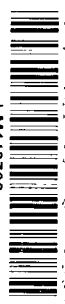


GAO

General Studies and Investigations Office

Report of the Chairman, Subcommittee on Oversight and Investigations

STANDARD AND METROLOGICAL PROCEDURE



LM140733

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United States  
General Accounting Office  
Washington, D.C. 20548

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**National Security and  
International Affairs Division**

B-223094

February 7, 1990

The Honorable John D. Dingell  
Chairman, Subcommittee on  
Oversight and Investigations  
Committee on Energy and Commerce  
House of Representatives

Dear Mr. Chairman:

In response to your December 14, 1988, letter, we reviewed the extent of foreign contracting in the Strategic Defense Initiative Program. Unless you publicly announce its contents earlier, we plan no further distribution of this report until 15 days after its issue date. At that time we will send copies to the Chairmen, House and Senate Committees on Appropriations and on Armed Services; the Secretary of Defense; the Director, Office of Management and Budget; and other interested parties.

Please contact me on (202) 275-4268 if you or your staff have any questions concerning this report. Other major contributors to this report are listed in appendix II.

Sincerely yours,

A handwritten signature in cursive script that reads "Nancy R. Kingsbury".

Nancy R. Kingsbury  
Director  
Air Force Issues

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# Executive Summary

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## Purpose

The Strategic Defense Initiative Program, announced by President Reagan in 1983, is intended to conduct research on possible ballistic missile defense systems for the United States and its allies. Since 1985 several allied countries have participated in this program. Because of his concerns about the amount of foreign contracts, the Chairman, Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, asked GAO to analyze the level and type of foreign participation in the Strategic Defense Initiative Program.

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## Background

The Strategic Defense Initiative Organization manages the Strategic Defense Initiative Program and allocates annual appropriations to seven program elements. Five of these program elements—Surveillance, Acquisition, Tracking, and Kill Assessment; Directed Energy Weapons; Kinetic Energy Weapons; Systems Analysis and Battle Management; and Survivability, Lethality, and Key Technologies—involve foreign contracting. The Strategic Defense Initiative Organization, the Army, the Navy, the Air Force, the Defense Nuclear Agency, and the Department of Energy administer the foreign contracts.

The Secretary of Defense has signed Memorandums of Understanding, which address broad-ranging government-to-government issues, with the Federal Republic of Germany, Israel, Italy, Japan, and the United Kingdom to facilitate foreign participation in the Strategic Defense Initiative Program. In addition, the Strategic Defense Initiative Organization has signed two Memorandums of Agreement with Israel and one with the Netherlands and one Cooperative Research Arrangement with the United Kingdom, which address the implementation of specific projects.

The flow of classified technology from the United States to foreign countries is controlled by legislation and executive regulations, including the Arms Export Control Act, as amended, and the National Disclosure Policy. These laws and regulations set forth procedures for exporting classified information, including obtaining an export license.

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## Results in Brief

GAO identified 67 foreign contracts valued at \$297.1 million, which represents about 3 percent of total Strategic Defense Initiative contract awards, and 86 foreign subcontracts from U.S. companies totaling \$48.4 million. The basis of award for the 67 foreign contracts was more often competitive than sole source, although sole-source awards accounted for a higher dollar amount. The basis of award by each of the U.S. agencies

administering foreign contracts varied. Israel has received the largest dollar value of contracts among foreign recipients.

Department of Defense and foreign embassy officials said that foreign contracts allow the United States not only to share technology with other countries but also benefit from technological developments in those countries.

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## GAO's Analysis

GAO identified 67 foreign contracts in eight countries valued at \$297.1 million. Of this amount, \$228.4 million had been obligated by March 31, 1989. At least \$31.6 million, or about 14 percent of total foreign contract obligations, was committed to U.S. subcontractors or other organizations.

In addition, organizations in 11 countries received 86 subcontracts from U.S. companies totaling \$48.4 million. Of this amount, 64 percent went to British organizations.

Allied participation in the Strategic Defense Initiative Program centers on theater missile defense, which accounts for 69 percent of the total foreign contract amount. Theater missile defense is the defense of an allied geographic area against ballistic missile attack.

Israel received the largest dollar amount of Strategic Defense Initiative foreign contracts (\$141.7 million). One Israeli company was awarded \$126.4 million under the largest individual foreign contract. The United Kingdom received the most foreign contracts (36).

About 57 percent of the foreign contracts were awarded on a competitive basis, but sole-source contracts accounted for 57 percent of total obligations. The basis of award varied by executing agency. For example, the Air Force awarded all of its contracts competitively, whereas all Defense Nuclear Agency contracts were awarded sole source.

The Strategic Defense Initiative Organization maintains a database on foreign contracts and subcontracts. The database was overstated by \$8.5 million and was frequently in error regarding details on individual contracts. The organization is attempting to improve the database by integrating it with other sources of information in its new management information system, which was not operational at the time of GAO's review.

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Department of Defense and foreign embassy officials said that even though the United States sends its technology overseas, it also receives technology from foreign countries. For example, the United States is providing an Israeli organization working on an electromagnetic railgun (used for firing projectiles at very high velocities) with barrels, capacitors, and a high-speed camera. In return, the Strategic Defense Initiative Organization is receiving a demonstration of the research results. The procedures for transferring technology in accordance with U.S. legislation and executive regulations can be time-consuming and, according to Department of Defense and foreign embassy officials, may limit foreign participation in the Strategic Defense Initiative Program.

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## Recommendations

GAO is not making recommendations in this report.

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## Agency Comments

The Department of Defense concurred with the information in this report. The Department's comments appear in appendix I.



# Contents

<b>Executive Summary</b>		<b>2</b>
<b>Chapter 1</b>		<b>8</b>
<b>Introduction</b>	SDI Foreign Contracting Database	8
	Objectives, Scope, and Methodology	10
<b>Chapter 2</b>		<b>11</b>
<b>Analysis of SDI Foreign Contracts</b>	Foreign Contractor Awards	11
	International Agreements	13
	Flow of Technology	14
	Transfer of Technology	15
<b>Chapter 3</b>		<b>18</b>
<b>Description of SDI Foreign Contracts</b>	Theater Missile Defense	18
	Surveillance, Acquisition, Tracking, and Kill Assessment	22
	Directed Energy Weapons	24
	Survivability, Lethality, and Key Technologies	26
	Innovative Science and Technology	27
	Miscellaneous Contracts	28
<b>Chapter 4</b>		<b>29</b>
<b>Description of SDI Foreign Subcontracts Awarded by U.S. Contractors</b>	Directed Energy Weapons	30
	Kinetic Energy Weapons	31
	Innovative Science and Technology	31
	Survivability, Lethality, and Key Technologies	31
<b>Appendixes</b>	Appendix I: Comments From the Department of Defense	32
	Appendix II: Major Contributors to This Report	34
<b>Tables</b>	Table 2.1: Foreign Contracts by Country	11
	Table 2.2: Basis of Contract Award by Executing Agency	13
	Table 3.1: Foreign Contracts by Program	18
	Table 4.1: Foreign Subcontracts by Country	29
<b>Figures</b>	Figure 2.1: Basis of Award by Number of Contracts	12
	Figure 2.2: Basis of Award by Value of Contracts	13

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**Abbreviations**

DOD	Department of Defense
GAO	General Accounting Office
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
NATO	North Atlantic Treaty Organization
SDI	Strategic Defense Initiative
SDIO	Strategic Defense Initiative Organization



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# Introduction

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When President Reagan announced the Strategic Defense Initiative (SDI) Program in March 1983, he emphasized that SDI should enhance allied as well as national security. To accomplish this, in March 1985 the Secretary of Defense formally invited 18 countries to participate directly in SDI research. The purpose of the SDI Program is to conduct research on possible ballistic missile defense systems for the United States and its allies.

The SDI Program is managed by the Strategic Defense Initiative Organization (SDIO), which allocates its annual appropriation to seven program elements. Five of the program elements—Surveillance, Acquisition, Tracking, and Kill Assessment; Directed Energy Weapons; Kinetic Energy Weapons; Systems Analysis and Battle Management; and Survivability, Lethality, and Key Technologies—involve foreign contracting. The other program elements are the Phase I Strategic Defense System, which is expected to receive funds for the first time in fiscal year 1990, and Management Headquarters, which provides administrative and other support to the SDI Program. Most of the program is executed by organizations other than SDIO, including the Army, the Navy, the Air Force, the Defense Nuclear Agency, and the Department of Energy, all of which are involved in foreign contracting.

SDIO has attempted to facilitate foreign participation through the use of Memorandums of Understanding (MOU) and Memorandums of Agreement (MOA), both of which address certain procedures and obligations regarding such issues as the transfer of classified information. MOUs address broad-ranging government-to-government issues, whereas MOAs focus on implementing a particular project. Since the SDI Program's inception, five countries have signed MOUs: the United Kingdom in 1985; Israel, Italy, and the Federal Republic of Germany in 1986; and Japan in 1987. Three MOAs have been signed to date: one with the Netherlands in 1987 and two with Israel in 1988 and 1989. A cooperative research arrangement, similar to an MOA, was signed with the United Kingdom in 1988.

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## SDI Foreign Contracting Database

SDIO's Office of Multinational Programs maintains a database on foreign contracts and subcontracts. We found that the database was overstated by \$8.5 million and was frequently in error regarding details on individual contracts. To improve its foreign contracting database, SDIO has recently begun integrating foreign contracting data into its new management information system. We did not review this system because it was not operational at the time of our review.

The database we reviewed contained information concerning each contract and subcontract, including effective start date; contract or subcontract number; a brief description; name and country of the contractor and/or the subcontractor; amount obligated by fiscal year; total contract funding; and contract or subcontract status (either ongoing or completed). According to officials of the Office of Multinational Programs, compilation of the database has been a labor-intensive process, depending heavily on the Department of Defense's (DOD) primary contract monitoring system (the DD-350 system) and contacts with DOD contracting officers, embassy officials, and contractors.

The Director of the Office of Multinational Programs said that maintaining such a database is not a requirement. Rather, the office created it for use as a reference source and for those interested in information on allied participation in the SDI Program. No other SDIO office maintains detailed information about foreign subcontracts. The Director added that SDIO is integrating the database into SDIO's management information system, but full integration is not expected until 1990. The Director said the management information system is expected to provide improved information about contract status. The system may also include subcontract information, but the Director said that obtaining this information will continue to be difficult.

To verify the accuracy of the database, we examined all contracts listed in the March 31, 1989, version of the database that were valued at over \$1 million and located at various DOD agencies in the Washington, D.C., area or at the Army Strategic Defense Command in Huntsville, Alabama. These contracts amounted to 85 percent of the foreign contracting total. We found that the two most common inaccuracies involved the contract date and the contract amount. For example, contract amounts were frequently incorrect either because they did not reflect contract modifications that had recently been made or they were allocated to the wrong fiscal years. The database total of \$321.5 million was close to the total we calculated of \$313.0 million partly due to offsetting errors. (Both amounts excluded obligations to U.S. subcontractors.) For example, the database erroneously showed that over \$24.2 million had been obligated to U.S. subcontractors, but we found that over \$12.5 million in foreign contracts and subcontracts had not been listed in SDIO's database.

The Director of the Office of Multinational Programs said that his office monitors foreign contracts to answer questions regarding foreign participation in the SDI Program. The Director added that contract information or changes are not systematically reported to his office, and thus the

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database is likely to contain some errors, especially for information regarding subcontracts.

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## Objectives, Scope, and Methodology

Because of his concern about the amount of foreign contracts awarded under the SDI Program, the Chairman, Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, asked us to analyze the level and type of foreign participation in the program.

We interviewed officials from SDIO; the Air Force Systems Command's Aeronautical Systems Division, Electronic Systems Division, Rome Air Development Center, Space Systems Division, Air Force Weapons Laboratory, and Wright Aeronautical Laboratories; the Air Force Office of Scientific Research; the Army Strategic Defense Command; the Office of Naval Research; the Naval Research Laboratories; the Naval Surface Warfare Center; the Naval Weapons Center; the Defense Nuclear Agency; the Department of Energy; two U.S. universities; and the embassies of Canada, the Federal Republic of Germany, Japan, and the United Kingdom. In addition, we reviewed contract files and other agency records. We conducted our review between January and August 1989 in accordance with generally accepted government auditing standards.

DOD concurred with our report. Its comments appear in appendix I.

# Analysis of SDI Foreign Contracts

As of March 31, 1989, the executing agencies of the SDI Program had awarded 67 contracts to foreign contractors in 8 countries. These contracts are valued at \$297.1 million, \$228.4 million of which has been obligated. The contract value represents about 3 percent of total SDI contract awards.

## Foreign Contractor Awards

The 67 foreign contracts awarded to foreign governments, companies, and universities ranged from a \$10,000 contract with an Italian company for chemicals to a \$126.4 million contract with an Israeli firm for an experimental missile defense system. These contracts were awarded both competitively and sole source. At least \$31.6 million, or about 14 percent, was obligated to U.S. companies and universities as subcontracts and procurement orders.

Israel was the largest recipient of SDI contracts in terms of dollars, receiving \$141.7 million. In terms of the number of contracts, the United Kingdom was the largest recipient, receiving 36 contracts, as shown in table 2.1.

**Table 2.1: Foreign Contracts by Country**

Dollars in millions							
Country	No. of contracts	Award total	Amount obligated				Total
			FY 85-86	FY 87	FY 88	FY 89	
<b>Countries with MOUs</b>							
Israel	8	\$141.7	\$0.6	\$7.6	\$22.8	\$55.3	\$86.3
West Germany	9	64.8	6.4	19.7	30.4	6.6	63.1
The United Kingdom	36	56.7	3.9	17.8	15.4	10.1	47.1
Italy	6	15.3	0.0	4.4	7.9	3.0	15.3
Japan	1	3.0	0.0	0.0	1.2	0.0	1.2
<b>Subtotal</b>	<b>60</b>	<b>281.5</b>	<b>11.0</b>	<b>49.4</b>	<b>77.7</b>	<b>74.9</b>	<b>213.0</b>
<b>Countries without MOUs</b>							
France	2	8.5	0.1	2.6	4.4	1.3	8.5
The Netherlands	1	5.0	0.0	4.0	1.0	0.0	5.0
Canada	4	2.2	0.2	0.6	0.5	0.6	1.9
<b>Subtotal</b>	<b>7</b>	<b>15.6</b>	<b>0.3</b>	<b>7.2</b>	<b>6.0</b>	<b>1.9</b>	<b>15.4</b>
<b>Total</b>	<b>67</b>	<b>\$297.1</b>	<b>\$11.3</b>	<b>\$56.6</b>	<b>\$83.7</b>	<b>\$76.8</b>	<b>\$228.4</b>

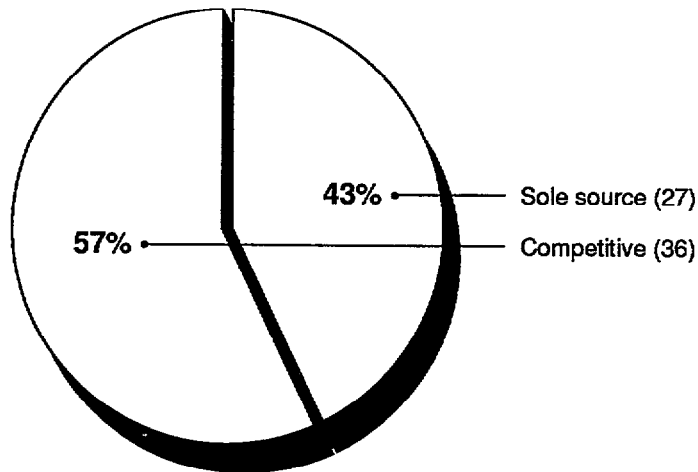
Note: Totals may not add due to rounding.

Note: Dollar amounts for award total, fiscal year 1989 amount obligated, and total amount obligated are as of March 31, 1989.

SDIO has awarded more foreign contracts than any of the other executing agencies. SDIO's contract awards amount to \$156.3 million, or 68.5 percent of the total amount obligated to date. This large amount is due to SDIO's interest and expertise in contracting with foreign organizations, according to SDIO officials. The Army is second with contract obligations of \$43.9 million, or 19.2 percent, and the Air Force is third with \$14.3 million, or 6.3 percent.

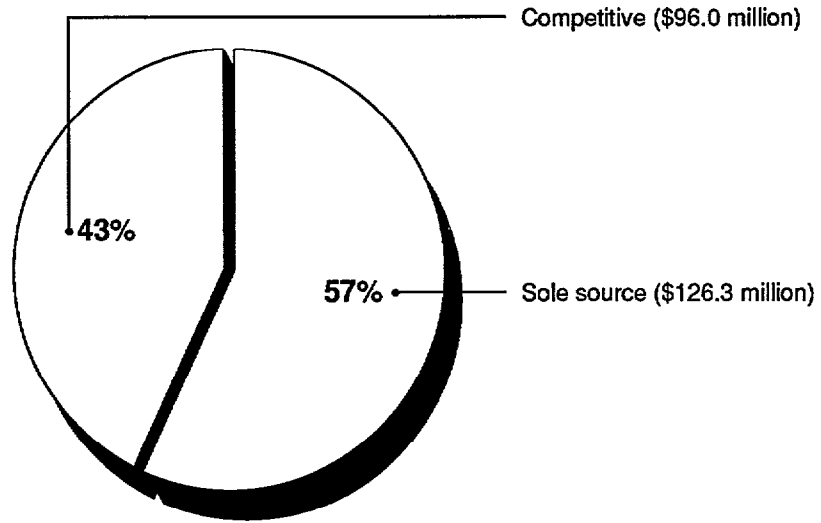
The basis of award is known for 63 of the 67 contracts awarded. (Information regarding the basis of award for four contracts was not readily available.) Of the 63, 36, or 57 percent, were awarded competitively, and 27, or 43 percent, were awarded sole source (see fig. 2.1). However, the sole-source contracts were valued (based on obligations to date) at \$126.3 million, or 57 percent, whereas the competitive awards were valued at \$96.0 million, or 43 percent (see fig. 2.2). The basis of these contract awards varied by executing agency, as shown in table 2.2.

Figure 2.1: Basis of Award by Number of Contracts



Note The basis of award for four contracts, valued at \$6.1 million, is unknown.

Figure 2.2: Basis of Award by Value of Contracts



Note: The basis of award for four contracts, valued at \$6.1 million, is unknown.

Table 2.2: Basis of Contract Award by Executing Agency

Executing agency	Basis of award			Total
	Competitive	Sole source	Unknown	
Air Force	7	0	0	7
Army	6	4	0	10
Defense Nuclear Agency	0	5	0	5
Department of Energy	3	2	0	5
Navy	16	1	0	17
SDIO	4	15	1	20
Other	0	0	3	3
<b>Total</b>	<b>36</b>	<b>27</b>	<b>4</b>	<b>67</b>

## International Agreements

Many countries have agreements with DOD that predate the SDI Program. Some of these agreements are used to facilitate the exchange of information on SDI-related projects. In addition, SDIO has developed MOUs and MOAs that specifically address SDI issues with foreign countries such as ownership of information or products and security arrangements.

According to DOD officials, MOAs with Israel, the Netherlands, and the United Kingdom are more specific than MOUs because they relate to a particular project. The Netherlands' MOA details a cost-sharing program on electromagnetic launch technology. The first MOA with Israel outlines a cost-sharing program on an anti-tactical ballistic missile project. The

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second Israeli MOA addresses a cost-sharing program on a theater ballistic missile defense test bed.

One item covered in MOUs and MOAs, as well as in contracts, is intellectual property rights, which determine ownership of the information or products produced as a result of contractual work funded by the United States on SDI research. According to an SDIO official, background information already owned by a contractor and information developed independently of U.S. funding, both known as proprietary information, usually remain the contractor's property; thus, SDIO cannot share this information with other contractors without permission. However, the official said that for most U.S.-funded projects, including those in which costs are shared with another country, the United States receives unlimited rights to all information that is derived from work on the contract.

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## Flow of Technology

DOD officials told us that SDI foreign contracts allow the United States not only to share technology with other countries but also benefit from technological developments in those countries. SDIO officials gave us the following examples of foreign entities that are providing the United States with technologies related to SDI research.

- An Israeli entity working on an electromagnetic railgun (a device using electromagnetic launching to fire projectiles at very high velocities) is giving SDIO a demonstration of unique traveling charge and hybrid gun concepts for accelerating small projectiles to very high velocities. In return, SDIO is providing this entity with barrels, capacitors, and a high-speed camera.
- A Dutch organization working on an electromagnetic launch facility is providing SDIO with research and experimental data. In return, SDIO is providing a leased homopolar generator (a generator that has a unidirectional flow between the poles of a magnet), a switch, a capacitor, and barrels.
- An Italian company working on a "smart" electro-optic sensor is providing SDIO an innovative infrared focal plane array architecture for enhanced signal processing.
- A French university working on innovative methods for processing electronic and optical materials is providing the Air Force with chemical anion precursors (negatively charged ions used to form other substances) for producing superconductivity materials.

Neither the Italian company nor the French university are using U.S. technology in their research.

Officials from two of three embassies that provided comments to us regarding the flow of technology concurred with DOD officials that the flow of technology has been beneficial to the United States. One embassy official stated that “the flow [of technology from his country] to the [United States] has been sizeable, commensurate with the extent of the contracts and sub-contracts awarded.”

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## Transfer of Technology

The flow of certain U.S. technologies, such as classified information and products, from the United States to foreign entities is controlled through legislation and executive regulations. The laws and regulations discuss not only the procedures to be followed in transferring technology but also the criteria in approving such a transfer.

The transfer of technology is provided for under the Export Administration Act of 1979, as amended, and the Arms Export Control Act, as amended. The Export Administration Act is implemented by the Department of Commerce under the Export Administration Regulations. These regulations primarily address “dual use” commodities and information (i.e., commodities and information that are intended for commercial or nonmilitary use but may be used for military applications). The Arms Export Control Act, as amended, is administered by the Department of State under the International Traffic in Arms Regulations. These regulations require controlled handling of specified information and products related to military applications, as stipulated in the regulations’ munitions list. DOD officials said that most transfers of SDI-related technology occur under these regulations.

The National Disclosure Policy is used in approving technology to be sent overseas. The policy outlines criteria that are used to determine whether classified technology should be transferred to foreign entities. The criteria, according to DOD sources, are (1) the proposed transfer is to be consistent with overall U.S. policy toward the recipient country, (2) the positive effects of the proposed transfer is to outweigh the inherent risk to U.S. military security, (3) the proposed transfer is to result in a benefit to the United States that is at least of equal value to that of the technology at issue, (4) the scope of the proposed transfer—in terms of both quality and quantity—is to be consistent with the purpose to be served by the transfer, and (5) the recipient country has formally agreed to afford the U.S. technology it receives a degree of protection from unauthorized disclosure that is equivalent to that provided by the United States. According to DOD security officials, use of the first four



criteria is largely subjective and incorporates input from varied political-military perspectives, whereas use of the last criterion is basically objective.

Foreign entities receive classified U.S. technology by acting as either subcontractors to U.S. companies or prime contractors to the U.S. government. Transactions between U.S. companies and foreign subcontractors are subject to the International Traffic in Arms Regulations and its export licensing procedures, described in the next section. Foreign prime contractors receive technical data through the U.S. government according to international agreements that govern the transfer of classified technology. Such transfers to foreign prime contractors must comply with all provisions of the International Traffic in Arms Regulations and other technology transfer criteria, although the U.S. government entity does not need to actually acquire an export license.

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## Export License Procedures

As stipulated under the International Traffic in Arms Regulations, export license applications are made to the Office of Munitions Control of the Department of State. SDIO security officials said that although the Department of State usually consults U.S. agencies responsible for the classified technology, such as DOD, the Department of State makes the final decision in approving the license.

After an export license is approved, which DOD officials said normally takes about 6 weeks, the Defense Investigative Service transfers the technology to the foreign government. The foreign government then transfers the technology to the foreign subcontractor.

DOD officials told us that although foreign organizations have received classified technology through the export license procedures quickly, the process is sometimes very time-consuming. For example, an official told us that the Army received numerous complaints from U.S. contractors regarding delays in obtaining export licenses for foreign subcontractors developing European theater missile defense studies. Army and Department of Energy officials also told us that complicated and time-consuming procedures have limited foreign participation in the SDI Program.

One foreign embassy official said that many companies from his country "...are of the opinion that participation in U.S. defense-related work is unwarrantedly limited by restrictions on technology transfer." An official from another embassy stated that U.S. export laws are perceived as an inhibition to working with American firms. He added that another

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perception is that some bids are being rejected because of obstacles in obtaining an export license.

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## Other Procedures

The International Traffic in Arms Regulations provide several exemptions that give DOD the authority to disclose or transfer classified information without getting an export license. DOD officials described two exemptions that they said could be approved by the administering service. The first and most commonly used exemption is a plant visit that allows the disclosure of oral or visual classified information between U.S. and foreign entities, provided that the visit is sponsored by DOD and that normal DOD security requirements have been met. The second exemption allows for the actual transfer of classified technical data and is subject to the same security requirements as those for a plant visit. This exemption, according to security officials, has been used only once by SDIO.

# Description of SDI Foreign Contracts

We grouped the foreign contracts awarded through the SDI Program according to the programs that they support. These programs are Theater Missile Defense; Surveillance, Acquisition, Tracking, and Kill Assessment; Directed Energy Weapons; Survivability, Lethality, and Key Technologies; and Innovative Science and Technology. Other foreign contracts have been included in a miscellaneous category. Table 3.1 provides information about the contracts.

**Table 3.1: Foreign Contracts by Program**

Dollars in millions			
Program	No. of contracts	Amount	Percent of total amount
Theater Missile Defense	21	\$205.0	69.0
Surveillance, Acquisition, Tracking, and Kill Assessment	11	58.1	19.5
Directed Energy Weapons	7	18.7	6.3
Survivability, Lethality, and Key Technologies	11	7.9	2.7
Innovative Science and Technology	14	5.7	1.9
Miscellaneous	3	1.7	0.6
<b>Total</b>	<b>67</b>	<b>\$297.1</b>	<b>100.0</b>

## Theater Missile Defense

SDI research and development for the Theater Missile Defense program focuses on interception of enemy missiles before they reach their targets, known as active defense, and related command, control, communications, and intelligence. Theater Missile Defense projects include Architecture Studies, the Arrow Experiment, Foreign Technology Support, Test Bed, Command Center/System Operation and Integration Functions, and Combined Allied Defense Experiment/Invite, Show, and Test. The goal of these projects is to form a foundation for a layered defense against ballistic missiles. This program accounts for \$205.0 million, or 69.0 percent, of the total SDI foreign contract amount.

## Architecture Studies

The initial focus of foreign participation in theater missile defense was to establish architecture studies in different regions to determine the need for missile defenses and identify an effective defense system for each region. Architecture studies describe the functional activities to be performed to achieve a desired level of defense and include a description and performance levels of those system elements making up the functional activities.

In support of these studies, the United States awarded seven contracts totaling \$50.3 million to allied contractors participating in SDI research to focus on active defense and command, control, communications, and intelligence issues. The studies included analyses of the missile threat to the European countries of the North Atlantic Treaty Organization (NATO), the United Kingdom, the Middle East (Israel), and the Western Pacific Basin (Japan).

#### NATO Europe

Countries participating in SDI research in NATO Europe are conducting architecture studies to evaluate theater missile defense from a conventional/tactical viewpoint. Seven companies were competitively selected and given contracts by the Army. Three were contractors from France, Italy, and West Germany, which together received \$23.8 million. In addition, NATO Europe subcontractors of four American firms received \$5.7 million.

The studies have two phases. Phase I, completed in 1987, focused on alternate architecture concepts, critical technologies, and missions for a theater defense system, considering near-, mid-, and far-term threats posed by tactical ballistic missiles. Five of the seven contractors were selected to continue into phase II; the two contractors that were dropped were both from the United States. Phase II is focusing on developing detailed system specifications; identifying detailed battle management and command, control, and communications requirements; and developing implementation plans in post-Intermediate Nuclear Forces Treaty scenarios. It was scheduled to end in September 1989.

#### United Kingdom

A British government agency received two contracts from SDIO totaling \$13.2 million. One contract is for a European Architecture Study and is a sole-source award for \$12.7 million. This study is to provide a British perspective on a European strategic global nuclear defense, in contrast to the NATO Europe studies, which are from the perspective of an independent European defense system. The study is to look at the defenses of independent strategic retaliatory forces of the United Kingdom and France. The other contract is for artificial intelligence research, which is to discriminate decoys and other objects from actual targets (re-entry vehicles). This is a cost-shared contract in which the United States is providing \$500,000 in funding and the British government is providing \$185,000 in funding and labor.

#### Middle East

An Israeli government agency received \$10.3 million from SDIO to study theater missile defense issues in the Middle East. The objective of this study is to develop a threat assessment and a defense architecture

design. The contract also provides for developing an Israeli test bed concept definition program and defining the overall concept of the Israeli test bed and the approach that will be followed in the test bed's development and implementation. A test bed is a facility that provides the capabilities to compare, evaluate, and test alternative architectures; develop command center/system operation and integration functions; and provide the simulation for a strategic defense system.

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Western Pacific Basin

This study is designed to develop a complete threat assessment to the Western Pacific region, emphasizing the defense of Japan and other territories in the area. The study is also intended to characterize the threat against the allied sea lines of communication in the western Pacific. Contracts were awarded in November 1988 by SDIO to a Japanese contractor and a U.S. contractor, each receiving \$3.0 million.

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Arrow Experiment

As part of an ongoing cooperative effort to develop U.S. and allied capabilities in countering short-range missile threats, SDIO contracted with an Israeli company to demonstrate the capability of the Israeli Arrow missile to intercept a target representing a tactical ballistic missile. The contract, awarded in July 1988, is for \$150.1 million. Of this amount, the United States contributed \$126.4 million and Israel contributed \$23.7 million.

The experiment will consist of four phases, two of which have been completed. Phase I included a design feasibility study that evaluated performance requirements for the target vehicle and missile interceptor. Phase II involved design and test specification development for all components involved in the experiment. Phase III—the current phase—consists of hardware fabrication and subsystem assembly. During this phase, laboratory and ground tests are to be conducted to flight qualify and test missiles, software is to be developed, and propulsion and control tests are to be conducted. Phase IV will consist of three flight tests of the missile. At the end of the contract period, expected to be in July 1991, SDIO is to receive reports on the experiments and specifications and detailed drawings for the missile, its subsystems, and components.

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Foreign Technology Support

The purpose of Foreign Technology Support is to demonstrate the feasibility of foreign technologies, leading to their integration into kinetic energy and theater defense interceptor designs. To support this activity, SDIO has awarded five foreign contracts worth \$14.8 million.

Three of the contracts, worth \$10.4 million, involve research on electromagnetic railguns. One of these contracts is with an Israeli research center that is examining the feasibility of using a combination of electrical and chemical energy sources to produce ultrahigh velocities needed for an effective railgun weapon. According to contract records, the research, if successful, could negate the need for large costly power supplies. This, in turn, could reduce the weight of space-based railguns, the cooling requirements for the railguns, and the cost of placing railguns in orbit. SDIO is providing equipment, such as barrels, capacitors, and a high-speed camera, to the railgun research effort.

A fourth contract is for determining the merits of an exoatmospheric radar seeker, which uses external sensors to distinguish and focus on a target outside the earth's atmosphere, including assessing the lethality performance of an erectable or "pop-out" antenna. According to contract documents, this work may confirm that radar seekers offer certain advantages over infrared seekers.

A fifth contract is for investigating the feasibility of using fluidic diverter valves, which are nozzles on a kinetic energy weapon used to control its movement. The use of this valve may lead to higher operating efficiencies and thus lower propellant requirements and overall system weight.

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## Test Bed

SDI officials are developing a National Test Bed for the United States, an Extended Air Defense Test Bed for U.S. forces and allies in Europe, and an Israeli Test Bed for the Middle East. Two foreign contracts with a total value of \$8.4 million were awarded for this purpose.

The contract receiving the majority of the funding was awarded to a British government agency in September 1988 for \$8.1 million. The British government is contributing an additional \$6.2 million to the project. This contract is for developing an Extended Air Defense Test Bed in the United Kingdom. Extended air defense is defined as defense against tactical ballistic missiles, cruise missiles, and aircraft. The test bed will consist of the computer hardware and software needed to evaluate ongoing extended air defense research and simulate an extended air defense in Western Europe.

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**Command Center/System  
Operation and Integration  
Functions**

This activity is to identify targets, allocate interceptors, execute and assess the defense, and manage resources. Three foreign contracts, with a total value of \$3.9 million, were awarded sole-source to support this activity.

The largest of these contracts, for \$3.3 million, was awarded to a British government agency that is to derive a battle management and command, control, and communications architecture to complement the European Architecture Study. According to an Army contracting official, the study, which was completed in August 1988, provided an independent perspective of a European battle management and command, control, and communications system and applicable issues, technologies, systems, and concepts.

The other two contracts involved the development and validation of an architecture model for sensor data fusion in SDI systems and the design and development of computer software to support SDI network simulations.

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**Combined Allied Defense  
Experiment/Invite, Show,  
and Test**

This activity is to test and evaluate U.S. and allied technological systems and subsystems and make recommendations for their use as elements of an interim theater missile defense capability. After soliciting proposals for applicable technologies, the Army awarded nine contracts based on proposals from six U.S. organizations and three British firms.

All three British contracts, totaling \$1.2 million, were awarded in 1988 and completed in 1989. One contract evaluated an enhanced warhead consisting of laser-guided darts through simulation, one conducted simulation testing of a missile that is used for ship defense and is to be fitted with a new guidance system and possibly converted to a point defense weapon, and one tested the surveillance and fire control capabilities of an experimental radar and simulated the electronic counter-countermeasure capabilities of the radar in a hostile environment.

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**Surveillance,  
Acquisition, Tracking,  
and Kill Assessment**

This program element is to provide the research and technology development efforts necessary to identify and validate various sensor concepts needed through all stages of a missile attack: boost, post-boost, midcourse, and terminal. The SDI Program has awarded 11 contracts to foreign entities under this program element (not including several Innovative Science and Technology contracts discussed later), valued at

\$58.1 million. The largest of these contracts is for the Infrared Background Signature Survey. Other contracts were awarded to support several projects, including Passive Sensors, Support Technology, and Laser Radar Technology.

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## Infrared Background Signature Survey

Infrared Background Signature Survey research focuses on developing a means of identifying targets by their plumes, which are created by the exhaust of vehicles. Studying the relationship between plumes and vehicles may facilitate the differentiation of decoys from missiles with warheads.

In July 1986 SDIO awarded a West German company a \$48.0 million contract, but that amount may increase to \$77.5 million. The company is to upgrade the Shuttle Pallet Satellite carrier (also known as SPAS-01), which the company previously used to launch experiments from the shuttle; perform the survey with an infrared spectrometer; and provide post-flight analyses. During testing the survey will analyze the plume and environment of the orbiter, scan the earth limb (a layer of dust surrounding the earth), perform celestial calibrations, and analyze chemicals and gases released from the orbiter.

The space shuttle launch for the Infrared Background Signature Survey is scheduled for July 1990. All work, including analyses derived from experiments performed during the launch, is scheduled to be completed by November 1990.

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## Passive Sensors

A passive sensor can be used for making discrimination measurements during various phases of a missile's flight by measuring the ultraviolet, visible, and infrared energy received from targets. SDIO awarded two contracts, totaling \$4.5 million, to foreign contractors under the Passive Sensors project.

The purpose of one contract is to establish the feasibility of an infrared focal plane array structure capable of improved clutter rejection and target detection. The ultimate goal is to design an electro-optical sensor that can distinguish between a target missile and decoys and other clutter with a high detection rate coupled with a low false alarm rate. The purpose of the other contract is to demonstrate the feasibility of long wavelength infrared detectors that operate in the 8 to 12 micrometers



waveband and at temperatures around 200 degrees Kelvin. These detectors are also to have a high detection rate. The design and fabrication of such sensors are also being undertaken.

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### Support Technology

SDIO awarded two contracts valued at \$3.3 million to foreign contractors for the Support Technology project. The larger of these contracts, which is ongoing, is with a British government agency for \$2.8 million. The contract was awarded to initiate development of suitable low-temperature carbon monoxide catalysts for use in carbon dioxide laser systems. Such lasers have the potential for use in radar systems. Low-temperature catalysts have advantages over high-temperature catalysts in space-based systems.

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### Laser Radar Technology

The overall goal of the Laser Radar Technology project is to support both fire control and discrimination functions for a strategic defense system. Four foreign contractors received a total of \$2.1 million for work under this project. Some of the work performed by the contractors includes conducting a feasibility demonstration of carbon dioxide laser programmable delay lines using hollow waveguide technology, researching ways to improve the performance of laser radar systems by use of distributed aperture laser radar receivers, and developing a method for simultaneously grinding and polishing a mirror.

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### Other Contracts

Two other contracts, totaling \$299,000, were awarded under other Surveillance, Acquisition, Tracking, and Kill Assessment projects. The larger of these contracts was awarded by SDIO to a Canadian firm in 1987 for \$269,045 to produce plans for an atmospheric platform.

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### Directed Energy Weapons

The Directed Energy Weapons program element supports engagement and destruction of attacking objects through identification and validation of the most promising directed energy concepts, such as ground- and space-based lasers and space-based particle beams. Seven foreign contracts, totaling \$18.7 million, were awarded to support the Neutral Particle Beams project and other Directed Energy projects.

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### Neutral Particle Beams Project

A neutral particle beam is a beam of energy consisting of neutral (no electric charge) atoms and can be used to identify targets and/or disable a target with lethal energies. Neutral particle beam projects fall into two

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areas of research and development: continuous wave and pulsed beam. A continuous wave beam functions without interruption; a pulsed beam operates periodically in short bursts.

Two contracts were awarded for continuous wave research and development. U.S. obligations for the two contracts total \$10.3 million. In addition, one subcontract, discussed in chapter 4, was awarded for continuous wave research and development.

A British laboratory received \$8.9 million through an Air Force contract to develop a high-current, low-emittance negative ion source that is continuous wave and will be tested on an accelerator. The accelerator uses magnetic force to accelerate charged particles to nearly the speed of light, then neutralizes them to form a neutral particle beam. Items to be delivered to the United States include an ion source producing a continuous wave negative hydrogen ion, a low-energy beam transport system, an ion source test stand, and a design of a low-energy beam transport to the radio frequency quadropole and a high-energy beam transport from the radio frequency quadropole. Analyses of the work are also to be performed.

Another neutral particle beam contract is for an international collaborative program based on a cooperative effort that began in fiscal year 1986 between a Canadian laboratory and the Los Alamos National Laboratory in New Mexico. The Canadian effort focuses on technical problems confronting neutral particle beams, particularly continuous wave and radio frequency quadropole experiments. The Canadian laboratory is building an accelerator and a beamline and is sharing information with contractors in the United States and the United Kingdom that are working on similar projects and with the U.S. government. To date, the U.S. share of the contract is \$1.5 million.

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## Other Directed Energy Projects

Five foreign contracts, totaling \$8.4 million, were awarded to support various other Directed Energy projects. One contract, for \$4.4 million, was awarded by the Air Force to a West German company, as part of the Chemical Lasers project, for fabrication of a lightweight high-energy mirror. The finished product will be a 70-centimeter mirror made of a lightweight, uncooled glass ceramic material with no thermal expansion.

Two contracts, totaling \$1.7 million, were awarded under the Concepts Definition Technology Integration project. One of these contracts is to conduct research on a chemical laser that could be made smaller and

lighter than current lasers and would operate at short wavelengths. The other contract is to analyze the capabilities of a satellite pointing system. According to this contract's statement of work, Directed Energy experiments require significantly better pointing accuracy and stability than provided by the space shuttle.

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### Survivability, Lethality, and Key Technologies

Many foreign contractors participate in SDI through the Survivability, Lethality, and Key Technologies program element, which includes research projects (e.g., those that support power needs, launches into space, and countermeasures) to develop a future defensive system. Eleven foreign contracts totaling \$7.9 million were awarded to support the Lethality and Target Hardening, Systems Survivability, Materials and Structures, and Power and Power Conditioning projects.

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### Lethality and Target Hardening

Two foreign contracts totaling \$3.4 million were awarded for the Lethality and Target Hardening project. These contracts are to develop estimates of kinetic energy weapon lethality against Soviet strategic targets. One contract, for \$2.5 million, was awarded to a West German company to conduct research on short-range ballistic missile lethality of kinetic energy weapons, lasers, and microwave pulses. The research is to (1) characterize the threats, including warheads, (2) determine requirements for destroying the targets, and (3) assess the results through test facilities and vulnerability analyses.

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### Systems Survivability

Once SDI systems are deployed, they may be subject to enemy attack. Thus, the goal of the Systems Survivability project is to ensure system effectiveness during an attack. Two foreign contracts totaling \$2.4 million were awarded under this project.

One contract is to use SDI concepts to identify potential Soviet countermeasures that may be used to enhance the penetration capability of short-range missiles against European defenses. The other contract is to develop advanced technologies for hardening optical systems against continuous wave and projected pulsed laser threats.

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### Materials and Structures

The Materials and Structures project is to develop and demonstrate advanced materials and structures technologies critical to SDI's goals of survivability, reliability, and affordability. The materials research includes tribology (the study of design, friction, wear, and lubrication of

interacting surfaces in relative motion), structural materials, and dynamic control of space structures. Five foreign contracts totaling \$1.7 million were awarded.

Two contracts were awarded to a British research center to develop “dry” lubricants for satellite systems and test high-strength, lightweight bearing materials. Current U.S. lubricants are “wet” (based on oil and grease) and can contaminate sensitive satellite systems.

The other three contracts are for studying materials that may be useful in SDI systems. These materials include (1) a thin-walled structure made of carbon-carbon that could be used to withstand the environment of space and of enemy countermeasures, (2) composite spacecraft materials, such as ceramic matrix composites, and (3) cryogenic inductors, which use substances—such as hydrogen, neon, or helium—to obtain very low temperatures.

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## Power and Power Conditioning

The Power and Power Conditioning project is to develop a power technology base—both nuclear and nonnuclear power generation—in the multimegawatt regime to support SDI mission requirements. To support this project, the Department of Energy competitively awarded two foreign contracts totaling \$400,000. Both contracts involve researching a method of generating multimegawatt electric power, which is needed for space-based systems, and using a method that will involve magnetohydrodynamics, which relates to phenomena arising from the motion of electrically conducting fluids in the presence of electric and magnetic fields. One approach being tried is to pass liquid metal through a magnetic field to generate electricity. Another approach is to use a nuclear source to reflect neutrons back into the reaction chamber to increase electrical conductivity.

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## Innovative Science and Technology

The Innovative Science and Technology program provides funds for advanced research in fundamental science and engineering, focusing on exploitable areas applicable to ballistic missile defense. Most of the executing agencies for the SDI Program have projects for this purpose. Through March 1989, 14 foreign contractors have been awarded a total of \$5.7 million. Most of these awards have been competitively awarded by the Navy to British universities and companies. One of these universities is to calculate the rate of photoionization (the conversion of particles into ions resulting from the collision of those particles with photons) of ions of SDI-related materials. The materials may be of use in

short wavelength lasers. Another university is to manufacture and evaluate prototype gate arrays based on nonlinear semiconductor switching devices. The arrays are key to the development of digital optical computing and may enable the realization of a viable parallel computing machine. Another university is to develop new signal processing strategies or adaptive sensor arrays that will enhance directional signals while reducing interference.

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## Miscellaneous Contracts

One contract not part of the programs discussed previously is a \$708,488 contract awarded by the Defense Nuclear Agency to a British government agency to study the relationship between lasers and target materials (i.e., how much energy should be directed at a target and how much energy is reflected).

In addition, SDIO could not provide detailed information on two completed contracts valued at \$1.0 million that were listed on the database provided by the Office of Multinational Programs.

# Description of SDI Foreign Subcontracts Awarded by U.S. Contractors

We identified 86 subcontracts that U.S. contractors had awarded to foreign organizations in 11 countries through March 31, 1989. These subcontracts totaled about \$48.4 million, of which \$27.3 million has been obligated. The United Kingdom leads all other countries in the number of subcontracts (42) and the subcontract amount (\$31.1 million), as shown in table 4.1.

**Table 4.1: Foreign Subcontracts by Country**

Country	No. of subcontracts	Award total	Amount obligated				Total
			FY 85-86	FY 87	FY 88	FY 89	
The United Kingdom	42	\$31,105	\$660	\$2,299	\$2,946	\$2,503	\$10,008 <sup>a</sup>
France	9	9,217	937	4,877	1,908	1,169	9,192 <sup>b</sup>
West Germany	13	5,670	1,369	1,353	2,033	915	5,670
Canada	6	775	37	205	429	104	775
Japan	1	650	0	0	650	0	650
Italy	5	469	0	281	155	33	469
Israel	6	310	0	131	160	19	310
Other European countries	4	193	56	137	0	0	193
<b>Total</b>	<b>86</b>	<b>\$48,389</b>	<b>\$3,059</b>	<b>\$9,283</b>	<b>\$8,281</b>	<b>\$4,743</b>	<b>\$27,267</b>

Note: Totals may not add due to rounding.

Note: Dollar amounts for award total, fiscal year 1989 amount obligated, and total amount obligated are as of March 31, 1989.

<sup>a</sup>Obligations of \$1,599,000 have been made but could not be allocated by fiscal year.

<sup>b</sup>Obligations of \$302,000 have been made but could not be allocated by fiscal year.

The major foreign subcontracts of U.S. contractors have been grouped according to the programs they support. These programs are Directed Energy Weapons; Kinetic Energy Weapons; Innovative Science and Technology; and Survivability, Lethality, and Key Technologies. The subcontracts for projects in these programs account for \$40.9 million of the foreign subcontract total. The remaining \$7.5 million consists of \$6.7 million for Theater Missile Defense subcontracts (discussed in part in ch. 3), \$0.3 million for Systems Analysis and Battle Management subcontracts, and \$0.5 million for subcontracts for which information was not readily available.

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## Directed Energy Weapons

Foreign subcontracts have been awarded for two Directed Energy projects: the Ground-Based Free Electron Laser project and the Neutral Particle Beams project. These subcontracts amount to \$27.3 million, or 56 percent of the foreign subcontract total.

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### Ground-Based Free Electron Laser Project

The ground-based laser system concept is to fire a free electron laser beam generated on the ground to a mirror relay system in space. The mirror relay system redirects the beam to a satellite (via an input telescope) that focuses the beam on the target (via an output telescope). Foreign participation in this project is based almost entirely on subcontracts with companies from five European countries and Canada. These subcontracts amount to \$13.3 million.

To provide ground-based support for the project, a French firm is supplying klystrons (electron tubes used for generation and amplification of ultrahigh frequency current) and other equipment at a total cost of \$8.4 million. Subcontractors from other countries are providing goods and services, such as magnets for the creation of magnetic fields, thyratron tubes (gas-filled hot cathode electron tubes with a trigger controlling the start of a continuous current), and rectifier diodes for converting alternating current into direct current.

West German subcontractors have provided or are providing space-based support for the free electron laser. One constructed a mirror made of zerodur (a glass ceramic with zero thermal expansion) to be used in one of the beam-directing telescopes for \$2.3 million. Another is researching and developing accelerator modules for the High Power Modular Components program under a subcontract for \$1.7 million.

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### Neutral Particle Beams Project

A major task of the Neutral Particle Beams project is for the Continuous Wave Deuterium Demonstrator to research and develop a continuous wave beam using deuterium (an ion of hydrogen). The demonstrator has low-energy requirements and is cryogenic (i.e., uses substances such as hydrogen, helium, or neon to obtain low temperatures).

One subcontractor, a British laboratory, is expected to receive \$14.0 million for research and development related to the demonstrator. Some of the subcontractor's expected contributions include development of the ion injector subsystem, the High Energy Beam Transport (including bending and focusing magnets), the beam stop (including cooling system), and a megawatt radio frequency power system to be used for the

front end accelerator operation. The demonstrator is designed to be taken apart and transported as a deliverable item at the completion of the contract, expected to be in May 1992.

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## Kinetic Energy Weapons

An Air Force contractor has awarded two subcontracts, totaling \$8.1 million, to two foreign companies for a Kinetic Energy Weapons project. The first subcontract, awarded to a British company, is for two prototype inertial measurement units for the Space-Based Interceptor. The second subcontract was awarded to a Canadian company to build an ammonia laser and a carbon dioxide laser for the interceptor.

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## Innovative Science and Technology

Foreign subcontractors are involved in five Innovative Science and Technology contracts—four with the Air Force and one with the Navy. The subcontracts are valued at \$3.7 million.

The subcontractors, mostly British and Canadian universities, are engaged in various research efforts. Examples of these efforts include (1) conducting research on polymers to find materials that can detect a range of threats and trigger appropriate countermeasures, (2) examining insulating materials subjected to nuclear radiation and extreme temperature, and (3) examining the effect of the earth's atmosphere on long path transmission spectra (ultraviolet to microwave), which could be used in communication systems with space platforms.

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## Survivability, Lethality, and Key Technologies

Foreign subcontracts totaling \$1.7 million support Survivability, Lethality, and Key Technologies projects. Two subcontracts for Power and Power Conditioning were valued at almost \$1.4 million and awarded to British companies. One subcontract is for technical expertise for the design of a nuclear reactor based on gas and fast neutron spectrum gas-cooled reactor technology, and the other is for high-power switches. In addition, an Army Systems Survivability contract involved three foreign subcontractors from France, West Germany, and the United Kingdom. These subcontractors performed a survivability analysis of proposed theater missile defense architectures against various threats under subcontracts that totaled \$354,000.



# Comments From the Department of Defense

Note: GAO comment supplementing those in the report text appears at the end of this appendix.



DEPARTMENT OF DEFENSE  
STRATEGIC DEFENSE INITIATIVE ORGANIZATION  
WASHINGTON, DC 20301-7100

December 14, 1989

Mr. Frank C. Conahan  
Assistant Comptroller General  
National Security and International  
Affairs Division  
U.S. General Accounting Office  
Washington, D.C. 20548

Dear Mr. Conahan:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report, "Strategic Defense Initiative Program: Extent of Foreign Participation," dated November 3, 1989 (GAO Code 392481), OSD Case 8172. The DoD concurs with the draft report.

This report accurately characterizes the difficulties the Strategic Defense Initiative Organization (SDIO) has had in maintaining historical records of contracting activities that are outside normal reporting requirements. These historical records, sometimes erroneously referred to as a "Data Base," have proven very useful in the management of the Allied program within the SDIO, as well as informing non-DoD activities of the nature and extent of Allied participation. As noted in the GAO report, numerous significant improvements in the system are underway.

The DoD has separately provided several technical corrections to members of your staff. The DoD appreciates the opportunity to comment on the draft report.

Sincerely,

A handwritten signature in cursive script, appearing to read "Anson W. Schulz".

ANSON W. SCHULZ  
Brigadier General, USA  
Acting Deputy Director

See comment 1

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The following is GAO's comment on the Department of Defense letter dated December 14, 1989.

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**GAO Comment**

1. We recognize that no formal requirement exists for maintaining this information. We use the word "database" in the general sense to describe a comprehensive collection of related data organized for quick access by computer.

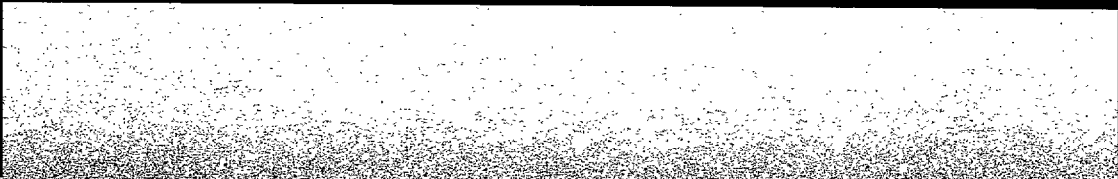
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# Major Contributors to This Report

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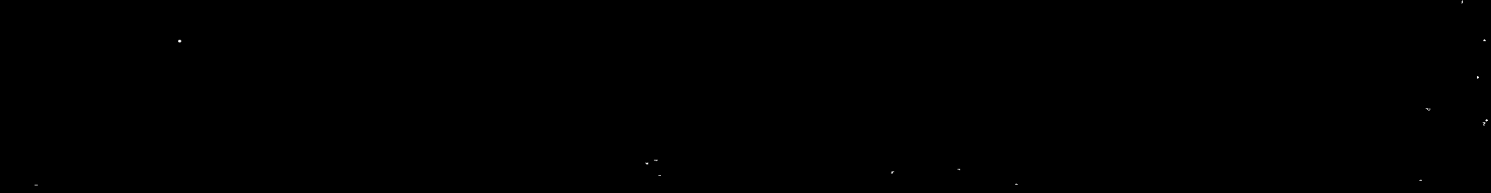
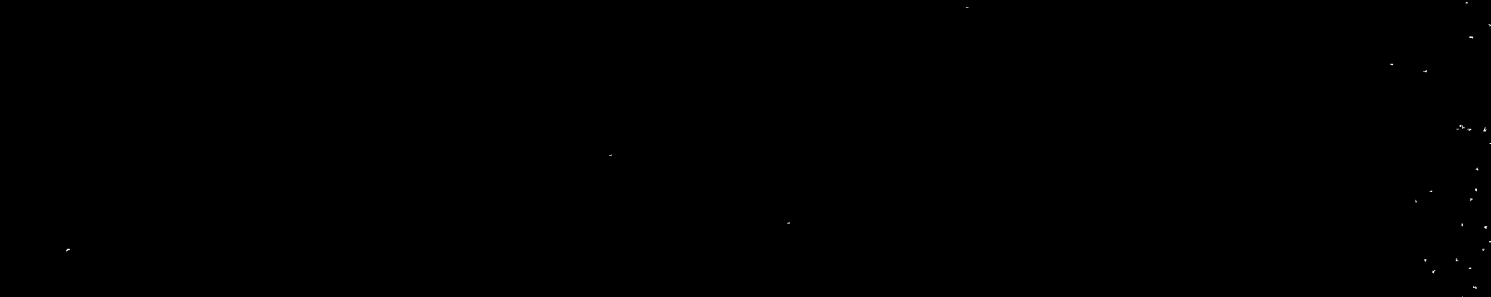
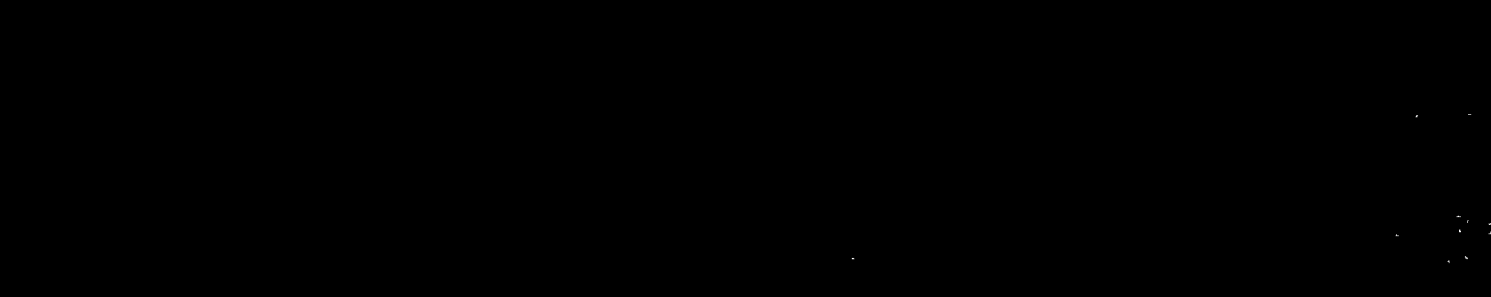
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