Chapter 11

The Military Role in Advanced Materials Development

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Chapter 11

The Military Role in Advanced Materials Development

FINDINGS

The military sponsors about 60 percent (roughly $98 million of $167 million in 1987) of Federal advanced structural ceramics and composites research and development in the United States. These figures do not include the additional R&D funded in classified programs and in other categories of materials research such as engineering development and operational systems development. The military establishment continues to provide the major U.S. market for advanced materials. However, military markets alone are not large enough to sustain a viable advanced materials industry.

Military advanced materials R&D investments could make a significant contribution to the competitiveness of U.S. firms. However, military and commercial interests in these materials differ. As commercial markets for these materials continue to grow, balancing military and commercial interests in advanced materials could become a critical factor in U.S. competitiveness. Among the major issues that will require resolution are export controls, controls on information, offsets, and government procurement practices.

Advanced materials are used in military systems, whose export is controlled by the Department of State, and in "dual use" products (those with both military and commercial application), whose export is controlled by the Department of Commerce. For national security reasons, the Department of Defense (DoD) also has a **major influence on export control decisions.**

Export controls, although necessary for national security reasons, are considered by U.S. industry to be cumbersome and outdated. Delays in processing export licenses can result in loss of sales abroad. Export control procedures relating to metal matrix composites (MMCs) are especially confusing, and it is not clear to U.S. MMC suppliers interviewed by OTA which Federal agency has the responsibility for controlling these materials. Commercial industry representation in export control policymaking bodies is minimal. Greater representation by commercially-oriented industry could help to provide a balance between military and commercial interests in export control policy.

Via an informal international agreement, the United States, all of the other NATO countries (except Iceland), and Japan have established an export control organization called the Coordinating Committee for Export Controls, or, informally, CoCom. This organization informally maintains multilateral controls on certain technologies that have been agreed upon by all member nations.

Export controls are intended to prevent direct shipment of militarily significant technologies to proscribed countries. Because U.S. technology exported to an approved country can often then be reexported to a proscribed country, the United States also maintains reexport controls. These reexport controls generally involve a requirement that a foreign company wishing to reexport technology received from the United States must apply to the United States for a license. Many countries view U.S. reexport controls as unwarranted interference in their political and commercial affairs, and in some cases these controls have been detrimental to U.S. trade as well as to relations with allied nations. The United States is the only country that seeks to control the reexport of information and products in a significant way.

Technical information about advanced materials is currently controlled under a complex regime of laws and regulations administered by the Departments of State, Commerce, and Defense. These controls can be confusing to the advanced materials community and tend to limit the transfer of military materials technology to the commercial sector. Some of the controls are intended to prevent non-U.S. citizens from receiving information; these policies are increasingly coming into conflict with the internationalization of the advanced materials industries. Such policies run the risk of provoking retaliatory restrictions on the flow of technical information into the United States. This could prove detrimental to the rate of technology development in the United States, especially in cases where superior technology exists abroad.

Although not strictly a military issue, controlled or proprietary information about advanced materials may be distributed worldwide by the practice of offsets. offsets are the offering of credits toward the acquisition of supporting technology to ensure sale of U.S. military systems (e.g., aircraft) to a foreign government. This newly acquired technology subsequently enables foreign companies to compete with the United States in the production of future military systems. Offsets are an integral part of the complex foreign policy considerations that go into such sales. Although offsets are reviewed for national security reasons, they receive no economic review for potential harm to the U.S. industrial base.

As with other technologies, such as microelectronics and machine tools, there is a growing recognition within DoD of the importance of maintaining a strong domestic manufacturing capacity for advanced materials. To fulfill its goals of supporting the U.S. industrial base, DoD has been developing a plan to pursue domestic production of some types of advanced materials regarded as critical, particularly polyacrylonitrile (PAN) fiber precursor for polymer matrix composites (PMCs). The Department of Defense Appropriations Act of 1987 (Public Law 100-202) requires that 50 percent of all PAN precursor used in U.S. military systems must be domestically produced by 1992. This legislation includes a timetable and incremental goals for achieving this level of domestic production. As yet DoD has not completed a plan for implementing the domestic PAN production requirements, causing uncertainty within industry regarding plant location and capacity, establishment of foreign-owned plants in the United States, and materials qualification,

INTRODUCTION

At present, the military is one of the largest customers for advanced materials, especially PMCs. DoD has committed to purchase 80 billion dollars worth of weapons systems that use various types of advanced composites.[1] DoD funding for basic research and exploratory development in advanced structural materials constitutes about 60 percent of total Federal R&D expenditures for these materials, as shown in table 11-1.

Composites are used in many military applications by all three services. The Army is pursuing PMCs and ceramic matrix composites (CMCs) for body and vehicle armor.[2] In addition, MMCs are being considered for use by the Navy and Air Force for structural components of aircraft, missiles, torpedoes, and other weapons systems components.[3]

In the past, PMCs have been used in the Army's Apache and Black Hawk helicopters, Navy aircraft such as the F-14, the FA-18, the AV-8B, and the Air Force's F-1 5 and F-16. With the experience gained in military applications such as fighter aircraft and rocket motor casings beginning in the 1970s, PMCs now have a solid record of performance and reliability, and are rapidly becoming baseline structural materials in the defense/aerospace industry.[4] In the future, military investment in composite materials is expected to grow rapidly. Composites will be enabling technologies for new programs such as the National Aerospace Plane.

[1] Kenneth Foster, U.S. Department of Defense, personal communication, June 1987.

[2] U.S. Department of Defense, Standardization Program Plan, Composites Technology Program Area (CMPS), Mar. 13, 1987.

[3] Ibid.

[4] Suppliers of Advanced Composite Materials Association, Annual Meeting and Industry Conference, May 5-8, 1987.

Table 11-1. -U.S. Government Agency Funding for Advanced Structural Materiais in Fiscai Year 1987 (millions of dollars)

Agency	Ceramics and ceramic matrix composites	Polymer matrix composites	Metal matrix composites	Carbon/carbon composites	Total
Department of Defense[a]	$21.5	$33.8	$29.7	$13.2	$98.2
Department of Energy	36.0	—	—	—	36.0
National Aeronautics and Space Administration	7.0	5.0	5.6	2.1	19.7
National Science Foundation	3.7	3.0	—	—	6.7
National Bureau of Standards	3.0	0.5	1.0	—	4.5
Bureau of Mines	2.0	—	—		2.0
Department of Transportation	—	0.2	—		0.2
Total	$73.2	$42.5	$36.3	$15.3	$167.3

[a]Includes only budget categories 6.1-6.3A.

SOURCE: OTA survey of agency representatives.

PMCs are under consideration for several systems including the Navy's V-22 Osprey (at this writing in prototype production using PMCs), the Army's LHX helicopters,[5] and the Air Force's Advanced Tactical Fighter (ATF).[6 7] Military research in PMCs has aimed at achieving higher operating temperatures, higher toughness, lower radar observability, and reduced weight, among other goals. For these reasons, military policies and regulations will continue to have a major effect on the future of these materials as they stat-t to be used more commercially.

Although DoD provides the major market for U.S. advanced material suppliers, DoD policies and methods can conflict with industry goals and preferences regarding the development of advanced materials. One source of conflict is that between national security interests and economic needs in terms of foreign trade in advanced materials. The conflict arises because such materials are a critical element in many new weapons systems, hence the military prefers to restrict their availability; at the same time though, these materials, through their potential use in a wide variety of civilian manufactured products, could play a valuable role in U.S. economic development and international trade.

A second source of conflict lies in how defense systems are procured by the Federal Government. DoD has two primary goals relating to procurement: securing a reliable domestic technology base, and having the widest spectrum of technologies available at the lowest possible cost. To achieve these goals, DoD employs a variety of incentives and regulations in its procurement programs. Participation by industry in these programs is more dependent on these DoD policies than on conventional economic criteria.[8]

Military advanced materials R&D investments could make a significant contribution to the competitiveness of U.S. firms. However, several controversial issues need to be addressed in order to make this contribution more effective. These include: export and reexport controls on products and technical information, access to data on materials, and materials procurement policies.

[5]The Army has recently restructured the LHX program; the restructuring plan is pending the approval of the Defense Acquisition Board. Brendan M. Greeley, Jr., "Army to Award Parallel Contracts for Revised Development of LHX," *Aviation Week and Space Technology,* Mar. 14, 1988, p. 247,

[6]Composite News, *Advanced Composites,* January/February 1987.

[7]"Materials Pace ATF Design," *Aerospace America,* Apr. 1987, pp. 16-22.

[8]Technology Management Associates, "Industrial Criteria for Investment Decisions in R&D and Production Facilities, " OTA contractor report, Jan. 28, 1987.

EXPORT CONTROLS

U.S. export control policies have been recently reviewed in the context of balancing national security and economic development goals.[9] Advanced materials technologies are considered to be "dual-use" technologies (as are, for instance, microelectronics or machine tools) because they have both civilian and military applications. As such, they are subject to U.S. export controls. Accordingly, the U.S. export control regime is an important factor in the present and future development of advanced materials in the United States.

U.S. Export Control Regime

Export of advanced materials products and technical information about advanced materials is currently controlled under a complex regime of laws and regulations. The Federal agencies responsible for export control are listed in table 11-2. Export control responsibility lies by law[10] primarily with the Departments of Commerce and State. DoD influences the policymaking of these departments and has power of refusal over export license applications, but has no export control authority of its own, as mandated by the Export Administration Act of 1979 (Public Law 96-72).

The Departments of Commerce and State each have their own lists of technologies that are export-controlled: the Department of Commerce administers the U.S. Commodity Control List; the

[9] National Academy of Sciences, *Balancing the National Interest: U.S. National Security Export Controls and Global Economic Competition,* (Washington, DC, National Academy Press, 1987).

[10] Export Administration Act, 1979, Public Law 96-72; Export Administration Act of 1981, Public Law 97-145; Export Administration Amendments Act, 1985, Public Law 99-64; Arms Export Control Act, 1976, Public Law 94-329.

Table n-2.-The Export Control Regime

U.S. agency	Controls	Regulations	Technology list
Department of Commerce (International Trade Administration)	Dual-use technologies	Export Administration Regulations (EAR)	US. Commodity Control List
Department of State (Office of Munitions Control)	Defense articles, defense services, and related technical data	International Traffic in Arms Regulations (ITAR)	U.S. Munitions List
Department of Defense	Advisory only	Guidelines only	Militarily Critical Technologies List (MCTL)
International (CoCom)			
NATO countries except Iceland, plus Japan	Dual-use technologies [Arms] [Atomic Energy]	None, Nontreaty Agreement	International Commodity Control List, or CoCom International List
Other U.S. Agencies	*Role*		
Department of the Treasury (U.S. Customs).	Enforcement		
Department of Justice	Enforcement		
Department of Energy	Nuclear Energy and Weapons Technologies		
Nuclear Regulatory Commission	Nuclear Energy and Weapons Technologies		
NASA, Intelligence Agencies	Advisory		
National Security Council	Advisory, Dispute Resolution		

NOTE: CoCom Arms and Atomic Energy controls are similar to U.S. Department of State and U.S. Department of Energy controls, respectively.

SOURCE: National Academy of Sciences, "Balancing the National Interest," 1987.

Department of State administers the U.S. Munitions List. DoD maintains a separate list of technologies, called the Militarily Critical Technologies List (MCTL), that it uses as a guideline on export control matters. Congress originally mandated in 1979 that DoD develop the MCTL to be a guideline of those technologies that are critical for national defense.11 Congress subsequently mandated in 1985 that the MCTL be merged with the U.S. Commodity Control List;[12] however, this merger has not occurred. The MCTL is currently only a guideline and has no other standing in regulation or law.

11 Export Administration Act of 1979, Public Law 9.6-72.

12 Export Administration Amendments Act of 1985, Public Law 99-64.

Table 11-3 describes how advanced materials are included in each of the lists. The U.S. Commodity Control List covers dual-use technologies and information, and is found at the end of the Export Administration Regulations (EAR). it has separate sections for 1) ceramics and ceramic matrix composites; 2) organic matrix materials; and 3) carbon fibers, polymer matrix composites, and metal matrix composites. Certain materials are specified in detail (e.g., polyamides, carbon fibers with certain stiffnesses and strengths), while other materials are described in a less specific way (for instance, metal matrix composites, which are described as structures or manufactures made with a metal matrix utilizing any of some specified fibrous or filamentary materials). The U.S. Com-

Table 11-3.—Export Controls on Advanced Materials

Administrative agency	Citation
Department of Commerce (EAR)	
***U.S. Commodity** Control List*[a]	
15 CFR Ch. *III*	ECCN 1733A
399.1	
Ceramics, ceramic matrix composites	“Base Materials, noncomposite ceramic materials, ceramic-ceramic composite materials and precursor materials for the manufacture of high temperature to high temperature fine technical ceramic products”
Organic matrix materials	ECCN 1746A “Polymeric substances and manufactures thereof” (includes polyamides, aromatic polyamides)
Carbon fibers, polymer matrix composites, metal matrix composites	ECCN 1763A “Fibrous and filamentary materials that may be used in composite structures or laminates and such composite structures or laminates”
Department of State (ITAR)	
U.S. Munitions List[a]	
22 CFR Ch. I	Category IV
121.1	Launch vehicles, guided missiles, ballistic missiles, rockets, torpedos, bombs, and mines
Ablative materials fabricated or semifabricated from advanced composites	
Department of Defense	
Militarily Critical Technologies List[b]	
Part A: Arrays of Know-How	*5.0* Materials and Processing Technology
Part B: Keystone Equipment	Group 3 General Industrial Equipment
Part C: Keystone Materials	ECCN #S 1733A, 1746A, 1763A
Part D: Goods Accompanied by Sophisticated Know-How	(various products and equipment)

NOTES: Export Administration Regulations (EAR) refer to some technologies in detail (PMCs, reinforcement fibers) and other technologies in a more general manner (MMCs).
International Traffic in Arms Regulations (ITAR) refer only to ablative materials, which include MMCs.
The Militarily Critical Technologies List (MCTL) refers to a wide range of advanced materials and related technologies, and is used as a guideline for approval of licenses,

SOURCES: [a]U.S. Code of Federal Regulations, revised as of Jan. 1, 1987.
[b]U.S. Militarily Critical Technologies List (unclassified version, Oct. 1984).

modity Control List also covers products and systems made from advanced materials, such as aircraft and components.

The Department of States' U.S. Munitions List covers defense articles, services, and related technical information and is found at the end of the International Traffic in Arms Regulations (ITAR). The only materials specified in this list are ablative materials (which are usually taken to include carbon/carbon and certain metal matrix composites). The Department of Defense's Militarily Critical Technologies List specifies many aspects of materials in varying degrees of technical detail, including equipment for producing these materials, some products and systems made from these materials, and technical information related to all of the above.

In some cases the responsibility for control is not clear from the lists. For instance, there is some dispute as to whether MMCs are controlled as a directly military technology under the International Traffic in Arms Regulations administered by the Department of State (U.S. Munitions List), or under the Export Administration Regulations (U.S. Commodity Control List) administered by the Department of Commerce (see box A). Normally, these two lists do not overlap in content. Except for its claim to regulate ablative materials technology, the Department of State does not regulate the export of any other advanced materials commodities or information. Because both the Department of Commerce and the Department of State send export license applications to DoD for approval, DoD has a very influential position in export controls despite the fact that it is not

Box A.—Export Control of Metal Matrix Composite Products and Information

The case of export control of MMCs provides a particularly confusing situation. The vast majority of MMC production is for military use. The Department of State has responsibility for licensing weapons and munitions and related technical data. The Department of Commerce licenses export of dual use items and related technical data. See table 11-2 for a description of the export control regime.

Both products and information related to MMCs are explicitly described in the Commodity Control List of the Department of Commerce export control regulations.[13] The Department of State's Munitions List cites "ablative materials" (usually taken to include carbon/carbon composites and certain metal matrix composites) used in such systems as launch vehicles and guided missiles. See table 11-3 for a description of advanced structural materials citations in the several export control lists.

Neither list is specific about which MMCs are controlled, and there is disagreement over which agency controls MMC information (technical data) as opposed to products. Because both agencies have regulations concerning the export of these materials, there is no one agency to which companies can routinely send all MMC export license applications. This has led to additional delays in processing of MMC export license applications.

Even after a license application has been submitted, the procedure is not clear as to whom it must be referred and which agency has final authority to issue or deny a license. This is due to the ambiguity in the technical descriptions of MMCs in the two control lists, and the overlap between Commerce and State regulations. In cases where license applications have been submitted to both agencies, contradictory responses have been received.[14]

Several actions could help alleviate this situation. Regulations regarding the control of MMCs could be rewritten to clarify which agency controls what types of MMC products and information. Both agencies should coordinate in a timely fashion to accomplish this objective. This activity could be mediated by the National Security Council. Consultations with the Materials Technical Working Group within DoD and the new Materials Technical Advisory Committee in the Department of Commerce could also help in developing regulations that are technically clear and relevant.

[13] MMCs are found in the U.S. Commodity Control List (15 CFR 399.1, Supplement 1, Group 7), under the section on fibrous and filamentary materials, ECCN 1763A, (d).

[14] "Industrial Investment in Advanced Materials," Office of Technology Assessment workshop, Washington, DC, Dec. 15-16, 1986.

permitted by Congress to have regulatory control over exports.

There is also an informal international export control agreement between the United States, all of the other NATO countries (except Iceland), and Japan. This set of countries has established the Coordinating Committee for Export Controls, or, informally, CoCom. For over 40 years, the CoCom countries have maintained lists of technologies that they have agreed to restrict from export to proscribed country destinations. The principal such list, called the CoCom international List, is similar to the U.S. Commodity Control List of the Department of Commerce except that the U.S. list includes 27 categories of dual-use products that are not on the CoCom list.[15] in addition, there are also two CoCom lists for munitions and atomic energy that are similar to U.S. control lists for these technologies.

Effects of Export Controls

Export controls are very important to national security.[16] Proscribed countries have three options for acquiring Western defense technologies: through espionage, diversions, or through legal purchases. Export controls exist to prevent proscribed countries from directly exploiting the latter two methods. Controls on exports to friendly nations are intended to prevent diversions to proscribed countries. However, export controls are sometimes at odds with the economic objectives of the open, free-market societies of the Western allies.[17]

The main problem with the export control regime is its size and complexity. The sheer number of agencies, laws, regulations, and guidelines causes confusion for companies applying for export licenses. In fact, some companies find it necessary to hire lawyers or consultants simply for the purpose of filling out and tracking export license applications.

One of U.S. industry's main complaints about export control regulation is the time taken to process an export license application. Because advanced materials export license applications usually require interagency referral, delays are longer than average for decisions regarding these licenses (see box B). The possibility that a U.S. exporter will face long delays or will not receive a license can be enough to discourage foreign customers from buying U.S.-manufactured products.[18]

A further complaint of the industries subject to export control involves the MCTL. Presently, the ambiguous status of this list is causing confusion among these industries. The integration of the MCTL with the U.S. Commodity Control List has not yet been done and the MCTL is still nominally only a guideline. However, there have been charges that this list is being used de facto to control the export of tech nologies.[25] For instance, **industry sources contacted by** OTA consider it to be as important to amend the MCTL as the U.S. Commodity Control List.

Although export controls affect a variety of high-technology industries, there are some aspects of export control (e.g., reexport controls) that affect the advanced materials industries more severely than some other industries. This is because materials are controlled as raw and processed materials (e. g., powders, fibers), as parts and components (e.g., missile nose cones), and as subsystems (e.g., aircraft wings). At all of these stages, advanced materials are also subject to reexport controls.

Reexport Controls

The United States is the only CoCom member country that requires companies within foreign countries to request U.S. permission to reexport U.S.-made dual-use items, and foreign-made products with U.S.-made components.[26] These

[15] National Academy of Sciences, op. cit., 1987.

16 For a full discussion of the reasons behind export controls, see U.S. Congress, Office of Technology Assessment, *Technology and East- West Trade: An Update, " OTA-ISC-209* (Washington, DC: U.S. Government Printing Office, May 1983).

[17] National Academy of Sciences, op. cit., 1987.

[18] Technology Management Associates, "Industrial Criteria for Investment Decision in R&D and Production Facilities, " contractor report prepared for the Office of Technology Assessment, Jan. 28, 1987, p. 42. See also U.S. Congress, Office of Technology Assessment, *Technology Transfer to China, " OTA-I SC-340* (Washington, DC: U.S. Government Printing Office, July 1987).

[25] National Academy of Sciences, op. cit., 1987.

[26] National Academy of Sciences, Op. cit., 1987.

Box B.—Export License Application Processing

According to the Department of Commerce, the average processing time for license applications that need no interagency or CoCom referral (80 percent of cases for all information and products) is down to nine calendar days from the receipt of the application until the time the license is issued, as of December 1987.[19] The average processing time is 52 days for cases requiring referral (CoCom or interdepartmental).[20] (Usually license applications are referred to CoCom only for shipments to Communist countries.)

The Department of Commerce processed about 122,000 license applications total in fiscal year 1985, up from approximately 71,000 in fiscal year 1981.[21] In about 5 percent of the 1985 license applications, processing times were over 100 days.[22]

The Department of Commerce already has in place the System for Tracking Export License Applications (STELA), a computerized voice answering service that allows exporters to monitor the status of their license applications. DoD has a similar system, called the Export License Status Advisor, ELISA.

Early in 1987, the Department of Commerce announced reforms in the export controls that it ad ministers.[23] New types of licenses are being made available to simplify the application procedure for a small number of exports to some of the CoCom countries. Average license application times were reduced for applications not needing referral. The Department of Commerce also proposed to loosen export restrictions on low-technology exports (e.g., personal computers) to non-CoCom countries. Parts and components regulations have also been modified.[24]

[19] Iain Baird, US, Department of Commerce, personal Communication, Jan. 4, 1988.
[20] Ibid.
[21] National Academy of Sciences, op. cit., 1987.
[22] Ibid.
[23] Malcolm Baldrige, *Department of Commerce News,* Feb. 9, 1987.
[24] Daniel Cook, U.S. Department of Commerce, personal communication, July 30, 1987.

reexport controls exist to make sure that products 'licensed for export from the United States to a particular foreign country do not end up in proscribed countries. However, many countries feel that these controls represent unwarranted interference in their political and commercial affairs.

The unilateral emphasis of the United States on reexport controls can result in a competitive disadvantage for U.S. firms. Foreign companies are concerned about potential loss of time and money involved in using U.S.-manufactured products. A reexport license application requires additional time to process here in the United States. It also requires significant effort on the part of the government of the reexporting country to make sure that those products requiring reexport control are dealt with accordingly.

In some cases, these controls have led to a process of "de-Americanization" in which foreign manufacturers avoid the use of U.S.-made products to sidestep the U.S. reexport controls. One example of de-Americanization is the barring of companies in countries requiring reexport licenses from bidding on supply contracts for the NATO fighter.[27]

For parts and components, the present reexport control regulations require that a foreign manufacturer get a reexport license" if the U. S.-made content of a foreign-made system exceeds 25 percent of the total content (dollar value), for exports to CoCom countries and specified Third World countries. For proscribed country destinations, the limit on U.S.-made parts and components is 10 percent and $10,000.[28]

This means that if an aircraft built by a company in a CoCom member country includes enough U.S.-made composite parts to fall under the U.S. export control regulations, this company

[27] Conference on export controls sponsored by the U.S. Department of Commerce for the United States Advanced Ceramics Association, Feb. 24, 1987.
[28] Iain Baird, Department of Commerce, personal communication, Jan. 4, 1988.

must apply to the United States for a reexport license, as well as to the country of manufacture for an export control license for the entire aircraft. Canada has a similar restriction in that it requires a reexport license for systems containing greater than 80 percent U.S.-made (not Canadian-made) parts and components. These reexport control regulations similarly affect the computer chip and avionics industries.

For U.S. products that are to be reexported on their own, rather than as part of a system, a reexport license must be obtained for quantities above a certain dollar value. This dollar value is the same as the limit for export from the United States, as given in the U.S. Commodity Control List.

For some products, e.g., ceramics, this threshold dollar value is zero. This low a threshold is chosen to enable control of export of inexpensive items that are critical for weapons systems, e.g., ceramic rocket nose cones; however, advanced ceramic products of greater commercial use are also under this reexport restraint. This suggests that export or reexport control of materials per se may be less efficacious than a more product-specific form of control.

Industry Representation

One mechanism for ensuring that commercial concerns are taken into account in U.S. export control policy is to have representation by nondefense-related industry in policy planning of export controls. Review of the CoCom list is carried out primarily by defense contracting industry personnel, and defense and national security-oriented government representatives. There is no trade-oriented representation on the board that reviews CoCom lists. Of particular concern in this assessment is the lack of channels open for helpful input from the advanced materials industries in export policy controls.

In response to the written requests from a substantial segment of the advanced materials industries, the Department of Commerce formed a Materials Technical Advisory Committee (TAC) in April 1986 to advise and assist in policy discussions stemming from the Export Administration Amendments Act (Public Law 99-64) of 1985.[29] The TAC will provide advice to the Department of Commerce on such issues as technical specifications, worldwide availability, licensing procedures, and unilateral or multilateral export controls.

This materials TAC was formed with **the intent of ensuring a more broad-based industry participation** in the Commodity Control List review process. To be successful, the committee must bring together members with technical expertise in all of the relevant materials technologies, including those with a trade-oriented viewpoint, and give them a meaningful role in the policy review process. As of this writing, the committee had received many applications for membership.[30]

[29] Charter of the Department of Commerce Materials Technical Advisory Committee, April 1986.

[30] Jeff Tripp, U.S. Department of Commerce, personal communication, Sept. 21, 1987.

INFORMATION CONTROLS

Perhaps even more than materials themselves, information about how to process them into high-performance structures is considered critical to the national defense. However, excessive controls on the dissemination of such information can also impede timely development of these technologies in the United States. This information, called "technology" or "technical data" within the system of export controls, can consist of software, patent applications, technical specifications, blueprints, operating manuals, or even technical advice.

To impede the flow of such information to proscribed country destinations, various restrictions, including export license requirements, are imposed by the Federal Government. An individual validated license (IVL) is required by the Department of Commerce for each advanced materials information transaction with a foreign national. Individual validated licenses for up to a 2-year period can be issued for related information transfers to the same company.

The above descriptions of export-controlled information are very broad. One guideline used by the Department of Commerce is to regard export-restricted technical data as any information relating to dual-use or military technologies that could be considered proprietary.[31] However, it is not always obvious what information falls in this category.

It is also difficult to determine what organizations are to be considered foreign. Since the advanced materials industries are increasingly global in scope, and there is an intermingling of U.S. and foreign advanced materials business interests (see ch. 9), the concept of corporate nationality is becoming less and less meaningful. The Department of Commerce currently intends to publish a guideline for determining what constitutes an export of information to a foreign national.[32]

The primary mechanism for information control by the Federal Government has long been the classification system, as reaffirmed in the President's National Security Decision Directive 189 of 1985. Currently, information on advanced materials can also be controlled by ITAR restrictions; EAR restrictions; the Defense Authorization Act of 1984 (Public Law 98-94), which permits restriction of sensitive information (i.e., information on any technology with military or space applications); and government contract restrictions. The many overlapping mechanisms for information control (see table 11-4) can be confusing.

In addition to these mechanisms, there are a host of internal DoD directives, instructions, and guidelines for controlling dissemination of information (table 11-5). The personnel obliged to apply these directives are those within the defense agencies, defense contractors, and the Office of the Secretary of Defense (OSD). These directives and instructions are developed for national security reasons for the control of classified and unclassified information in the context of communications with foreign governments, foreign representatives, and international organizations.

There is a tradeoff inherent in any system of information control between simplicity and flexibility. The present system of many control mechanisms allows flexibility in targeting distribution of information to different audiences. However, having many mechanisms has seemed arbitrary to the private sector and can have a chilling effect on legitimate exchanges of information. A

[31] Jim Seevaratnam, conference on export controls sponsored by the U.S. Department of Commerce for the United States Advanced Ceramics Association, Feb. 24, 1987.
[32] Ibid.

Table 11-4.-Mechanisms for Controlling Information on Advanced Materials

Mechanism	Agency	Controls	How to access/transfer
International Traffic in Arms Regulations (ITAR) Export Controls	Department of State Office of Munitions Controls	Information on defense articles, services, and related technical data	Apply for an export license
Export Administration Regulations (EAR) Export Controls	Department of Commerce Export Administration Office	Information on "dual-use" technologies	Apply for an export license
Defense Authorization Act of 1984 (10 U.S.C. 130)	Undersecretary of Defense for Acquisition within the Department of Defense	"Sensitive" information with military or space applications—blocks requests under the Freedom of Information Act (Public Law 93-502)	Not to be exported; Canadian, U.S. resident aliens and U.S. access granted through certification form DD 2345, "Militarily Critical Technical Data Agreement"
Classification	Department of Commerce Information Security Oversight Office	Classified information of any nature	Security procedures including clearance and a need to know
Contract Clauses	Federal Acquisition Regulations Council	Any work done for that contract	Distribution can be cleared through the contracting agency

SOURCE: Frank Sobieszczyk, U.S. Department of Defense, personal communication, Nov. 10, 1987.

Table 11-5.—Department of Defense Directives and Instructions for Information Control

Directives:	
5230.27	Presentation of DoD-Related Scientific and Technical Papers at Meetings (Oct. 6, 1987)
5230.25	Withholding of Unclassified Technical Data from Public Disclosure
5230.24	Markings on Technical Documents (Mar. 6, 1987)
instructions:	
5230.17	Procedures for Disclosure of Military Information to Foreign Governments and International Organizations
5230.20	Control of Foreign Representatives

NOTE: For additional directives and instructions that can be used to control **information relating to advanced materials, see table 11-4.**

SOURCE Frank Sobieszczyk, US Department of Defense, personal communication, Nov. 10, 1987.

simpler system, e.g., one involving greater reliance on classification, would be more easily comprehended and complied with by the private sector, but such a system would reduce the ability to control the distribution of information in a flexible manner.

The current information controls can have significant effects on joint ventures, licensing agreements, and customer relations between U.S. and foreign companies. License applications for advanced materials information transfer must be filed to enter into negotiations, during the negotiation process, and after the agreement is made. Significant license application processing delays can discourage the formation of these joint ventures by undermining the faith of a potential foreign partner in the U.S. firm.

Such joint venture and licensing agreements are important to U.S. advanced materials firms. Because the role of the end-user is so significant to investment in advanced materials, materials supplier companies often enter into joint ventures or licensing agreements with end-users to develop a particular technology. Currently, end-user companies willing to explore the commercial possibilities of advanced materials are more easily found in foreign countries. Consequently, some U.S. companies assert that to develop certain materials technologies at all, they must be able to conduct joint venture or licensing arrangements with foreign-owned companies.

Closed Conferences*

In 1982, there was a disruption of a Society of Photo-Optical Instrumentation Engineers (SPIE) conference when, 2 weeks before the conference, DoD informed the society that 20 percent of the 219 papers scheduled, including papers with sponsors other than DoD, could not be presented, even in a closed session.[33 34] Since then, there have been fears on the part of professional societies that DoD restrictions on presentations at conferences (particularly restrictions imposed at the last minute) will have an adverse effect on both the organization and the conference.

DoD currently imposes certain limits on technical conferences to prevent the export of technology with national security implications, while still permitting its distribution to interested U.S. citizens. In recent years, some professional engineering societies have closed conferences or parts of conferences on their own initiative for fear of last-minute removal of key papers sponsored by DoD. The most notable examples in advanced materials have been conferences on PMCs.

At present, most closed conferences only have one or two closed sessions and foreign nationals may attend the other sessions.[35] In other cases, however, only the exhibit area of a conference is open to foreign nationals, and the advanced technology meetings are closed. DoD maintains that the use of closed sessions at open conferences permits the dissemination of DoD-sponsored research that might otherwise be withheld.[36] Critics note, however, that even the closed sessions are frequently limited in technical content.

*Closed conference sessions are those from which foreign nationals are excluded; however, see footnote 35.

JJ"Incident over SPIE Papers Muddies Scientific Secrecy Issue, " *Physics Today,* June 1985, pp. *55-57.*

[34]Eric J. Lerner, "DOD Information Curbs Spread Fear and Confusion," *Aerospace America,* Mar. 1985, pp. 76-80.

[35]Exceptions are foreign nationals from countries whose defense ministries have science and technology agreements with DoD. Foreign nationals from these countries may obtain permission to attend closed sessions. For instance, for advanced composites, these countries are: Canada, the United Kingdom, New Zealand, and Australia.

[36]The procedures for presenting information at a Conference with foreign national attendees are the same as those for transmitting a document to a foreign national.

Such restrictions on conference attendance also cause ill-will among foreign researchers and are in any case not a reliable means of preventing information transfer, since a determined individual can readily obtain conference proceedings or admittance to closed sessions. Furthermore, they may be self-defeating from a national point of view in areas where foreign companies and researchers have developed superior technology.

Department of Defense-Generated Databases

There is a wide variety of technical information on advanced materials generated by the military. One major source of this information is the Defense Technical Information Center (DTIC). Participants at an OTA workshop cited DTIC as an underused source of advanced materials technical information and a more complete and up-to-date source than its civilian counterpart, the National Technical Information Service (NTIS).[37]

DTIC maintains two major bibliographic databases, offering information on completed projects that have been sponsored by DoD and the armed services, and on projects that are in progress.[38]

JT"Industrial Investment in Advanced Materials, " Office of Technology Assessment workshop, Dec. 15-16, 1987.

[38]William Thompson, Defense Technical Information Center, personal communication, Mar. 26, 1987.

In addition, there is a database of military contractors' industrial R&D.[39] The characteristics of the three main databases and distribution listings that allow access to these databases are given in table 11-6. **Anyone wishing access to these databases must be a registered** user; that is, be endorsed by a DoD agency. To be endorsed, one must be a past, current, or potential government contractor, or a member **of** a government agency .[40]

All three databases contain some classified or proprietary information. A substantial amount of information contained in DTIC **is neither proprietary** nor classified but is still limited, meaning that it is only available to registered users. Limited information may consist of software documentation, technologies listed in the MCTL (including all advanced structural materials), technologies falling under other types of export control, information furnished by foreign governments, or administrative information.[41]

Slightly less than 50 percent of the database on completed DoD-sponsored projects is cleared for public release and is available to NTIS. This information is thereby available to anyone, whether

[39]Ibid.

[40]Charles Gould, Defense Technical Information Center, personal communication, Mar. 26, 1987.

[41] Department of Defense Directive 5230.24, Distribution Statements for Use on Technical Documents, Mar. 18, 1987.

Table n-6.-Defense Technical Information Center Databases

Database	Type of information	Proprietary? Classified?	Goes to NTIS?
Bibliographic	Published reports of completed government-sponsored R&D	Not proprietary; some classified	50% does, all basic research identified as being unclassified and unlimited
Work Unit Information System	Government-sponsored R&D in progress	Not proprietary; some classified	None; distribution only to DTIC-cleared users
IR&D	Company-sponsored research of interest to government	All proprietary and some classified	None; only open to DoD and other agencies, *not **available to contractors***
Department of Defense R&D Program Plannning (not in place yet)	Descriptive summaries	Some classified	Possibly Congressional distribution; not open to public
Proposed Database (untitled)	Database of all DoD agency databases	Both proprietary and classified	Distribution unknown

NOTE: Each document in these databases is cleared for distribution to one of the categories of users below:
a. U.S. Government only
b. U.S. Department of Defense only
c. U.S. Government agencies and their contractors
d. U.S. Department of Defense and its contractors
e. Domestic public/U.S. citizens.

SOURCE: William Thompson, Defense Technical Information Center, personal communication, Mar. 28, 1987 a U.S. or foreign citizen.[42] Information on DoD-sponsored projects in progress is available only to DTIC users and not to NTIS. Only a small percentage of applied R&D in DTIC goes to NTIS.[43]

A DoD directive requires the individual armed services to contribute information to DTIC databases. At present their compliance with this directive represents only about 60 percent of known reports.[44] The armed services and other DoD agencies (e. g., the Defense Advanced Research Projects Agency, DARPA) maintain their own separate technical databases. DTIC is now working to develop a database of all available DoD agency technology databases.

Access to **DTIC databases by firms not under contract to the government is quite difficult because** DTIC is not **authorized to extend information to other than contractors and potential contractors. A potential subcontractor company can be helped to enter the defense community by working with an established primary contractor. Each service also has a potential contractor** program to help companies access the DTIC.

DTIC contains a significant amount of information on advanced materials that is neither proprietary nor classified (and would contain more if the directive requiring submission of DoD-sponsored reports were fully complied with). This information would be of interest to commercial, market-oriented firms, but is unavailable to them. By permitting greater access to the technical information in DTIC by commercial firms, subject to necessary restrictions on proprietary or classified information, DoD could help to make more efficient use of its R&D investments, and to promote the timely transfer of technology to the commercial sector.

[42] Charles Gould, op. cit., Mar. 26, 1987.

[43] William Thompson, Defense Technical Information Center, personal communication, Mar. 26, 1987.

44 Ibid.

TECHNOLOGY TRANSFER FROM THE MILITARY

There has long been a debate over the extent to which technologies developed to fulfill DoD mission requirements can be spun off and used in commercial applications.[45] In general, technology transfer occurs most readily at the level of basic research.[46] As the research becomes more system-specific, or in the case of military R&D, more mission-specific, transfer is more difficult.[47] Effective technology transfer may also occur when the military and commercial applications are similar and the same companies are involved.

The military investment in advanced materials has accelerated the development of the advanced materials industries, but its benefits for commercial use of the materials remain in doubt. On the positive side, the fact that these higher performance materials have been developed to the extent that they have is largely due to the experience gained by using these materials in weapons systems. DoD funds a great deal of basic research of broad general interest. In addition, there can be significant overlap between the materials requirements of certain military and commercial systems. For instance, much of the PMC technology used in civil aircraft has been derived from military PMC applications. As experience **is** gained in the production of these materials for military purposes, manufacturing costs can decrease, thereby facilitating technology transfer to commercial endeavors.

DoD also supports research in materials processing technology; for instance, DoD's Manufacturing Technologies (ManTech) program (see table 11-7) has provided funds for composite materials processing research such as the B-1 B wing project sponsored by the Air Force Materials Laboratory.[48] This project, conducted by Rockwell, Avco/Textron, and Hercules Aerospace, uses automated tape laying, filament winding, and other innovative techniques to construct wing

[45] J. David Roessner, "Technology Policy in the United States: Structures and Limitations, " *Technovation, vol. 5,1987,* p. 240.

[46] Ibid.

[47] Ibid.

[48] "Rockwell Team Demonstrates Automatic Construction of Large Composite Wings," *Aviation* Week &Space *Technology,* June 15, 1987, pp. 333-338.

Table 11-7.–Manufacturing Technology (ManTech) Program Funding Levels for Advanced Materials= Related Projects (mIlllons of dollars)

Category	Fiscal year 1986	Fiscal year 1987	Fiscal year 1988
Air Force[a]	7.5	8.6	13.4
Navy[b]	1.6	**1.1**	3.0
Army[c]	0.5	**0.9**	1.4
Total	9.6	10.6	17.8
Total ManTech[d] funding	205	124	165

NOTES: About 3 percent of ManTech funding goes to the Defense Logistics Agency. While DARPA and SDIO sponsor signficant materials processing R&D, they are not formally under the ManTech Program.

SOURCES: [a]Thomas Fitzgerald, U.S. Department of Defense, Air Force.
[b]Chris Current, U.S. Department of Defense, Navy.
[c]Ken Rice, Army Materials Technology Laboratory.
[d]Lloyd Lehn, U.S. Department of Defense, Office of the Secretary of Defense.

skins, box spars, ribs, and stiffeners. Total funding for this program is $7.5 million since September 1983.49 Research such as this, funded by the military, can lead to more cost-effective production methods.

However, in many cases, there are few technical synergisms between military uses and potential commercial applications. The military applications of advanced materials require high performance, and cost is typically a secondary consideration. The difference in acceptable material and manufacturing costs between military and commercial structures can be orders of magnitude, and thus military production methods and materials may not be directly transferable.

The difference in acceptable costs is illustrated by the fact that the graphite fibers used in military PMC structures cost at least $25 per pound (and may cost over $1,000 per pound), whereas the E-glass fibers used in automobiles cost $0.80 per pound (see ch. 8). Large cost differences also exist between aerospace epoxy matrix materials and automotive poly - and vinyl-ester matrices.[50]

Similarly, the process of hand lay-up of PMCs, used in the production of military aircraft components, would be too expensive and time-consuming to apply to automotive use. Hand lay-up produces pounds per hour of material, whereas, to be economically feasible in automobile manufacturing, pounds of material per second must be produced, using such processes as resin transfer molding.

It is difficult to transfer technology when the military and commercial systems requirements are different. The recently proposed National Aerospace Plane (NASP) provides an illustration of this. As a commercial aircraft, the NASP is envisioned as passenger carrier that would be able to fly halfway around the globe in 2 hours, opening up large potential markets of travel between the United States and the Far East. Nicknamed the "Orient Express" by President Reagan, this commercial aircraft would have to be able to attain speeds of about Mach 5 and be capable of cruising at altitudes of 30 to 40 kilometers.[51]

The military is also interested in the NASP as a platform for launching small payloads into space. Such a launch vehicle would have the advantage of being reuseable and having conventional take-off and landing capability. However, military requirements for this type of plane are much higher than are necessary for a commercial version. The NASP is under consideration as an SDI launcher because it would offer much-needed lower launch costs. In contrast to the Mach 5 capability of the commercial version, the military version would have to achieve Mach **25 to attain Earth orbit.**[52] **This** could require different propulsion systems (turbo ram jet vs. scramjet engines) as well as far more heat-resistant materials than for the commercial plane. To meet the extreme performance (high temperature) demands for the NASP, advanced materials technologies will play a large part. For a cruising speed of Mach 3, average temperatures can reach 630° F (332° C) at the leading edges of wings.[53] Titanium alloy aircraft skins start to weaken at 1,000° F (538° C), which occurs after a few seconds at Mach 5.[54] At the higher Mach numbers,

[49]Ibid.

[50]P. Beardmore, C. F. Johnson, and G.G. Strosberg, "Impact Of New Structural Materials Technology–Case Study: Composite Automobile Frame, " contractor report prepared for the Office of Technology Assessment, Mar. 1987.

[51]Jerry Grey, "The Aerospace Plane: The Timing Is Right," *Issues in Science and Technology,* Spring 1987, p. 18.

[52]James F. Loomis, Battelle Memorial Institute, *Toward a Hypersonic Commercial Transport,* talk given at the Office of Technology Assessment, Washington, DC, Jan. 13, 1988.

[53]"High Speed Commercial Flight: The Coming Era," James P. Loomis, cd., (Columbus, OH, Batelle Press, 1987, p. 193.

[54]T.A. Heppenheimer, "Launching the Aerospace Plane, " *High Technology,* July 1986, p. 47.

wing leading edge temperatures as high as 4,000° F (2,205° C) could be reached. Ceramic matrix composites or carbon/carbon composites would be required for the hottest structures, and metal matrix composites could be used in the cooler structures.

PROCUREMENT ISSUES

Military markets for advanced materials are unique in that the Federal Government is the principal customer. Because of this, participation of U.S. advanced materials companies is dependent on DoD policies and regulations, rather than on conventional economic criteria. The overriding DoD policy objectives are to secure reliable domestic sources of advanced materials and the widest selection of materials technologies at the lowest possible cost. DoD procurement policies that strongly influence the cost and availability of materials technologies include materials qualification requirements and domestic sourcing requirements. DoD procurement issues not covered in this assessment include military specifications and DoD auditing.[55]

Materials Qualification Databases

Before a material can be used in a military system, it must be "qualified" for use. As indicated below, the time and cost involved in testing a material for qualification are substantial. While it is desirable to have a rigorous screening procedure to assure performance and reliability, inefficiencies in the present system of qualification can limit the number of materials available and can add to their cost.

In the aerospace industry, materials databases are continually being developed for the purpose of qualifying new materials or new combinations of materials. Aerospace prime contractors conduct extensive testing on potentially useful materials, to avoid any possibility of liability due to structural failure. Each prime contractor maintains proprietary databases as well as expensive in-house testing facilities dedicated to its preferred methods of testing. Taken together, though, these databases carry redundant information, and their development is costly to the military, materials suppliers, and prime contractors. Also, they require a great deal of time to generate.

It costs as much as $10 million each for databases on individual new materials.[56] This process can involve up to 3,000 individual tests by the prime contractor and a similar amount by the material supplier.[57] Most of this $10 million for a database comes from the Federal Government.[58] This is the cost of a first database development; retesting for these databases occurs at a cost of roughly $1.5 million per additional set of tests.[59]

Under the present system, if six contractors intend to use a given material for an application, the material is qualified six times, each by a separate set of tests. If the same material is used by the same contractor but in a different application, it must be qualified again.

The cost of qualification varies depending on how much of the material is new (see table 11-8 for types of material and associated costs). The time taken in qualifying a new material can be more important to a company than the direct cost; it can take up to 2 years to qualify a new material.[60] Overall, the time and expense in-

[55] For a discussion of DoD procurement issues, see U.S. Congress, Office of Technology Assessment special report, "The Defense Technology Base: Introduction and Overview, OTA-ISC-374 (Washington, DC, U.S. Government Printing Office, March 1988)

[56] Michael Dubberly, Naval Air Command, Suppliers of Advanced Composite Materials Association, Annual Meeting and Industry Conference, May 5-8, 1987.

[57] Richard Ostlund, Boeing Vertol Company, Suppliers of Advanced Composite Materials Association, Annual Meeting and Industry Conference, May 5-8, 1987.

[58] Independent Research and Development (IR&D) funding is used for much of the development of these databases. IR&D funds are charged to the Federal Government as overhead by contracting companies, for the purpose of internal research related to a given contract. Generally these funds are some 2 to 6 percent of the contract and their use is determined by the company, with the government acting as an auditor. Government contractors consider IR&D money to be private in nature; there is a significant amount of debate in the Federal Government as to whether this overhead charge should be considered public or private.

[59] Dubberly, op. cit.

[60] Ibid.

Table n-8.-Qualification Costs of New Materials

Vendor/material	cost	Time to qualifv
Same material system; new vendor	$300,000	6 months
Equivalent resin; same fiber	$1.5 million	one year
Same resin; new fiber.	$6-8 million	18 months
New resin; new fiber	$10 million	2 years

NOTE: Median values given. Cost depends on: how much material will be used, in which parts of the plane, service environment, and specifications. In general, using the same material in a different application, the material must be requalified.

SOURCE: Michael Dubberly, Naval Air Command, Suppliers of Advanced Composite Materials Association, Annual Meeting and Industry Conference, May 5-8, 1987, Washington, DC.

volved in qualifying a new material can add up to a significant deterrent to testing new, possibly better materials in situations where there is already an available qualified material.

No fully satisfactory solution to the problem of overtesting has been suggested. However, possibilities for reducing the number and cost of materials databases have been proposed. DoD could promote the introduction of standardized testing. There are several groups that are each planning to develop limited sets of testing and materials standards. These are described in ch. 5, and include: the Aircraft Industries Association Composite Materials Characterization, Inc.; the Suppliers of Advanced Composite Materials Association; DoD's **Standardization Program, (Composites Technology Program Area), directed by the Army** for use by the Military Handbook 17 (MI L-1 7); and the Amercian Society for the Testing of Materials (ASTM). DoD could also promote greater sharing of data among prime contractors, and between prime contractors and materials suppliers. However, this would meet with considerable resistance from prime contractors who see these databases as proprietary in nature. Solutions to the overtesting problem are likely to involve some combination of the above.

Domestic Supply of Advanced Materials

There are several methods the Federal Government can use to ensure sufficient domestic supply of strategic and critical materials and to promote the well-being of the domestic industrial base via Federal Government purchases.[61] It is possible to establish domestic supplies of various products via the Defense Production Act of 1950 (50 USC 2166a).[62] Title III of that act authorizes purchase guarantees and loans to ensure domestic production capacity of certain materials (for instance, purchase guarantees for stockpiling of pitch-based fibers). It is also possible to establish domestic supplies of materials via the amended Defense Production Act of 1984 (Public Law 98-265)[63], and the annual Defense Authorizations or Appropriations Acts. [64]

Present U.S. markets for composites are dominated by military needs. Accordingly, DoD and the Congress have taken steps to ensure an adequate domestic supply and production capacity of certain composite constituents. Of particular importance to the advanced PMC community is the current requirement for assuring domestic sources for PAN (polyacrylonitrile) carbon fiber precursor, which Congress mandated in the Department of Defense Appropriations Act of 1987. PAN precursor is drawn into fibers and then heated to 1,600° F to form the carbon fiber.

Carbon fiber derived from PAN precursor is the single most important fiber used in advanced composites for aircraft and space applications. As of this writing, 100 percent of PAN precursor for fibers qualified for military use is imported from Japan and the United Kingdom. The United States currently has domestic production facilities for all phases of PMCs, from fibers and resins to finished components, except for the production of PAN fiber precursor. Amoco Chemical Co. has production facilities in the United States for PAN precursor but prior to this directive, the company was not a qualified supplier. Although Amoco is currently working toward qualifying as a domestic military supplier, DoD still **requires a second domestic** source, opening up opportunities for other companies as well.

The Congressional mandate follows an initiative by DoD to devise a plan (which has been

[61] Marvi n Goldstein, Department of Defense, personal communication, March 30, 1987.
[62] Ibid.
[63] DoD identifies the specific projects after Congress authorizes the funds.
[64] Ibid .

under consideration since 1985[65]) for the development of a domestic base of PAN precursor production. Congress has set requirements for 15 percent of all PAN used in military systems to be domestically sourced by 1989; 20 percent by 1990; 25 percent by 1991 and 50 percent by 1992.[66] Congress also endorsed the planning approach of DoD, which is to designate several high technology weapons programs to use 100 percent domestically-sourced PAN fiber. As of March 1988, no guideline has been developed by DoD for implementing this procurement plan.

The lack of a detailed plan has caused confusion among fiber vendors. Because material suppliers generally sell to particular prime contractors for specific weapons systems, it is important to industry to know the systems that will require domestic PAN fiber. Qualification of new fibers is also system-specific and must occur as the design of the system occurs. This means that a new domestic PAN precursor plant must be built in time to begin the qualification process while the weapon system design is still flexible. With no guarantees as to which systems would require domestic PAN fibers, individual companies do not know whether undertaking such a sizable investment would pay off.

Another concern on the part of potential U.S. precursor suppliers is that once production facilities are established in the United States, the Federal Government will not want to pay higher costs incurred initially for domestic PAN fiber precursor. A plant to produce PAN precursor costs as much to build as a plant to produce the carbon fiber from the precursor.[67] There is general agreement in industry that domestic fiber will cost more than imported fiber, at least in the beginning. Industry representatives are concerned that commitment to domestic sources will not hold if less expensive foreign-made precursor is available.

[65] Because of the importance of PAN-based carbon fiber *PMCs* to military systems, the Under Secretary of Defense for Research and Engineering issued a statement in 1985 expressing concern that there be some domestic source of production of PAN fiber precursor, and a policy directive was subsequently developed for achieving this.

[66] U.S. Congressional Record, No. 205, Part III, (Washington, DC, U.S. Government Printing Office, Dec. 21, 1987), pp. HI 2546-547.

[67] William Bennett, Amoco Performance Products, Inc., personal communication, Apr. 13, 1987.

OFFSETS

Offsets involve an agreement between a U.S. high technology systems manufacturer and a foreign buyer in which production technology is transferred to the buyer to promote the sale. Offsets are commonly used by U.S. aircraft manufacturers to promote sales of aircraft abroad. Historical examples of offsets include transfer of aluminum forging or PMC technologies to such nations as Canada, Sweden, France, Italy, Spain, the Netherlands, and Japan to encourage them to buy military aircraft such as the F-16 and the F-1 8, or commercial aircraft such as the Boeing 757, the 767, and the McDonnell-Douglas MD-80.[68 69]

Offsets are useful in promoting U.S. foreign policy interests. They also help achieve sales for U.S. aircraft manufacturers, who are not competing directly with the buyer. However, offsets can be harmful to the competitive position of materials suppliers, since suppliers may be compelled to transfer proprietary technology to potential competitors abroad.

In accordance with the Defense Production Act Amendments of 1984 (Public Law 98-265), Congress requires an annual report on offsets from the Office of Management and Budget. However, the situation is not currently receiving much attention. This is because offsets are only a small part of a larger picture of aircraft sales, which includes foreign policy goals such as rights to maintain air bases, coastal access or protection, or other policies not directly related to the sale of aircraft. Foreign nations wishing to purchase

[68] James N, Burns, Hercules, Inc., persona! communication, Apr. 20, 1987.

[69] Greg Barthold, Aluminum Company of America, personal communication, Mar. 5, 1987,

costly weapons systems require offsets to increase their domestic technology capabilities. Offsets are not merely a practice concerning a foreign nation or buyer and a U.S. vendor as part of an aircraft trade negotiation. They are part of the package of foreign policy actions that the United States undertakes as a military and economic superpower.

Offsets are a primary mechanism by which proprietary materials technology is transferred abroad. Advanced composite technology has already been transferred via offsets by airframe manufacturers to Spain, Italy, Sweden, and Japan on sales of commercial aircraft. Sales of military aircraft have included offsets of advanced aluminum processing technologies to Japan and France. Airframe manufacturers consent to offsets because they are required by foreign countries in requests for bids. Materials suppliers tolerate this loss of proprietary technology because to do so allows them to compete in a situation where all suppliers must offer offsets.

Another practice related to offsets, and detrimental to the U.S. advanced material supplier, is that of coproduction. A foreign country purchasing aircraft may require that parts of the aircraft be produced in that country. This is a situation where a U.S. prime contractor helps to set up a plant in a foreign country that is contracted to supply components or materials processing technology. This is technology that a U.S. advanced materials company could supply.

Offset agreements, as with other types of trade in advanced materials, must receive export licenses to proceed. Export controls exist, however, not for economic protection, but for national security and foreign policy reasons. The trade-offs in offset agreements are not only between national security and economic concerns, but also between national security and foreign policy. The two seemingly contradictory processes of offsets and export controls are focused on different goals (foreign trade, national security, and foreign policy) that are increasingly difficult to pursue concurrently in the highly integrated world marketplace.

There are many forms of offset practices. Although not easily calculated, their impacts on the competitiveness of advanced materials industries are believed to be extensive by many industry experts. A thorough, up-to-date analysis of the costs and benefits of offsets is desirable.

THE BALANCE OF COMMERCIAL AND MILITARY INTERESTS

With the growing dependence of the military on a range of high technologies, including advanced materials, DoD can be expected to take a larger policy role aimed at ensuring a domestic production capacity for key technologies. The large DoD funding for the Sematech Microelectronics Consortium ($100 million for 1988[70]) is one example of this trend; the PAN precursor procurement described above is another. DoD plans for a more comprehensive industrial policy were described at a May 1987 workshop held by the Suppliers of Advanced Composite Materials Association (SACMA).[71] This policy initiative, intended for the preservation of the U.S. industrial base, proposes targeting particular technologies, among them machine tools, bearings, castings, semiconductors and advanced composites, for DoD support. The policy initiative will address such issues as domestic technology erosion, availability of trained scientists and engineers, acquisitions of U.S. firms by foreign firms, contract and regulatory reform, research and development, energy, intellectual property rights, international cooperation, U.S. government-industry-academia collaborations, and better relations between DoD and the business community. Targeting of particular industries is deemed crucial.

If military investment is to benefit commercial materials applications, and vice versa, there must exist a broader policy perspective on materials.

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[70] *IEEE Spectrum,* February, 1988, p. 3.

[71] Robert Costello, Department of Defense, Annual Meeting and Industry Conference, Suppliers of Advanced Composite Materials Association, May 5-8, 1987.

To enhance the long-term competitiveness and health of the advanced materials industries, it will be essential to balance military and commercial **interests** more effectively. Options for taking better commercial advantage of military investments are discussed in the next chapter.