	50frame/sec ; PAL
Package	High strength plastic portable box
Fileld of view	20.6°×15.5°
Min focus distance	0.5m ~ ∞
Respond time	4ms
Video output	PAL
Startup	45 second
Focusing	Built-in focus motor

Power

Power	7.2V Li-Lon battery >3 hours
Power Dissipation	<3.5W

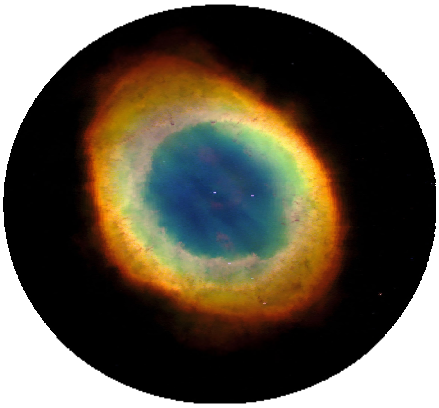
Measurement function

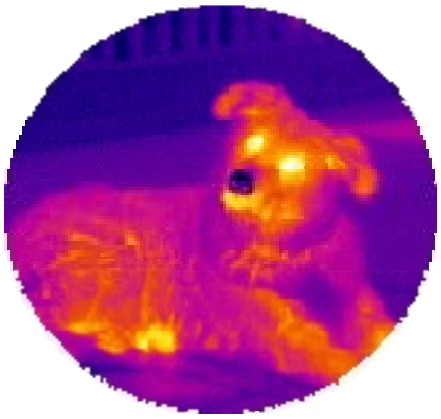
Operation	Drop-down menu
Adjustion	Auto adjust brightness/contrast, Auto/manual mix colours
Dot temperature	Decussation dot temperature display,and sustain 10 dots contemporary most

Max/min temp capture	Max/mini temperature capture availabe
Visible light image	CCD
Laser point	1mw/635nm(red)
Simulation colour option	User can setup simulation option , sieve the background to emphasize high temperature target
Magnify of image	Real time magnifying of images
Temperature range	-20□ ~ 250 □ (Standard)
Temperature accuracy	±2% or ±2□

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.

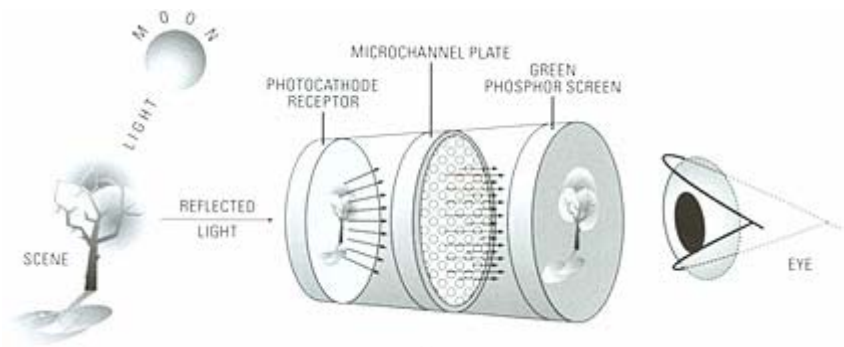
There are several different generations of image enhancement devices starting from the first crude devices developed near the end of the Second World War. The earliest versions required an active infrared source to "illuminate" the object being viewed. These earlier devices were not practical for combat 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. • Requires a visual contrast to generate a clear image, i.e., similarly colored or camouflaged objects are difficult to distinguish one from another. • Is negatively affected by point light sources and shadows. Can bloom or shut down in direct light. • Cannot easily detect camouflaged, still objects, or those in foliage due to low visible contrast. • Provides positive facial recognition under good conditions. • Cannot see through smoke and haze. • Costs less and is more compact. • Sees through visible glass.	• Sees long-wave infrared energy or radiant heat emitted by objects. • 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. • Does not require or see visible light, and is not affected by shadows or changing light conditions. • Can see people or objects in dark areas regardless of color, clothing, or shadows. Highlights animate objects in a scene or in foliage. • Does not provide positive facial recognition. • Sees through smoke and haze. • Costs more and is less compact. • 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

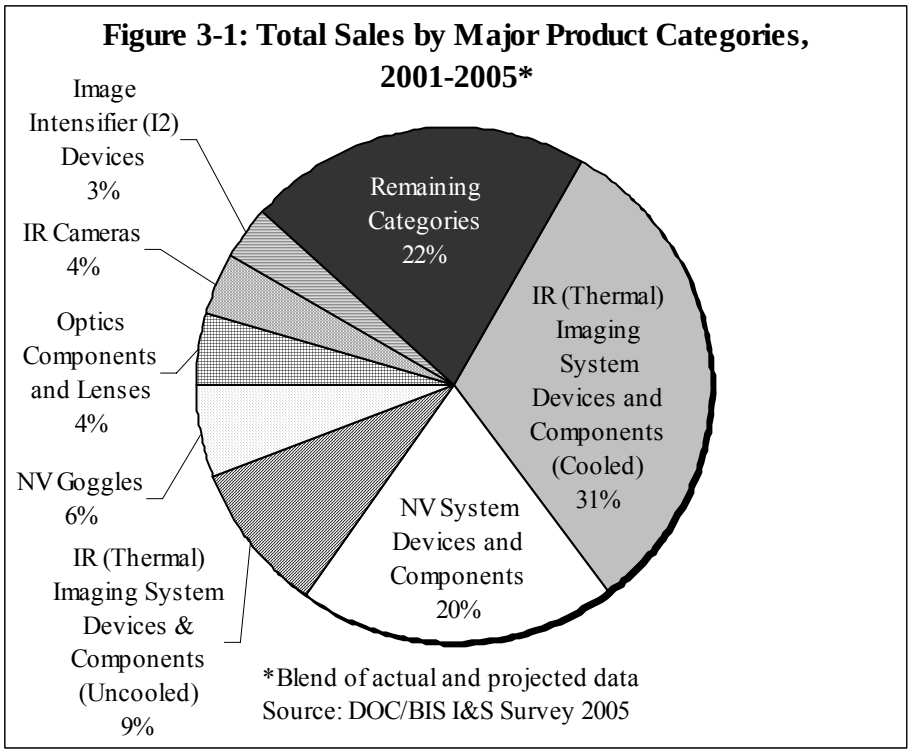
The period of 2003 to 2004 saw the largest growth in total sales during the timeframe; total sales jumped by 21.9 percent, which included a 22 percent spike in defense sales and a 21.7 percent rise in non-defense sales.

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%		

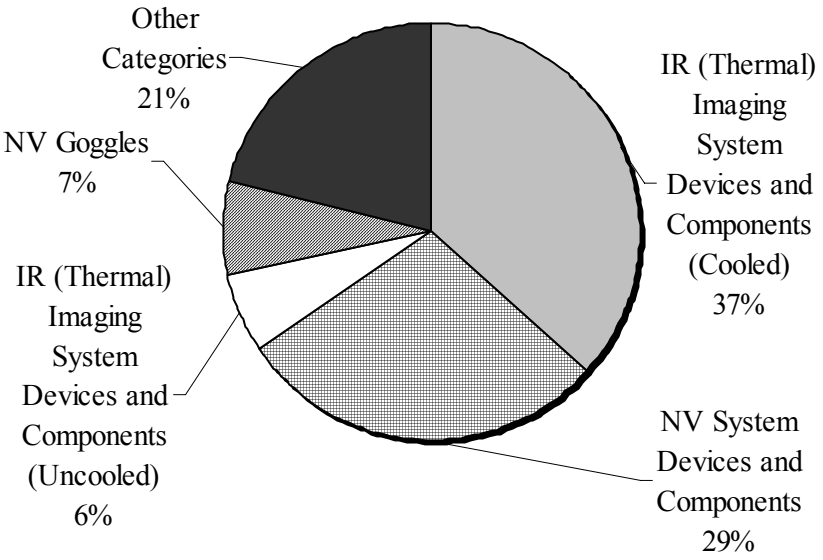
[1] 5-year compound annual growth rate
*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005



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).

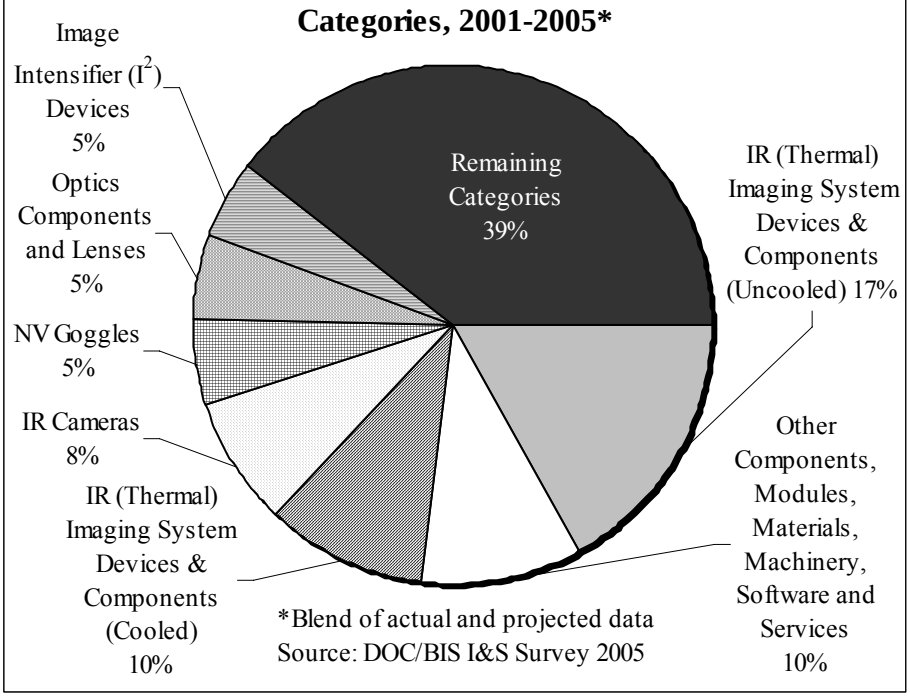
Figure 3-2: Defense Sales By Major Product Categories, 2001-2005*



*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*



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

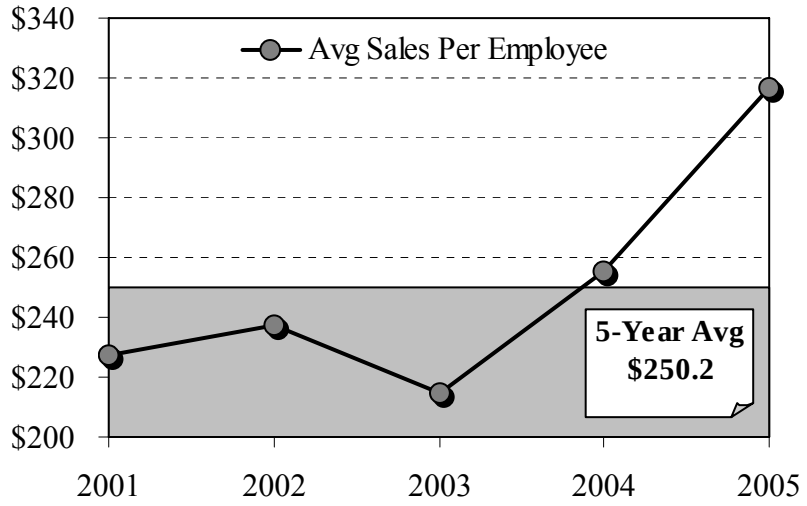
[1] 5-year compound annual growth rate
*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

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 Source: DOC/BIS I&S Survey 2005					

C. Capital Investment

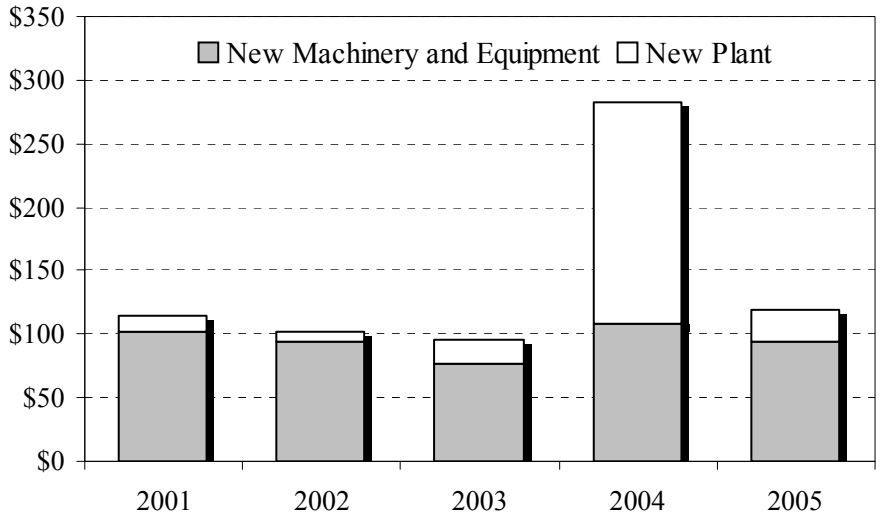
According to the BIS industry survey responses, new investment in plant, machinery and equipment fluctuated up and down during the period of 2001 through 2005, as Table 3-8 illustrates. The spike in investment for 2004 can be treated as a statistical outlier because it captured a large new plant investment 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 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

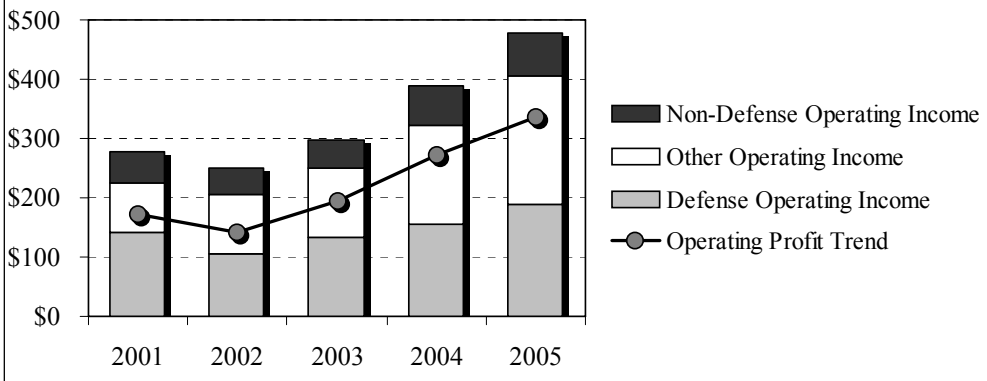
D.1 Image and Sensor Operations

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

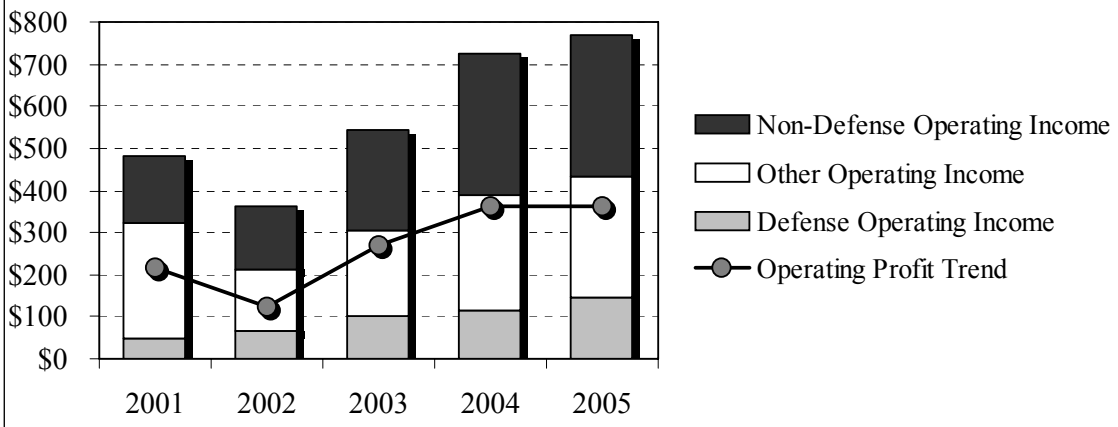
*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

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

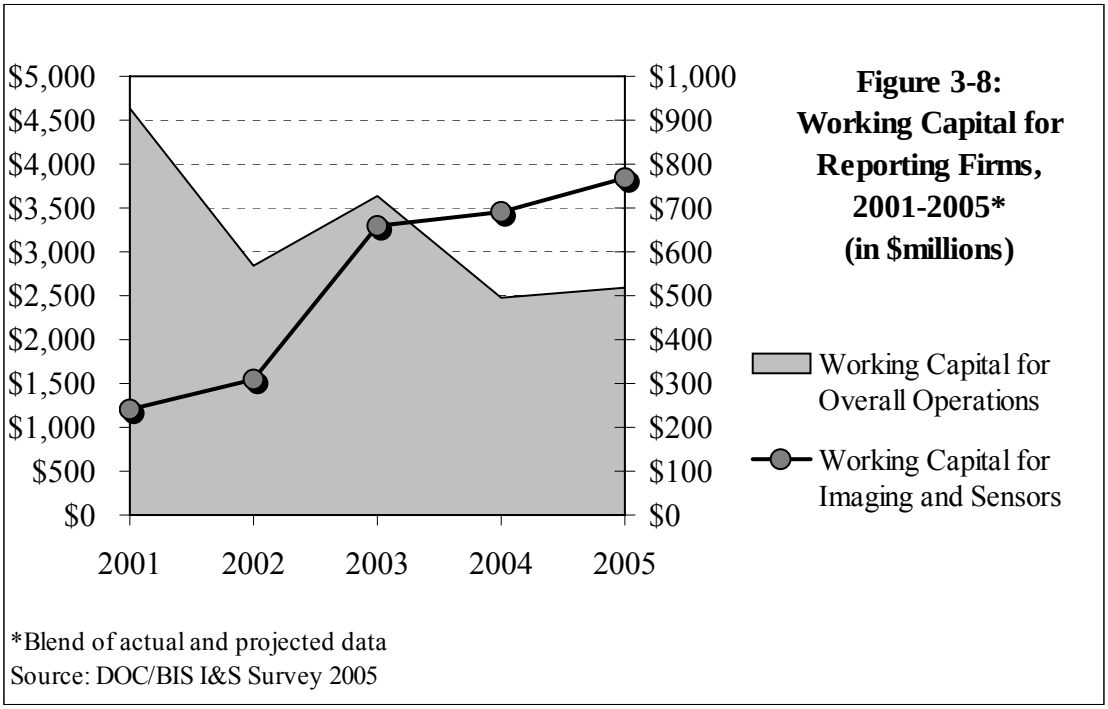
2001	2002	2003	2004	2005*
1.64	1.41	1.68	1.27	1.27

*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.

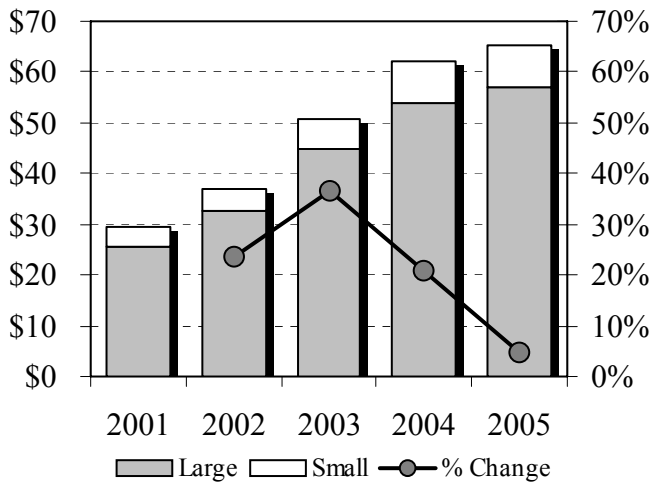


E. Earnings

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).

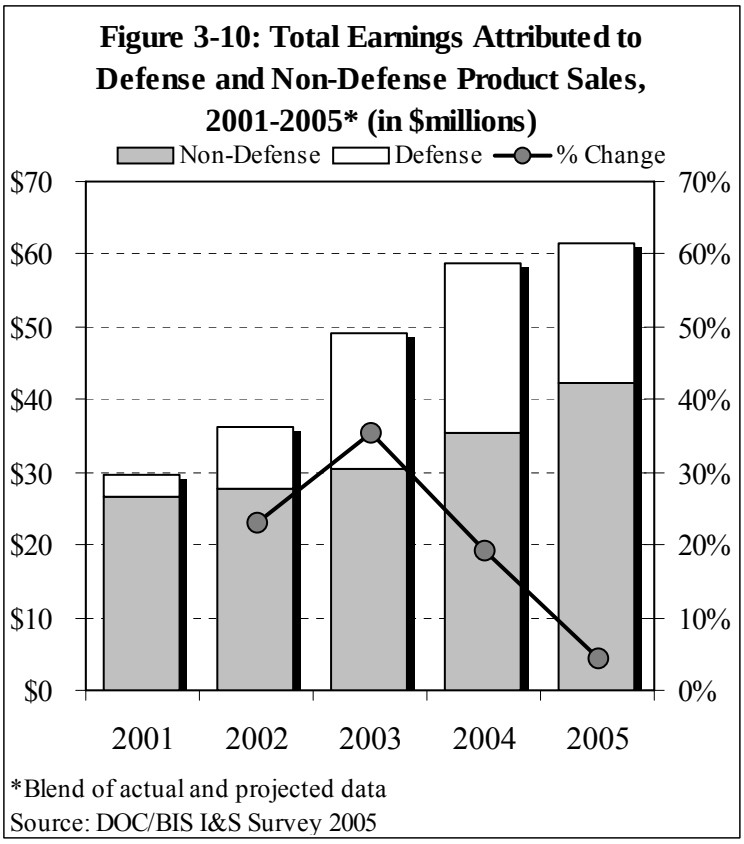
Figure 3-9: Total Earnings for Large and Small Retailers, Distributors, Resellers and Brokers, 2001-2005* (in $millions)



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

E.2 Defense and Non-Defense Earnings

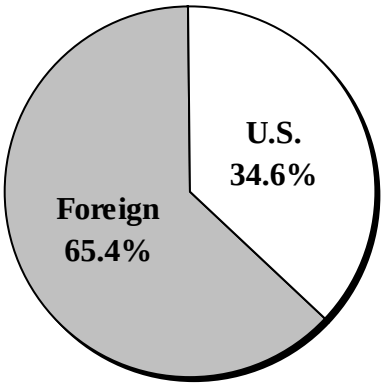
Retailers, distributors, resellers and brokers also reported data on earnings attributed to defense and non-defense-related sales of imaging and sensors products. Non-defense earnings represented the majority of total earnings over the five-year period, increasing to $41.1 million in 2005 from $25.5 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.

Figure 3-11: Percent of Earnings Attributed to U.S./Foreign-Made Products 2001-2005* Average



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

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).

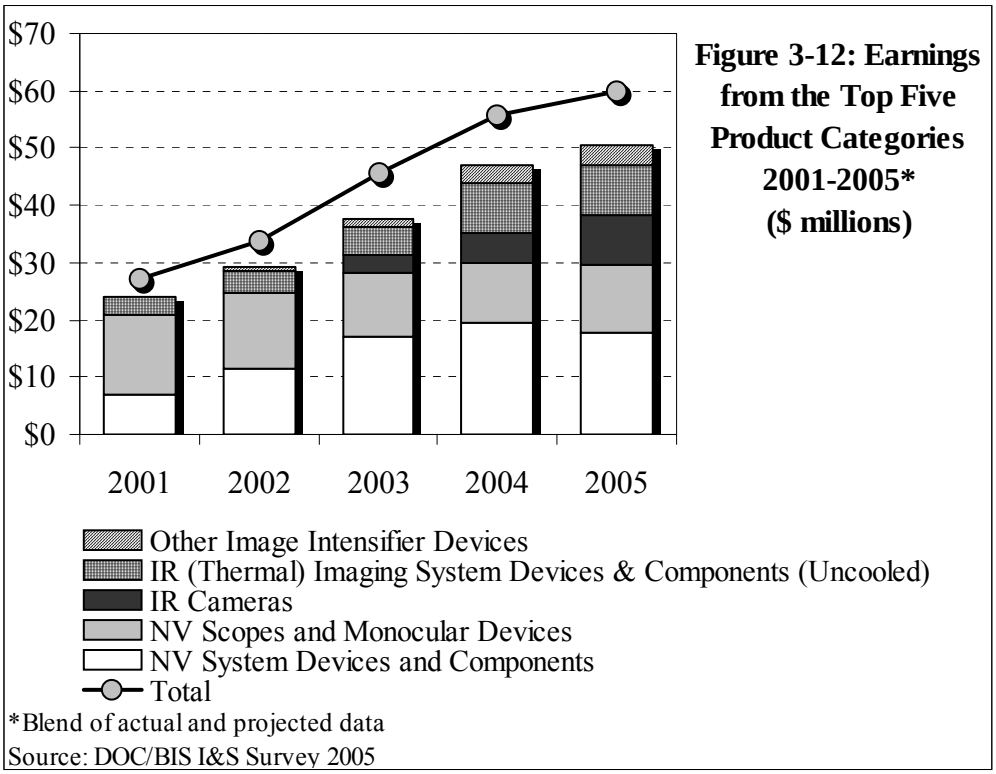


Figure 3-12: Earnings from the Top Five Product Categories 2001-2005* ($ millions)

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.

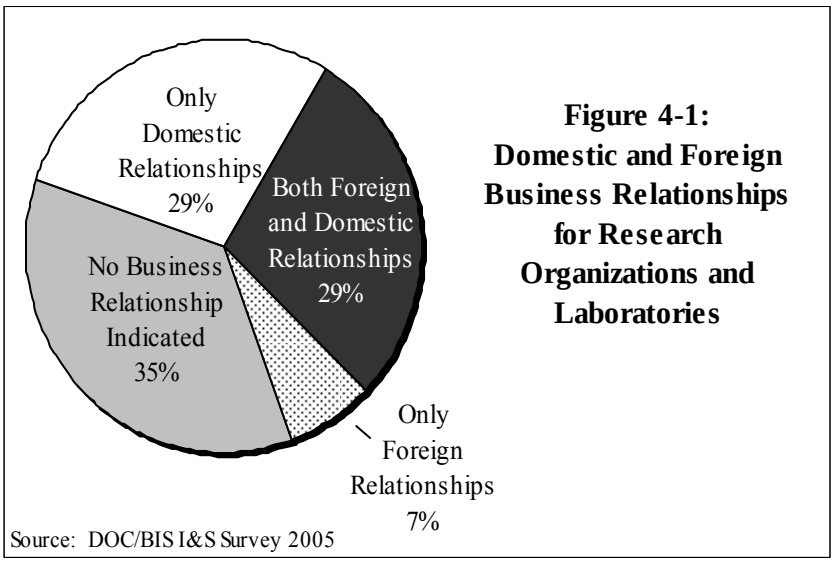


Figure 4-1: Domestic and Foreign Business Relationships for Research Organizations and Laboratories

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
Note: Because of rounding, totals may not add to 100 percent.
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 electro-optical systems	$67
2001	FLIR Systems	Saab Optronics Division thermal imaging subsystems for missiles	$1
2001	Northrop Grumman	Litton Electro-Optical Systems electro-optical/infrared products	Not provided*
2001	II-VI Incorporated	Litton Systems' Silicon Carbide Group crystal silicon carbide substrates	Terms not disclosed
2002	DRS Technologies	Nytech Integrated Infrared Systems uncooled thermal imaging systems	Terms not disclosed
2002	ITT Industries	Xybion Electronic Systems image intensification systems and metal-oxide semiconductor cameras	Terms not disclosed
2002	L-3 Communications	Wescam electro-optic surveillance systems	$118
2002	Fluke Corpration	Raytek Corporation non-contact infrared temperature measurement instrumentation	Terms not disclosed
2002	Mikron Infrared	IMPAC Electronic GmbH infrared temperature measurement instrumentation	Terms not disclosed
2003	L-3 Communications	Aeromet electro-optic/infrared and airborne instrumentation	$20
2003	FLIR Systems	Indigo Systems infrared cameras and detectors	$160
2004	ITT Industries	Kodak Remote Sensing Systems high-resolution satellite imaging systems	$725
2004	DRS Technologies	Night Vision Equipment Company (NVEC) night vision and thermal imaging technology	$42
2004	II-VI Incorporated	Marlow Industries, Inc. thermoelectric cooling solutions	$31
2004	L-3 Communications	Brashear LP electro-optical systems	$36
2004	L-3 Communications	Raytheon Commercial Infrared uncooled thermal infrared and imaging systems	$42
2004	L-3 Communications	Cincinnati Electronics infrared thermal imaging and space electronics	$172
2004	L-3 Communications	AVISYS infrared countermeasure (IRCM)	$8
2004	Axsys Technologies	Telic Optics infrared optics and optical assemblies	$14
2005	Axsys Technologies	Diversified Optical Products, Inc. (DiOP) infrared surveillance camera solutions	$60
2005	Goodrich Corp	Sensors Unlimited shortwave-infrared technology	$60
2005	L-3 Communications	EOTech holographic weapon sights	$49
2005	L-3 Communications	Sonoma Design Group 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.
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 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

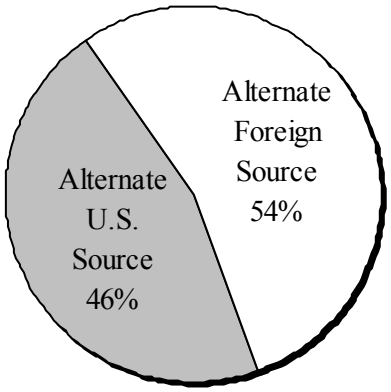
Approximately 66 percent of the 141 respondent firms procure products or services from at least one foreign firm. Leading foreign sole sourced items (based on the number of cases reported) were raw materials with 17.7 percent, image intensifier devices with 13.9 percent, and electronics/electrical controls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



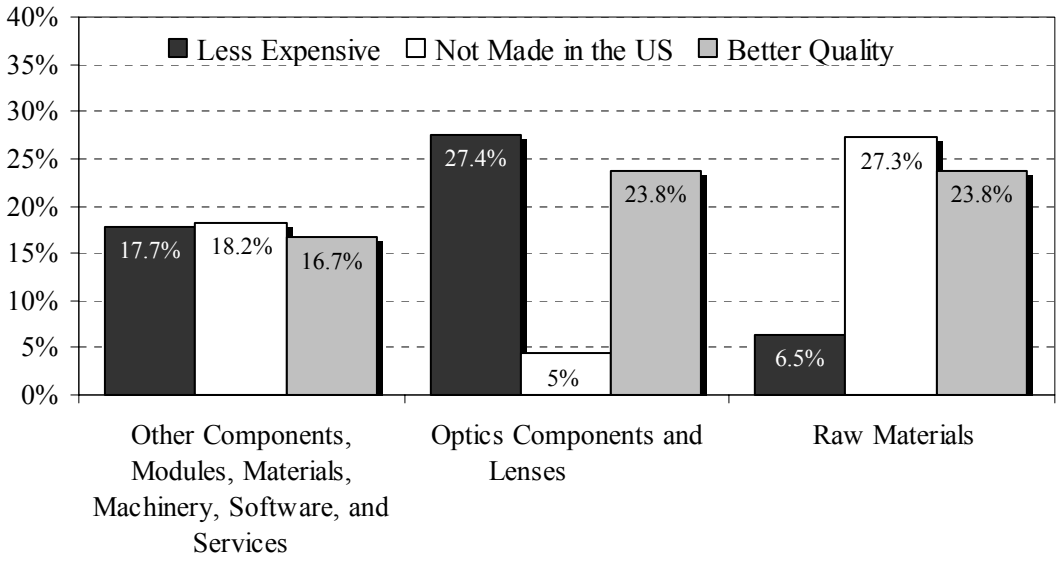
Source: DOC/BIS I&S Survey 2005

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).

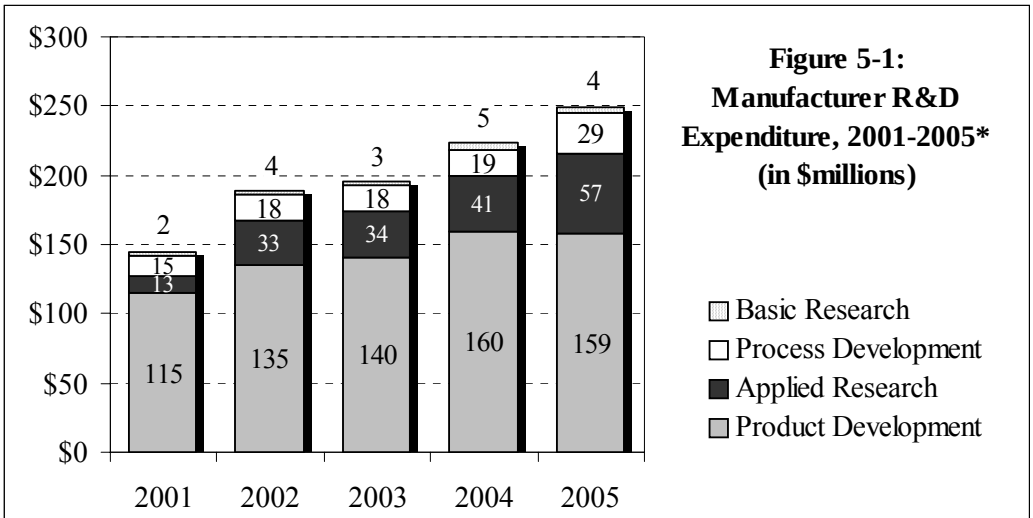


Figure 5-1: Manufacturer R&D Expenditure, 2001-2005* (in $millions)

*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 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).

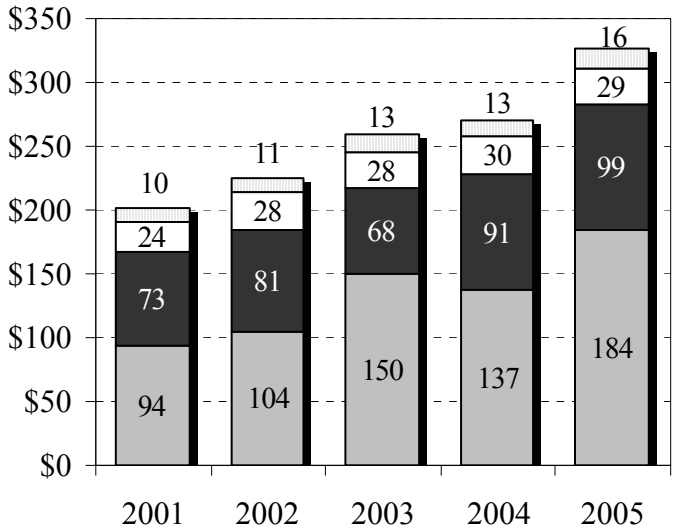


Figure 5-2: Lab/Research Organization R&D Expenditure, 2001-2005* (in $millions)

Basic Research
Process Development
Applied Research
Product Development

*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.

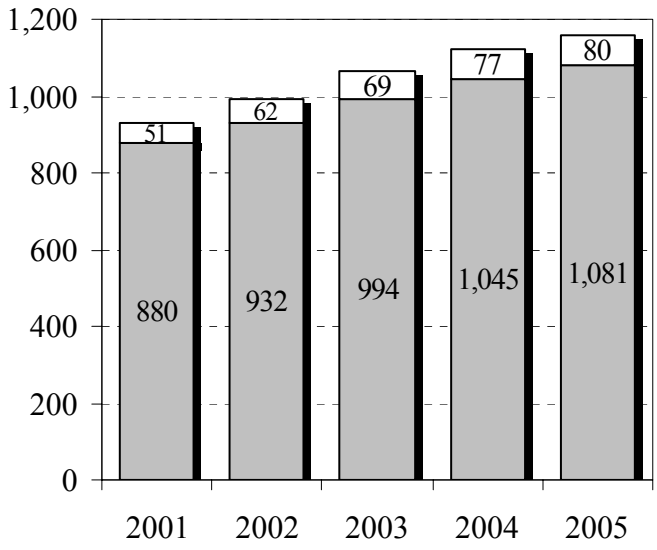


Figure 6-1: Total Employment at U.S. Research Organizations and Laboratories, 2001-2005* (# of Employees)

Non-U.S. Citizens
U.S. Citizens

*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.

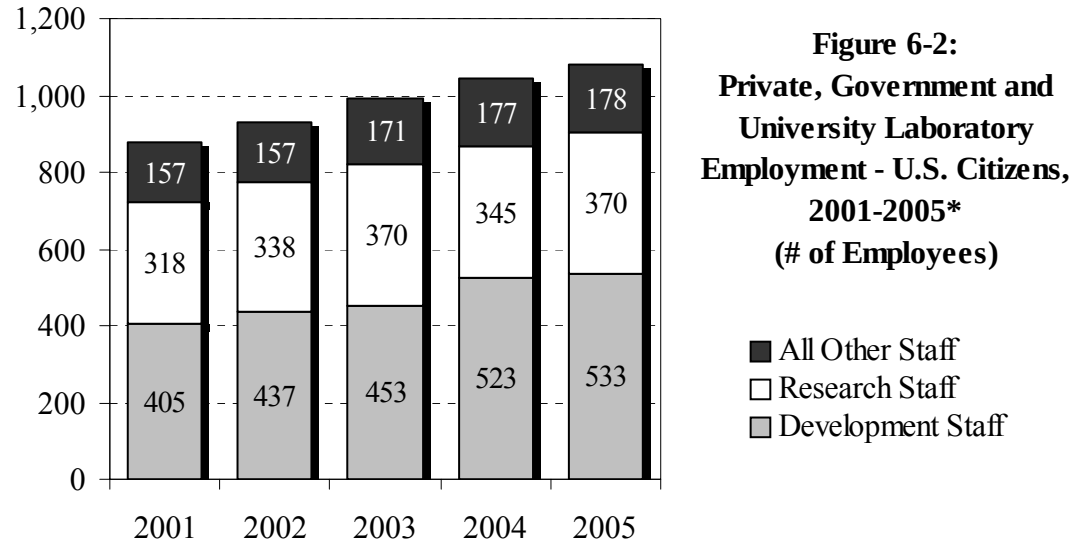


Figure 6-2: Private, Government and University Laboratory Employment - U.S. Citizens, 2001-2005* (# of Employees)

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

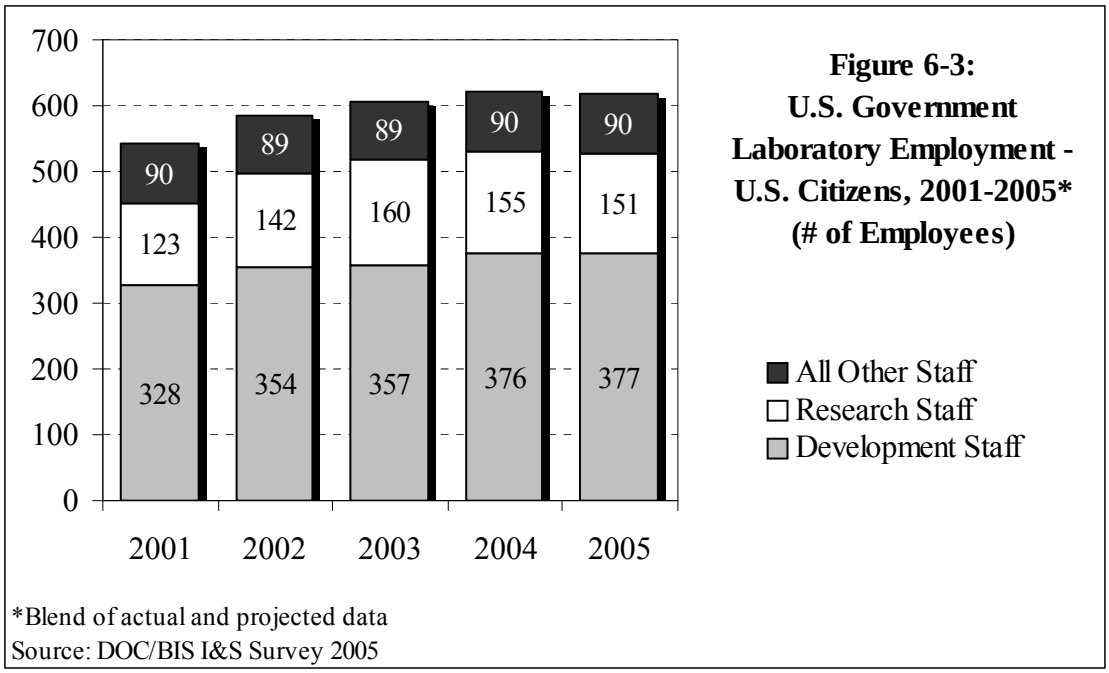


Figure 6-3: U.S. Government Laboratory Employment - U.S. Citizens, 2001-2005* (# of Employees)

*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.

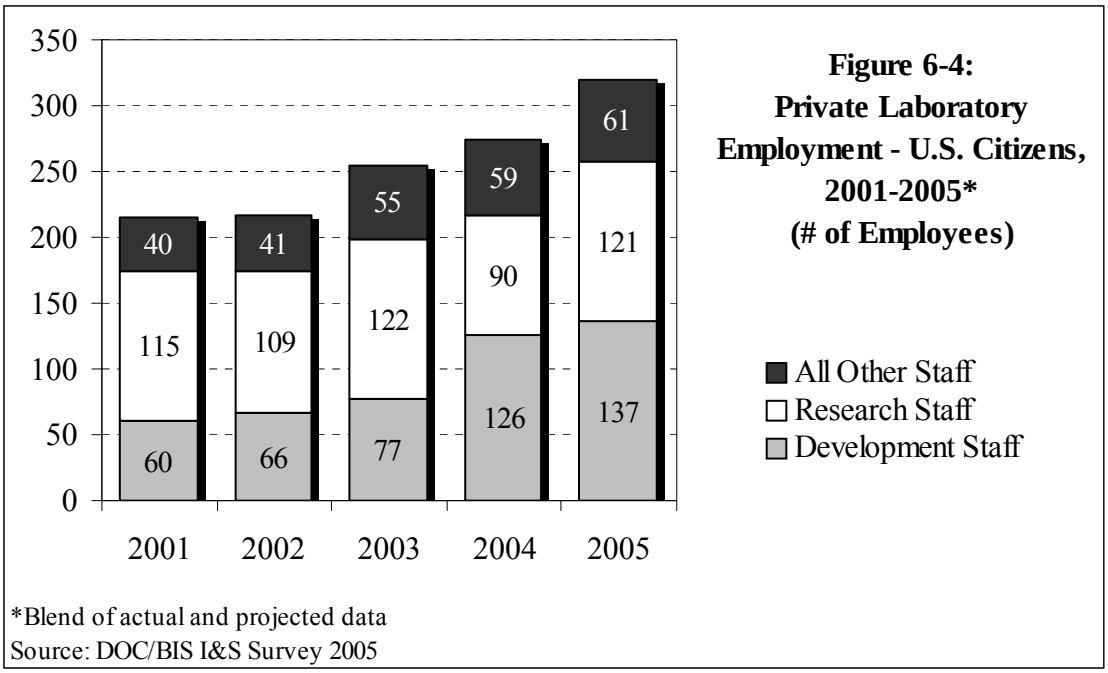


Figure 6-4: Private Laboratory Employment - U.S. Citizens, 2001-2005* (# of Employees)

*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.

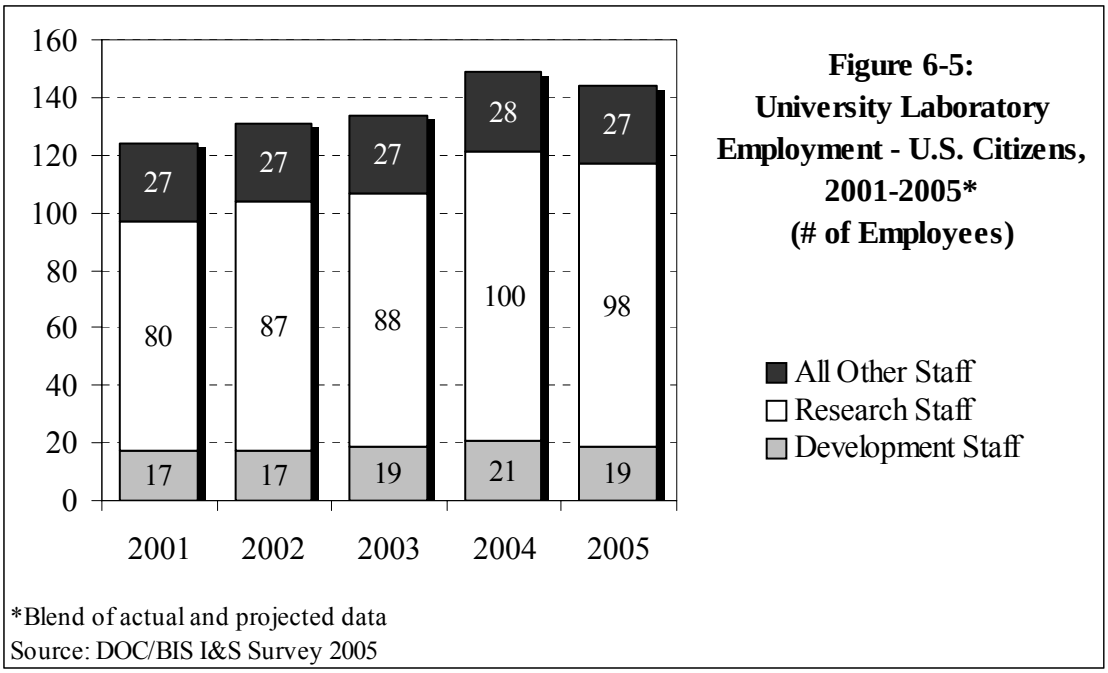


Figure 6-5: University Laboratory Employment - U.S. Citizens, 2001-2005* (# of Employees)

*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).

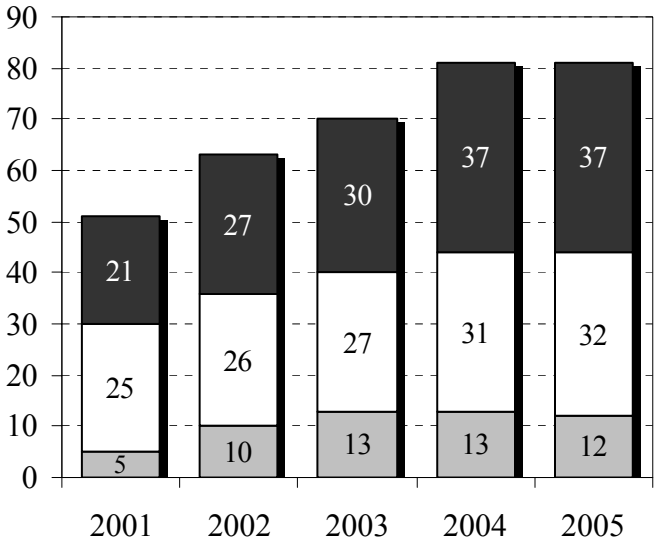


Figure 6-6: Private, Government and University Laboratory Employment - Non-U.S. Citizens, 2001-2005* (# of Employees)

All Other Staff
Research Staff
Development Staff

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

E.1 Private Industry Laboratories

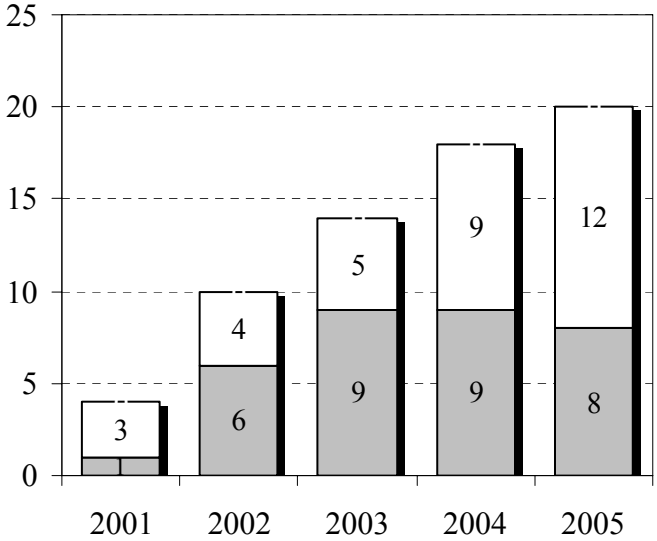


Figure 6-7: Industry Employment Non-U.S. Citizens, 2001-2005* (# of Employees)

Research Staff
Development Staff

*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.

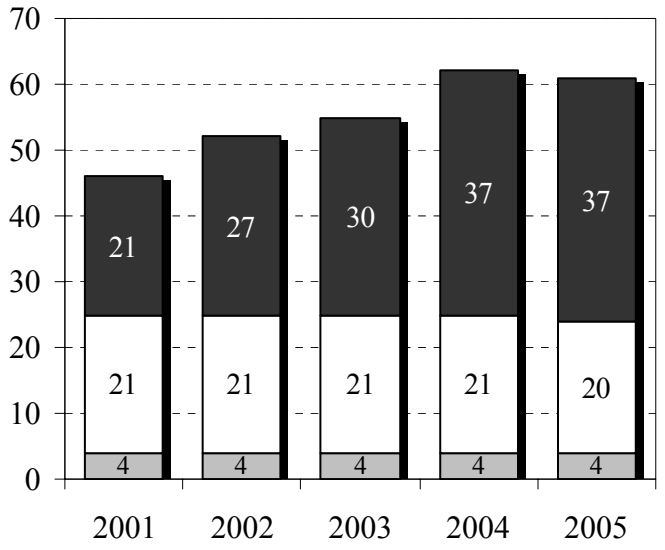


Figure 6-8: University Laboratory Employment - Non-U.S. Citizens, 2001-2005* (# of Employees)

All Other Staff
Research Staff
Development Staff

*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.

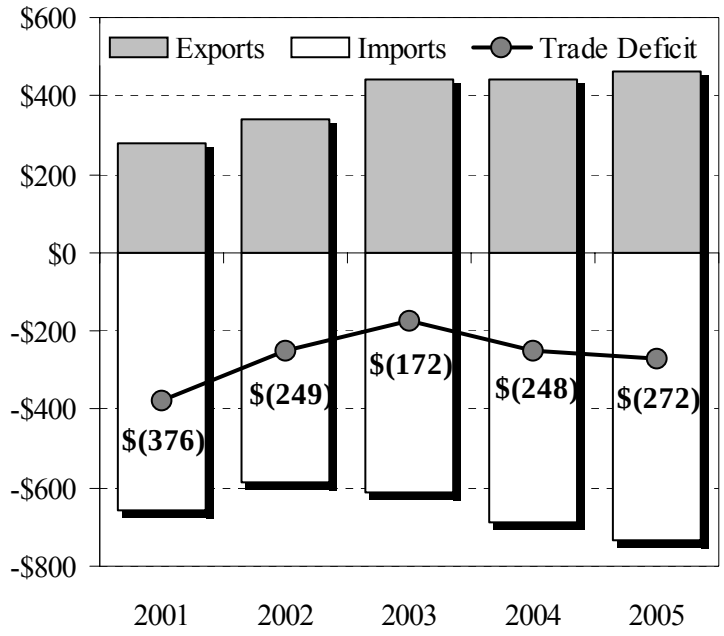


Figure 7-1: U.S. Imports and Exports of Imaging and Sensors Products 2001-2005* (in $millions)

*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.

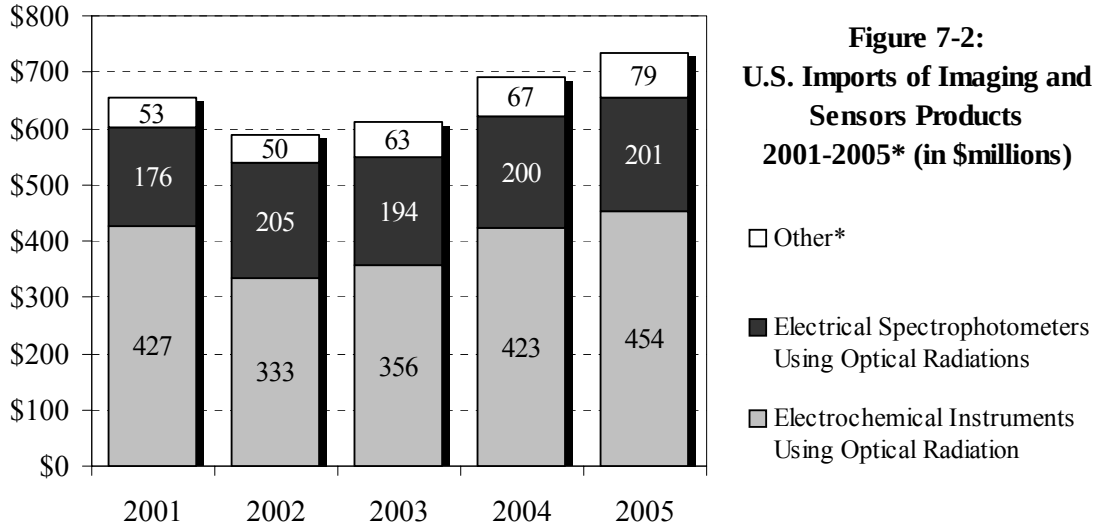


Figure 7-2: U.S. Imports of Imaging and Sensors Products 2001-2005* (in $millions)

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.

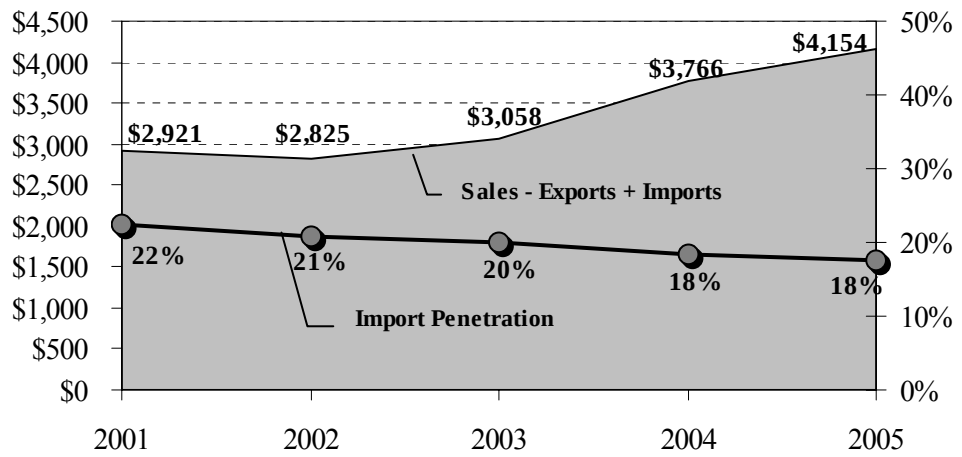
Table 7-1: U.S. Imaging and Sensors Import Sources, 2001-2005 (in $millions)

	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

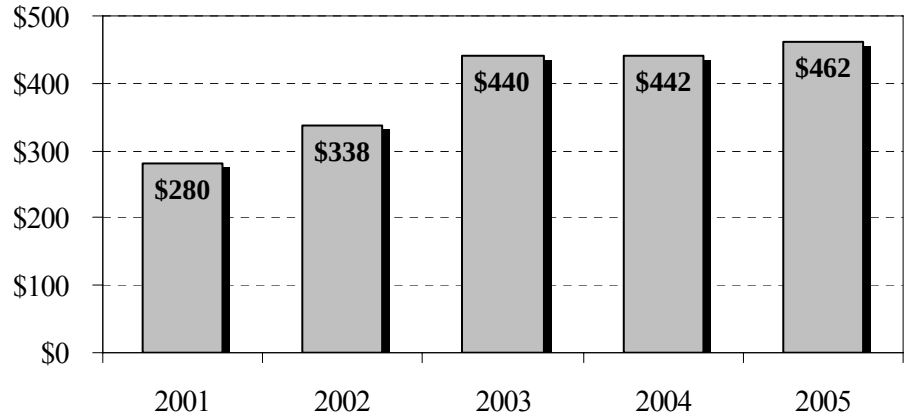
A total of 91 firms reported exports of imaging and sensors products during 2001-2005. U.S. exports reached $462 million in 2005, from $280 million in 2001 (see Figure 7-4). This 65 percent growth in exports since 2001 compares to import growth of 12 percent during the same period.

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%**

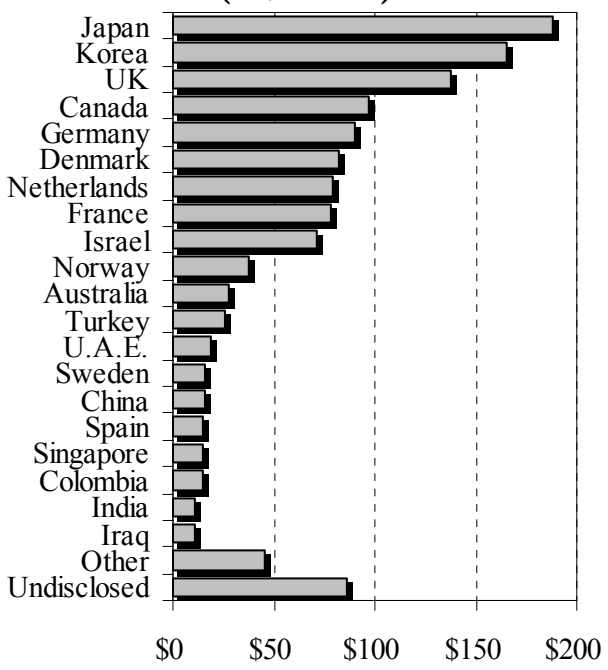
*Blend of actual and projected data
Source: DOC/BIS I&S Survey 2005

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).

Figure 7-5: U.S. Exports of Imaging and Sensors Products 2001-2005* Aggregate (in $millions)

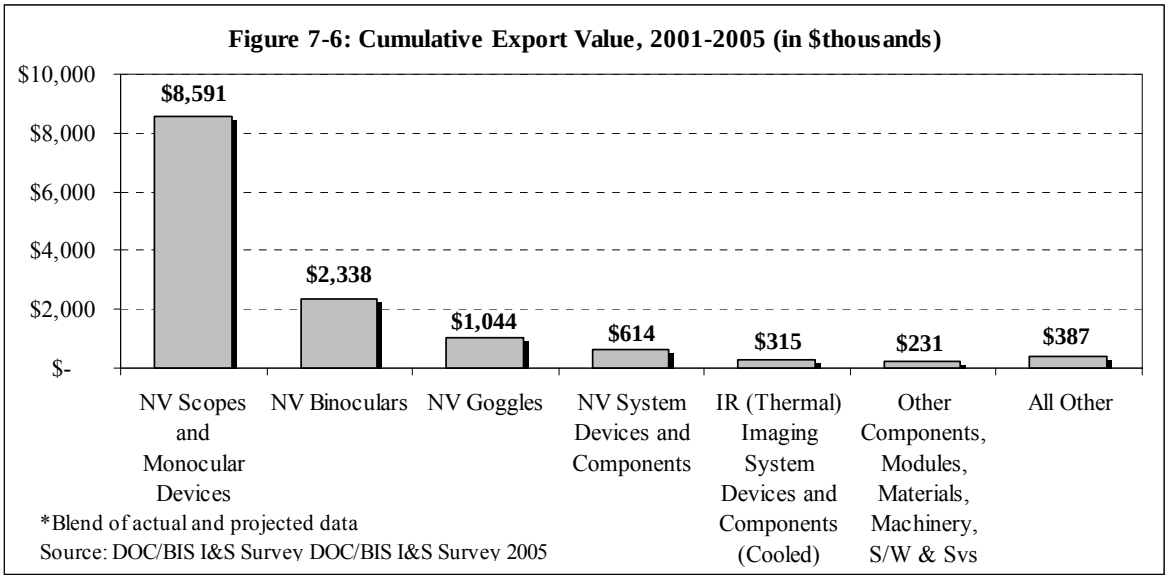


*Blend of actual and projected data
Source: DOC/BIS I&S Survey DOC/BIS I&S Survey 2005

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

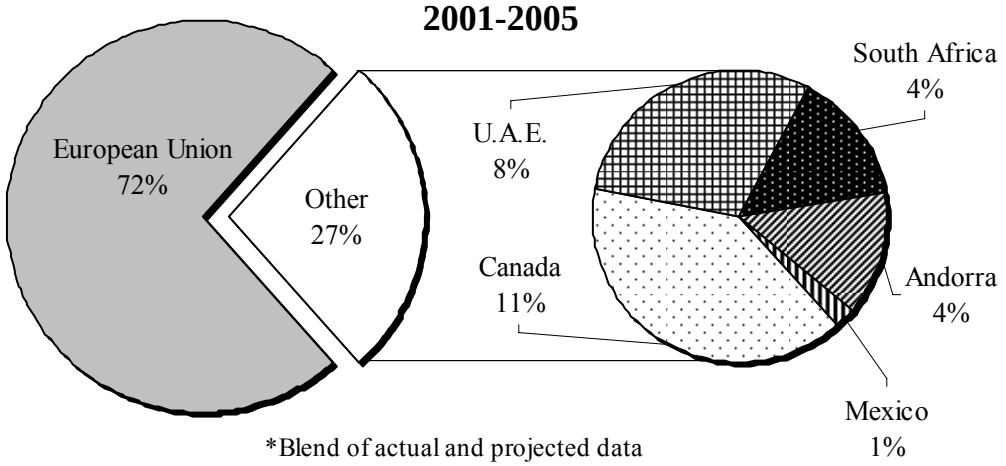
A total of 14 companies classified as retailers, distributors, brokers, or resellers of imaging and sensor products reported earnings attributed to exports during 2001-2005. Cumulative exports for this group during the five-year period totaled $13.5 million. Four of the top five export categories were 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.



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.

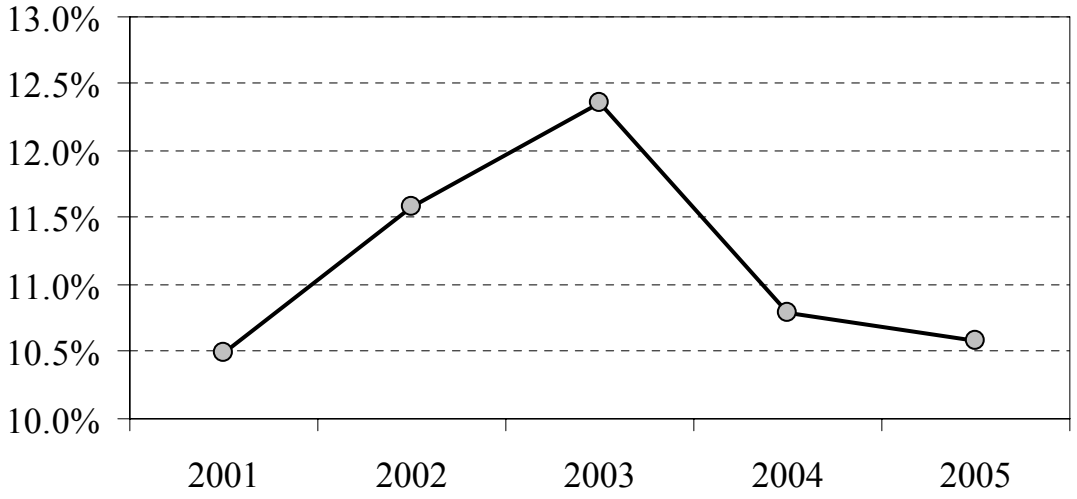
Table 7-3: Global Exports of Imaging and Sensors Products, by Country (in $millions)

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
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.

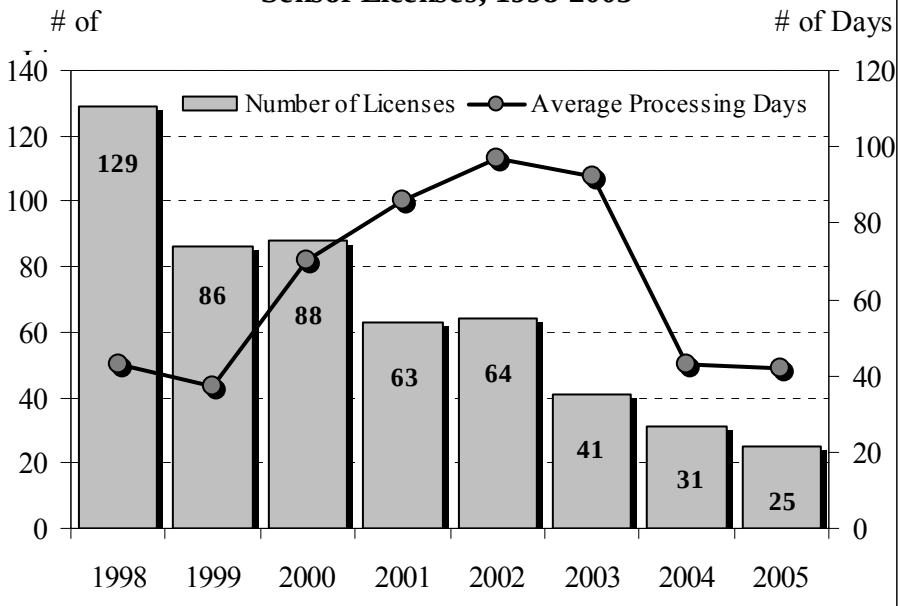
---

[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

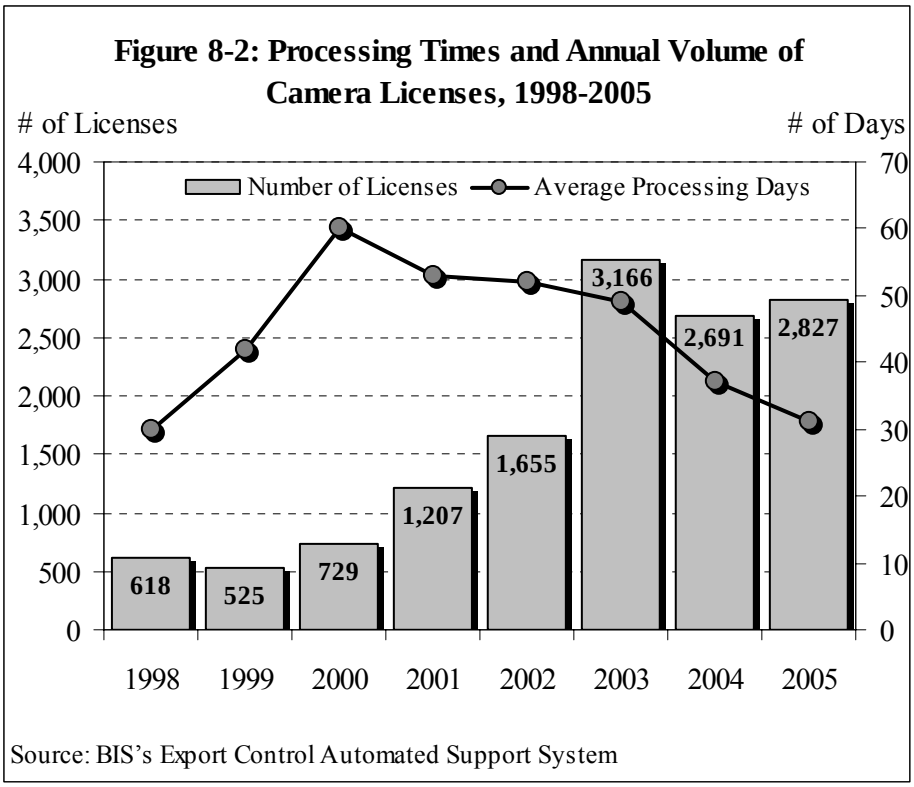
An examination of the licensing history of sensors (ECCN 6A002) from DOC over the past eight years indicates that the annual volume of licenses steadily dropped from 129 in 1998 to only 25 in 2005. The average processing time (in days) was nearly the same in 1998 (43 days) as in 2005 (42 days), though 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

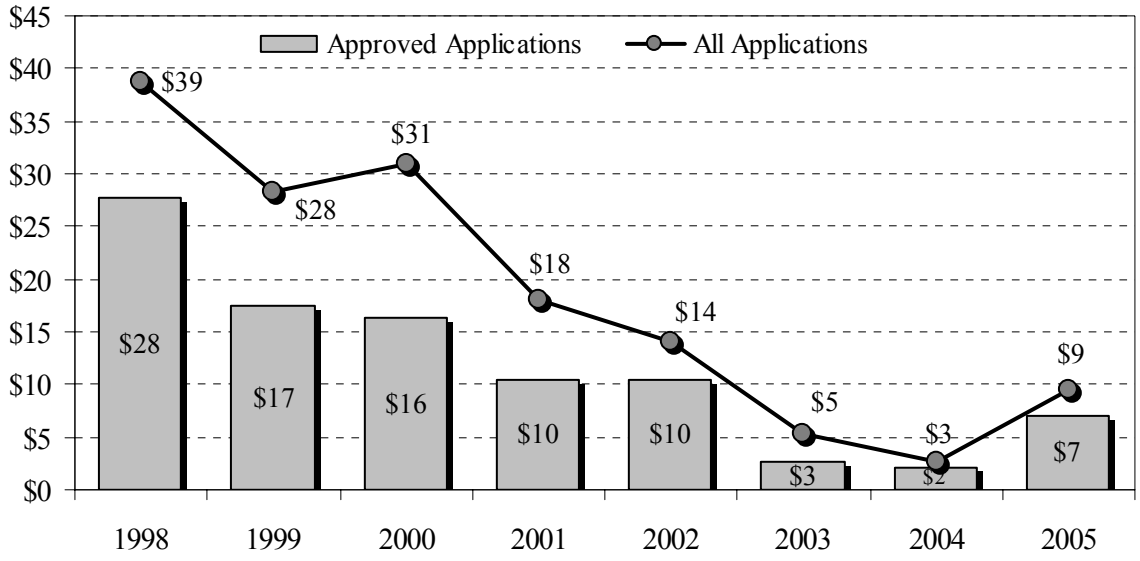
In contrast, the licensing history of cameras (ECCN 6A003) from DOC over the same eight year period indicates rapid growth in annual volume, from 618 licenses in 1998 to 2,877 in 2005, with a spike to 3,166 in 2003. After a 15-percent drop in 2004, license volume climbed 5 percent in 2005. Average processing 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.

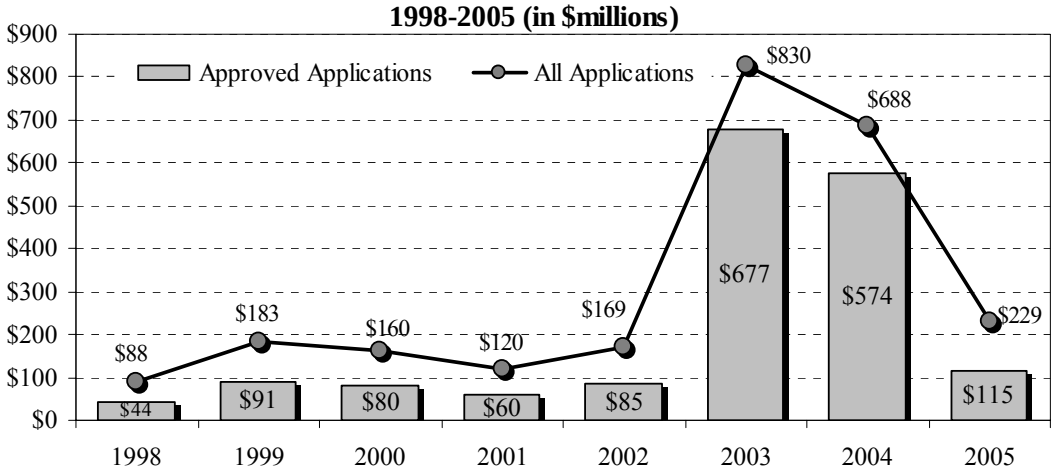
Figure 8-3: License Applications for Sensors-DOC, 1998-2005 (in $millions)



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)

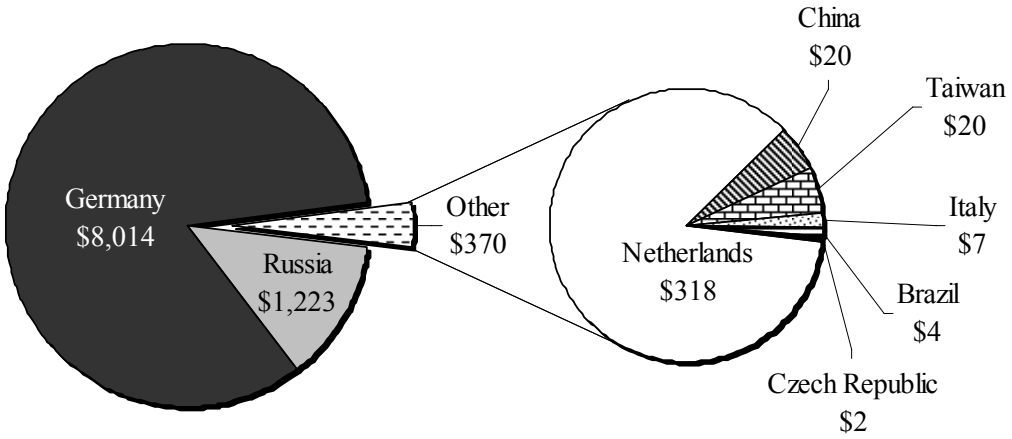


*From 2001 to 2004, portions of the EAR that affect export controls of sensors and cameras were amended, though amendments did not have a significant impact on the total annual license values or volume. One exception however involved the decontrol of night vision cameras used in automobiles produced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

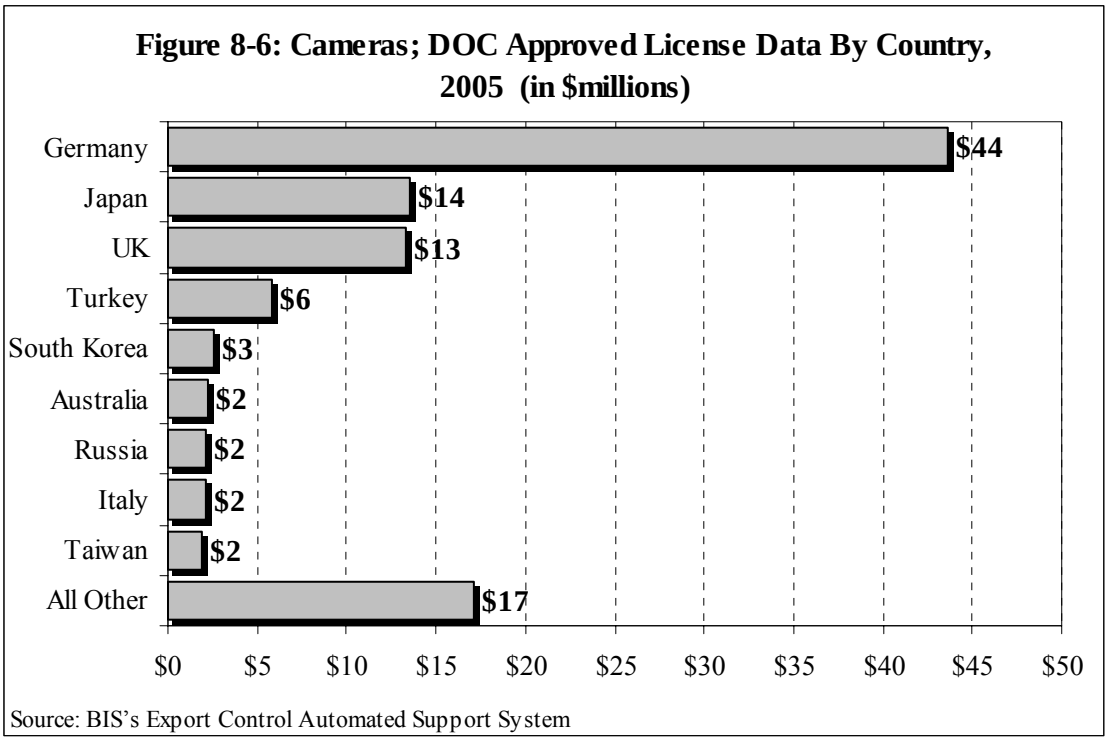
Source: BIS's Export Control Automated Support System

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



C. ITAR Controls

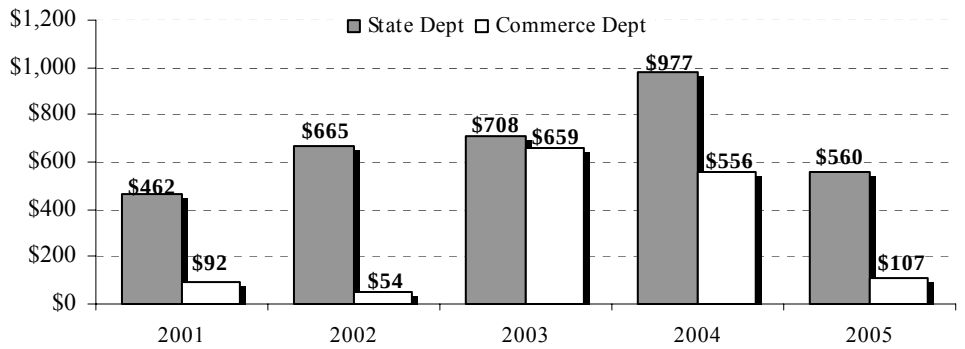
The ITAR classifies imaging and sensors products into one section of the regulations, Category XII, paragraph C, entitled Fire Control, Range Finder, Optical and Guidance and Control Equipment. The ITAR operates differently from the EAR in terms of product coverage. If an item is subject to the ITAR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

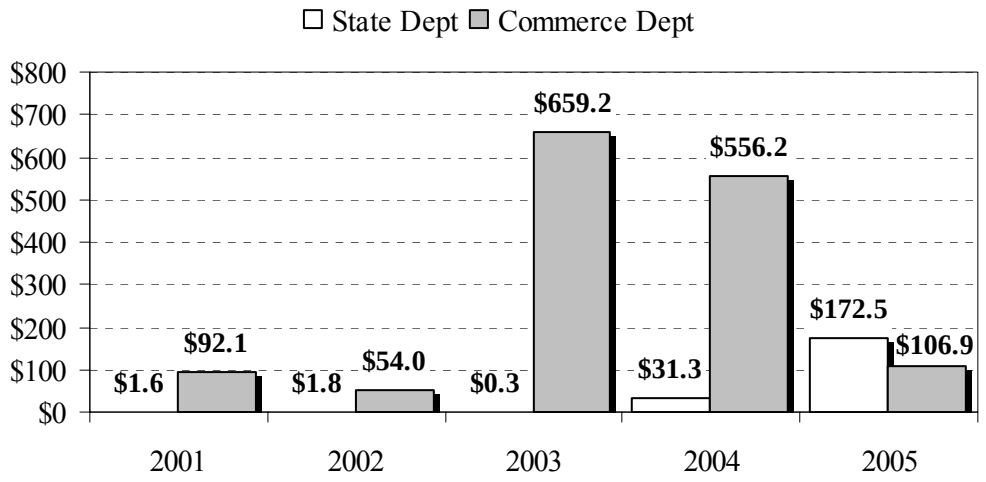
D.1 Export Controls and the Uncooled Thermal Imaging Sector

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.

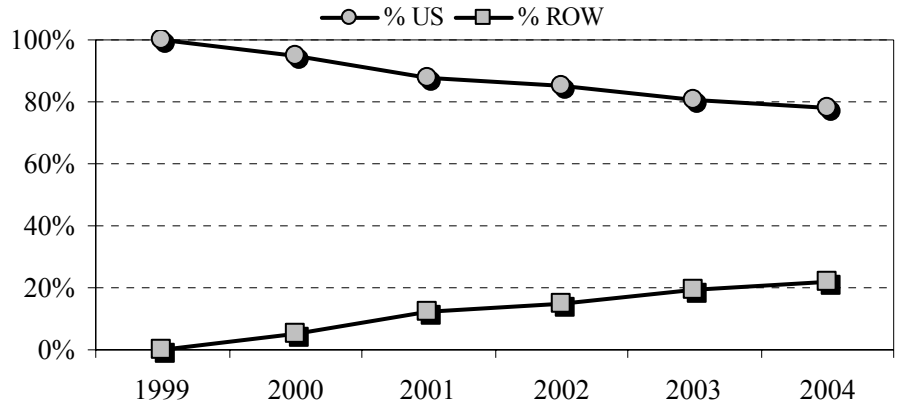
China, which has several companies that export thermal imaging cameras and is not a WA Participating State, does not require an export license for any exports of dual-use thermal imaging cameras. Survey respondents expect China to be a major competitor in future years.

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]

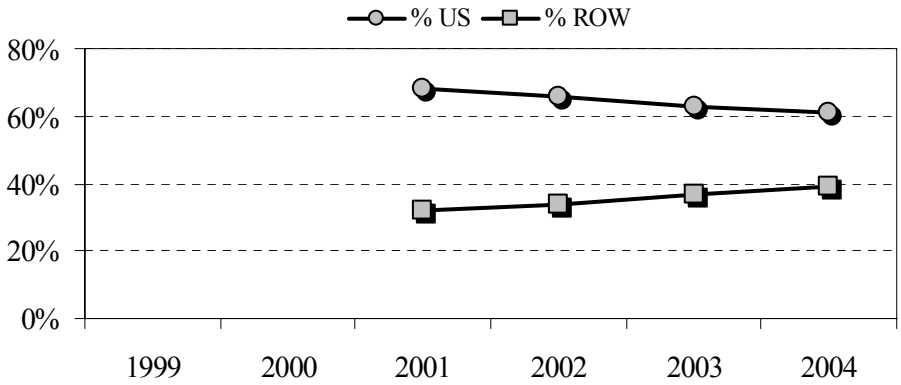
[18] Maxtech International, Inc.
[19] Ibid.

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** Who Must Respond/Exemptions (page 3) **PAGE 3**	Changes in Government expenditures (page 19) **PAGE 29** 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.

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.

_____

_____

_____

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					

BUSINESS CONFIDENTIAL

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 -** Please 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.	

BUSINESS CONFIDENTIAL

SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

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							

BUSINESS CONFIDENTIAL

SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

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					

BUSINESS CONFIDENTIAL

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 ❐				

BUSINESS CONFIDENTIAL

SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

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)				

BUSINESS CONFIDENTIAL

SURVEY OF MANUFACTURERS/INTEGRATORS/SERVICE PROVIDERS

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 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