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THE DEPARTMENT OF DEFENSE STATEMENT ON CRITICAL TECHNOLOGIES FOR EXPORT CONTROL

by

Dr. Ruth M. Davis
Deputy Under Secretary of Defense for
Research and Advanced Technology

before the

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STATEMENT ON

THE CRITICAL TECHNOLOGY APPROACH IN
THE CONTROL OF EXPORTS OF U.S. TECHNOLOGY

BY

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RESEARCH AND ADVANCED TECHNOLOGY

BEFORE THE

SUBCOMMITTEE OF INTERNATIONAL ECONOMIC POLICY AND TRADE
OF THE
COMMITTEE ON FOREIGN AFFAIRS

UNITED STATES HOUSE OF REPRESENTATIVES

22 MARCH 1979

Mr. Chairman and Members of the Committee:

I am pleased to respond today to your invitation to discuss the concept of the Critical Technology Approach as it pertains to export control and the role that it is playing in the Department of Defense's formulation of improved procedures for carrying out its responsibilities in the export of U.S. technology. I am accompanied by Colonel John Hager, USAF, who is the Acting Director for Technology Export in my office.

After some brief observations on DoD's policy regarding the control of the export of U.S. technology, I will:

- Describe the genesis of what has become known as the Critical Technology Approach to the control of exports of U.S. technology.

- Discuss some of the actions taken by DoD in the past few years to provide for more effective controls on the export of technology with significant military value.
- Discuss the present status of our work in developing the Critical Technology Approach to controlling the export of U.S. technology, and
- Provide a prognosis of the next steps in the implementation of the Critical Technology Approach which will highlight some of the relevant issues.

My statement provides answers to the nine questions you posed in your letter to me of March 13, 1979.

I. OBSERVATIONS ON DOD'S POLICY TOWARD EXPORT CONTROLS

DoD strongly supports the currently stated Administration policy regarding exports which emphasizes the importance to the national interest of having both the private sector and the Federal government place a high priority on trade which strengthens the domestic economy. We know from experience the necessity of encouraging trade to further the sound growth and stability of our domestic economy. Indeed, our national security is dependent upon the strong and diversified industrial base that has been built-up over the years. It is the most powerful industrial base in the world: it must remain so since [illegible] is the foundation for our national security as well as our national well-[illegible]

At the same time we would point out that although the Export Administration Act [illegible] has been amended in a number of respects, there has been no retreat from its statements highlighting Congress's interests in using export controls "to the extent necessary to exercise the necessary vigilance over exports from the standpoint of their significance to the national security of the United States." In this Act as amended, Congress specifically stated its finding that "the defense posture of the United States may be seriously compromised if the Nation's goods and technology are exported to a controlled country (country to which exports are restricted for national security purposes) without an adequate and knowledgeable assessment being made to determine whether the export of such goods and technology will make a significant contribution to the military potential of such country."

We endorse this policy and have manifested our endorsement by conscientiously carrying out the important responsibility assigned to the Secretary of Defense: namely, the responsibility for this military assessment and for recommending to the President that exports be disapproved if they make such a contribution which would prove detrimental to the national security of the United States.

II. THE GENESIS OF THE CRITICAL TECHNOLOGY APPROACH

A. MILITARY TECHNOLOGY SUPERIORITY

Our national security has, in recent times, become increasingly dependent upon our military technological superiority which in turn is based on maintaining our technological lead time. To maintain this technological lead time demands that we use, in concert, all the applicable mechanisms available to us. There are four principal mechanisms that we can apply: namely,

1. Real increases in our research, development and acquisition resources,

2. Improved armament cooperation with our Allies,

3. Support to enhance and exploit our domestic advantage in commercial technology and our industrial base, and

4. Controls over the export of military critical technologies and of critical products of direct military significance.

It is apparent that export controls must figure prominently in our national security calculations. I will discuss export controls in this context in the following sections.

The measurement of technological superiority is inexact. It is primarily a measurement based on judgment - judgments based, in part, on assessments of comparative differentials between competitors. Judgments on military technological superiority are based on such comparative factors as: (1) the date at which new technologies are first seen as product embodiments in competitive military systems, (2) the date at which activity in a given militarily useful technology is initiated by each competitor, (3) the demand by one competitor for the militarily useful technology of another, (4) the comparative rate of advance of technologies of military value among competitors, and (5) the resources allocated to technologies of military value by each competitor.

B. MILITARY CRITICAL TECHNOLOGIES

Not all technologies are of equivalent value to national security. There [illegible] an [illegible] assumption that one can select that subset of technologies of significant military value on which our national military technology superiority can be presumed to be most dependent. Experience seems to validate this assumption.

These technologies of significant military value have been traditionally described in terms of their applied science or engineering substance. We mention, for example, jet engine technology, avionics technology, nuclear technology, guidance and control technology, surveillance technology, munitions technology, armament technology, etc. as being important to our national security. Such technologies described in terms of their applied science or engineering content have often been referred to as strategic technologies.

The phrase "strategic technology" in this sense depicts an area of applied science and/or engineering which is of significant military value.

"Technology" is also used to mean structured methods for achieving a practical or material goal as differentiated from scientific knowledge per se. As such, it is the know-how used in such applied scientific or engineering functions as design, manufacturing, utilization, testing and maintenance. "Know-how" as used here means some combination of engineering skills, scientific procedures, structured processes and technical information and contributing equipment (or products).

The phrase "critical technology" has been introduced in the last several years, as for example in the Secretary of Defense's Interim Policy on the Control of Exports of U.S. Technology of August 1977, to denote a technology whose acquisition by a potential adversary would make a significant contribution to its military potential and thus prove detrimental to the national security of the United States. Its first use seems to have been in 1977.

These several definitions of technology, strategic technology and critical technology with their varying meanings may be combined to provide a description of a "military critical technology." Specifically:

A military critical technology is:

. Know-how* used for such practical functions as design, manufacturing, utilization, testing and maintenance,

. In areas of applied science or engineering which have significant military value,

. Whose acquisition by a potential adversary would make a significant contribution to its military potential and thus prove detrimental to the national security of the United States.

*"Know-how" is a combination of engineering skills, scientific procedures, structured processes, technical information and contributing equipment (or products).

This definition is consistent with but represents a refinement and synthesis of earlier related definitions found in documented export control procedures, the 4 February 1976 Defense Science Board Report on Export of U.S. Technology, and the Secretary of Defense's August 1977 Interim Policy Statement on the Export of U.S. Technology.

C. THE CRITICAL TECHNOLOGY APPROACH TO EXPORT CONTROL

Current export control legislation and the COCOM agreement govern the export control practices of the Federal government. The control of exports of military equipment or technology (weapons, armament, etc.) for which there is little or no commerical market is done under the authority of the Munitions Control Act.

The control of exports of technology and products of military value which also have a commerical market is performed primarily under the authority of the Export Administration Act of 1969 as amended and the COCOM agreement. Such technologies and products have become known as "dual-use" technologies and products since they have both a military and commerical use. It is through the international commercial market place that military critical technologies and products of significant military value find their way to potential adversaries.

It is over this international commercial market place that controls must be exercised which reflect the many policies of the United States. It is in this market place that the tensions resulting from the simultaneous desire to promote trade and to control exports which will degrade our national security manifest themselves.

The Department of Defense's more recent efforts to better control experts of military value so as to protect national security without restricting U.S. trade any more than necessary have centered on determining the best procedures to control the export via the commercial market place of military critical technologies. This recent quite extensive effort, underway for the last two-three years (1976-1979), has become known as the Critical Technology Approach (CTA) to export control.

Some of its more salient features are:

1. The presumption of a set of military critical technologies - "small" in number and relatively stable over time. This appears to be a correct presumption after 18 months of developmental activity.

2. The presumption that control of military critical technologies will:

a. More adequately protect our military technological lead time than existing export control procedures.

b. Require controls on a fewer number of products, than the existing export control procedures on the assumption that the sale of products per se will not usually transfer any associated military critical technology, and

c. Make the export control process a more simple, and expedited process, on the assumption that many case-by-case review can be eliminated.

3. The presumption that assessments of comparative military and technological differentials between ourselves and potential adversary countri can be made for each military critical technology, and

4. The presumption that technology transfer mechanisms can be identified and that government control can be exercised over the more effective (or active) technology transfer mechanism for each military critical technology

I would point out that the second feature of the Critical Technology Approach cited above can also be considered as the real purpose of attempting this approach to export control: namely,

- To more adequately protect our military technological lead time.
- To permit DoD to require export controls on a fewer number of products, and
- To make the export control process as it relates to national security a more simple and expedited process.

I believe that my discussion thus far has accentuated a key point - namely that the principal motivation for DoD's interest in establishing an effective procedure through which it can control the export of military critical technologies is the compelling evidence of the importance to national security of protecting our military technological lead time relative to that of our principal potential adversaries. It is the urgency for better protection of this lead time that underlies our present emphasis on pursuing the Critical Technology Approach to export control.

D. TWO CONTRIBUTING DOCUMENTS IN DOD'S ACTIVITIES (1976-1979)

There are two principal contributing documents that were published in the three years from February 1976-February 1979 that serve to identify DoD's interests and policies and have spearheaded its development of the Critical Technology Approach to export control. They are:

1. The Defense Science Board Study published in February 1976 and titled "An Analysis of Export Control of U.S. Technology - A DoD Perspective."

This report is often referred to as the Bucy report as Mr. Fred Bucy was the Chairman of the group performing the analysis. A chart showing its recommendations and findings is contained in Attachment 1.

2. The 26 August 1977 memorandum issued by the Secretary of Defense stating his "Interim DoD Policy Statement on Export Control of U.S. Technology." Its key points related to findings and recommendations of the Defense Science Board report are found in Attachment 1.

III. IMPLEMENTATION BY DOD OF THE CRITICAL TECHNOLOGY APPROACH

A. IDENTIFICATION OF THE CRITICAL TECHNOLOGY APPROACH WITH NATIONAL SECURITY

I have in previous sections stressed the proper identification todate of the Critical Technology concept with the DoD objective of utilizing controls on the export of technology as one important mechanism for protecting our military technological lead time without restricting U.S. trade more than is absolutely necessary. The corresponding initiative and responsibility for the development of policies and strategies for introducing and recommending procedures for the protection of military critical technologies via the export control process rests firmly on DoD: DoD has accepted both this initiative and the associated responsibility.

B. OUTLINE OF STEPS IN THE IMPLEMENTATION PROCESS FOR CONTROL OF EXPORTS OF MILITARY CRITICAL TECHNOLOGIES

This implementation process has been underway for not quite three years, that is since the summer of 1976. It has been characterized primarily by ad-hoc or interim actions, one-time studies and reliance on volunteer-participatory groups from industry and government. This is not atypical of formative, innovative process design activities.

The principal steps in the formative stages of implementation of the Critical Technology Approach are presented here in outline form.

1. Determination of the areas of applied science or engineering constituting the first current list of Military Critical Technologies (MCT's).

This list was completed in January 1979. It is phrased in the terminology of the commercial market place since this is the gateway through which military critical technologies flow to potential adversaries. The technology areas are thus broadly titled and serve as pointers to the gross areas of technology in which will be found the specific military critical technology products, transfer mechanisms, and information over which DoD believes export controls are warranted. The 15 areas are:

- Computer network technology
- Large computer system technology
- Software technology
- Automated real-time control technology
- Composite and defense materials processing and manufacturing technology
- Directed energy technology
- LSI-VLSI design and manufacturing technology (LSI refers to large scale integration and VLSI to very large scale integration in microelectronics)
- Military instrumentation technology
- Telecommunications technology
- Guidance and control technology
- Microwave componentry technology
- Military vehicular engine technology
- Advanced optics technology (including fiber optics)
- Sensor technology
- Underseas system technology

Illustrative descriptions of some of these technology areas are provided in Attachment 2.

2. Determination of the specific component technology areas within each of these 15 areas of applied science or engineering which are of significant military value.

This step is partially completed. Recent work has been accomplished in 9 of the 15 areas by voluntary technical experts from industry and in informal conjunction with DoD staff. This step also can rely heavily on the technical efforts which resulted in the current Commodity Control List (CCL) used for export control and on the current COCOM List Review activity. Completion of this step is tied to the resources identified for it. Its accomplishment has been shown to be technically and managerially feasible. An illustration of a listing of militarily significant component technologies for Composite and Defense Materials Processing and Manufacturing Technology is provided in Attachment 3.

I would point out that this step makes evident the many component technology areas in each of the identified 15 primary technology areas of concern to DoD which are not of significant military value. This important listing is illustrated also in Attachment 3.

3. The identification in each of the 15 identified areas of military critical technology of the contributors to the relevant design, manufacturing, utilization, testing and maintenance functions which can be subjected to export controls.

This step makes evident the fact that a military critical technology does not, per se, lend itself to export control. Only tangible manifestations of the technology or the mechanisms of technology transfer lend themselves to explicit control. For example, one can control the export of products and of technical information not in the public domain. Similarly, control can be exercised over mechanisms of technology transfer such as the provision of training, the construction of turn-key factories or the initiation of co-production agreements.

Attachment 4 contains, for information purposes, a listing of recognized mechanisms for technology transfer.

4. Recommendations as to what products, technical information, or other controllable features of each Military Critical Technology should not currently be exported.

This step is vitally time-dependent and corresponds roughly to what is now performed in the case review of individual export applications. It relies on determinations of:

a. Foreign availability of identified products, information, etc.

b. The technological capability in and military reliance on each Military Critical Technology by potential adversaries, and

c. The comparative differential between U.S. and foreign military reliance on and capabilities in each Military Critical Technology along with the rate of change of this comparative differential.

Such information implicitly influences the outcome of all of the steps of the Critical Technology Approach. It explicitly underlies the successful completion of this step. This step however is an on-going process itself because its resultant recommendations rely on what has been shown to be continually changing data and on the allocation of resources by the Intelligence Community to this effort.

The carrying out of this step involves extensive cooperation and interaction by the Intelligence Community. It also depends upon the support of the Department of Commerce and of U.S. industry in obtaining estimates of foreign availability.

I asked CIA and DIA by memorandum of January 16, 1979 to assist in this step. I have been most impressed and pleased with the intensive support effort now underway by the Scientific and Technical Intelligence Committee (STIC).

5. Delineation of technology transfer mechanisms effective for each of the Military Critical Technologies along with recommendations on what governmental controls can and should be invoked over them.

This step is well underway. It was initiated in late 1977. It appears feasible and its completion is dependent upon resources allocated to it.

These five steps just outlined are necessary for implementation by DoD of the Critical Technology Approach. No technical problems have emerged as barriers to their completion. The carrying out of the supporting efforts with associated time-schedules is dependent upon the resources allocated by DoD which depend in turn on the priority assigned by DoD to this particular means for protecting our national security.

Approval of an Office of Technology Export reporting to me with responsibilities for developing and implementing the Critical Technology Approach has been obtained only this fiscal year. The first opportunity for having budgeted resources identified by DoD for Presidential and Congressional approval will occur in conjunction with the FY 81 budget process. I will be providing time-tables for supporting activities as an integral part of our first formal budgetary request.

IV. CONCLUDING COMMENTS

The implementation by DoD of the Critical Technology Approach to export control as a means for protecting our military technology lead time with minimum interference to trade is taking place in the manner described in my statement. It will include as an integral component a list of products and technical information which we will recommend should not be exported. It will also include a list of technology transfer mechanisms which we would ask to be subjected to recommended export controls. Both lists will be categorized within the framework of the already identified 15 substantive areas of Military Critical Technologies.

The incorporation of these lists and recommended implementation processes into the existing governmental export control process will involve interagency support, cooperation and agreement. The principal involved Departments are the Departments of State and Commerce who have administrative responsibilities for export control.

Similar support, cooperation, and agreement by COCOM members is also required.

Transition from present lists of controlled products (e.g., the Controlled Commodity List and the COCOM List) to the Military Critical Technology Product and Information List, either through substitution or merger, will need to be effected.

DoD will also need to obtain agreement that controls can be explicitly exercised, as appropriate, over technology transfer mechanisms. There is no corresponding current exercise of control.

After three years of exploratory and developmental activity by both government and industry, we have encountered no technological or institutional hurdles which would prevent the implementation of the Critical Technology Approach as I have presented it. I have been impressed by the widespread support industry has voluntarily provided over the last year to helping implement this new approach. I believe I correctly infer from this support, that industry views it essential just as we do, to find an improved means of using export controls to protect our national security with minimum interference to trade.

I believe that DoD needs to pursue with adequate and dedicated resources the Critical Technology Approach to export control. The urgency of maintaining our military technological superiority and the increasing attractiveness of the Critical Technology Approach for so doing together produce a compelling reason for eliciting Congressional support of DoD's effort and for vigorously expediting our on-going efforts.

Attachments 4

ATTACHMENT 1

SUMMARY OF FINDINGS
DEFENSE SCIENCE BOARD REPORT ON
EXPORT CONTROL OF U.S. TECHNOLOGY

The Assessment of selected technologies, their impact on U.S. strategic requirements, transfer mechanisms and current effectiveness of export control restrictions reinforce the need for export controls and the COCOM agreement as a defense necessity. The effectiveness of these controls for the more critical technologies needs to be improved through definition of policy objectives, simplified criteria and a more pragmatic approach to the review and approval of license applications. Products of technology not directly of significance to the Department of Defense should be eliminated from controls to enable more effective control of significant items.

The findings and principal recommendations of the Task Force are:

I. Design and manufacturing know-how are the principal elements of strategic technology control.

These categories of export should receive primary emphasis:

1. Arrays of design and manufacturing know-how.

2. Keystone manufacturing, inspection and test equipment.

3. Products accompanied by sophisticated operation, application or maintenance know-how.

II. The more active the relationship, the more effective the transfer mechanism.

1. The more active mechanisms must be tightly controlled.

2. Product sales do not usually transfer current design and manufacturing technology.

III. To preserve strategic U.S. lead time, export should be denied if a technology represents a revolutionary advance to the receiving nation, but could be approved if it represents only an evolutionary advance.

1. Tactics to protect lead time must differ depending on the technological position of the U.S. as compared to that of the prospective receiving country:

a. When both are on the same evolutionary track, export control decisions should weigh the receiving country's immediate gain from the acquisition of the technology.

b. When the U.S.' position results from a revolutionary gain, export controls should focus on protecting all key elements of this gain.

2. Because of its importance as a factor in strategic lead time, a viable R&D effort should be continued.

IV. Current U.S. export control laws and the COCOM agreement provide a continuing means of protecting the lead times of strategic technologies.

1. U.S. export control activity should place primary emphasis on control of the active transfer mechanism.

2. Control of product sales should emphasize their intrinsic utility, rather than commercial specifications and intended end use.

3. A simplified criteria should be developed in order to expedite the majority of license requests.

4. The U.S. should release to neutral countries only the technologies we would be willing to transfer directly to Communist countries.

5. The U.S. should pursue actions and decisions to strengthen the COCOM network of export controls.

6. Key elements of technology that constitute revolutionary gains should not be released--excepting to COCOM nations. Any COCOM nation that allows such technology to be passed on to any Communist country should be prohibited from receiving further strategic know-how.

V. "Deterrents" meant to discourage diversion of products to military applications are not a meaningful control mechanism when applied to design and manufacturing know-how.

1. Deterrents such as end-use statements and safeguards should not be used to control applications of design and manufacturing know-how.

2. Deterrents should not be relied upon to prevent manufacturing equipment from being used for military purposes.

3. Deterrents attached to product sales may have some face value, but they should be supplemented by vehicles for enforcement against violations.

4. Deterrents should not be used when a high degree of certainty is required that diversions to military applications will not occur.

VI. The absence of established criteria for evaluating technology transfers reinforces the cumbersome case-by-case analysis of all export applications.

1. The Department of Defense should develop policy objectives and strategies for the control of key high-technology fields.

2. These objectives should include sufficient information to identify key elements of technology, including critical processes and key manufacturing equipments.

3. Technology exchange opportunities should be identified by citing technologies in which the U.S. lags the Communist world.

4. Policy objectives should be communicated broadly to interested U.S. agencies, private firms and COCOM nations to obtain a wider base of cooperation in effecting controls.

5. Advisory committees consisting of individuals from government and private sectors should be used to recommend policy objectives and strategies.

6. The Department of Defense should reevaluate and increase the resources required to perform and implement these studies.

INTERIM DOD POLICY STATEMENT EXCERPTS

Defense Department Policy in Export Control of US Technology

In assessing and making recommendations upon those export applications referred to it by the State and Commerce Departments, Defense will place primary emphasis on controlling exports to any country of arrays of design and manufacturing know-how; of keystone manufacturing, inspection and test equipment; and of sophisticated operation, application or maintenance know-how. (DSB Finding I)

In order to protect key strategic US lead times, export control of defense-related critical technology to all foreign countries is required. To this end, Defense will: (DSB Findings I, III, IV)

1) request the Department of Commerce to alter existing regulations so as to require a validated license for proposed exports of critical technology to all destinations;

2) recommend to, and support the negotiation by, the Department of State with COCOM countries, and such other nations as may be appropriate, of new measures to control or restrict the flow of critical technology to Communist countries, as well as recommendations as to the revision of the list of embargoed products.

3) recommend to the Secretary of Commerce that procedures be streamlined in such a way as to minimize delays in forwarding and processing export applications by a) speeding referral by Commerce of export applications for review and b) making use of new and/or improved technical guidelines to be supplied by DoD, which will allow maximum emphasis to be placed upon applications for the export of critical technologies and associated end products, thereby also allowing more rapid processing of applications for other, non-critical end products.

Defense will support the transfer of critical technology to countries with which the US has a major security interest where such transfers can 1) strengthen collective security, 2) contribute to the goals of weapons standardization and interoperability, and 3) maximize the effective return on the collective NATO Alliance or other Allied investment in R&D.

In assessing the advisability of the transfer of critical technology to either COCOM or other non-Communist countries, Defense will carefully assess the proposed recipient's intent and ability to prevent either the compromise or the unauthorized re-export of that technology. Where classified information is involved, security classification guidance will be provided to the recipient, and where feasible, security surveys will be accomplished in addition to the completion of appropriate military and industrial security arrangements. (DSB Finding IV)

The Department of Defense will look to the State and Commerce Departments and the intelligence and security communities to identify those instances in which the initial recipient makes unauthorized further transfers, or allows compromise, of critical technology. The Department will incorporate the results of such observations in its assessments of subsequent applications for commercial export, Foreign Military Sales (FMS), Data Exchange Agreements (DEA), Information Exchange Programs (IEP), and other transfers to such recipients. Violations of US third-country transfer prohibitions or instances of compromise will normally be considered grounds for employment of sanctions involving critical technologies. Coordination within DoD will be strengthened to meet the requirements of military and industrial security. (DSB Finding V)

Defense will normally recommend approval of sales of end products to potential adversaries in those instances where 1) the product's technology content is either difficult, impractical, or economically infeasible to extract, 2) the end product in question will not of itself significantly enhance the recipient's military or warmaking capability, either by virtue of its technology content or because of the quantity to be sold, and 3) the product cannot be so analyzed as to reveal US system characteristics and thereby contribute to the development of countermeasures to equivalent US equipment. (DSB Finding I)

There shall be a presumption for recommending disapproval of any transaction involving a revolutionary advance in defense-related technology to the proposed recipient country (if the resultant military capability threatens US interests). Defense will assess a proposed export of technology not on the basis of whether the item is obsolete by US standards, but on whether the proposed export would significantly advance the receiving country's potential and prove detrimental to the national security of the United States. (DSB Finding III)

End-use statements and safeguards are not to be considered a factor in approving exports to potential adversaries of critical technologies and products except as may be otherwise provided in Presidential directives. Departure from this procedure will occur only with specific approval of the Secretary of Defense, or his designee. (DSB Finding V)

Defense recommendations to approve the export of end products to potential adversaries are to be made primarily on the basis of an assessment that the products' inherent performance capabilities, or the quantity sold, do not constitute a significant addition to the recipients' military capability which would prove detrimental to the national security of the United States. (DSB Finding IV)

This policy shall be applied without regard to whether the exporter is a government department or agency, a commercial enterprise, an academic or non-profit institution, an individual entrepreneur, or in the case of re-export requests, a foreign government or an international organization; and without regard to the transfer mechanism involved, e.g., turnkey factories, licenses, joint ventures, training, consulting, engineering documents and technical data.

Explicit account shall be taken of the relative efficiency of the various mechanisms of technology transfer (e.g., foreign liaison activities, scientific and technical exchanges, commercial visits, trade fairs, training programs, sales proposals and consulting agreements, as well as in specific technology export cases). When the potential for inadvertent transfer of critical technology is considered to be high, Defense shall formulate and recommend to the responsible agencies restrictions on the amount, extent or kind of interpersonal exchange in a given transaction. Visitor control mechanisms within the Department of Defense will be improved. (DSB Finding II)

The Department of Defense, in coordination with other Departments and Agencies, shall identify and maintain a continuously updated list of specific critical technologies and/or end products whose export should be restricted for reasons of national security. This list and its updates will be communicated to Departments responsible for administering US export controls. It is recognized that these list items will be time-dependent. Appropriate items will be added and/or deleted from the list as time goes by. (DSB Finding IV)

In coordination with and assisted by the intelligence community, Defense will undertake to improve the information and data base pertaining to technology transfer by studying in greater depth and on a continuous basis selected aspects of US technology transfers over time in order to ascertain their impact on the military capabilities of potential adversaries and on critical US lead-times. (DSB Finding III)

In the interagency arena, Defense will propose and support means by which national security considerations can be taken fully into account from the beginning stages of any international projects having the potential of promoting the transfer of critical technologies. (DSB Finding IV)

The Department of Defense will propose and support means of improving interagency communication and coordination on matters of export controls and technology transfers in order to help achieve adequate and appropriate interagency coordination in these areas. (DSB Finding VI)

ATTACHMENT 2

GUIDANCE AND CONTROL TECHNOLOGY

Definition: This technology is that of sensors and detector , transmitters, signal processing and their integration with control functions including feedback control systems.

Scope: Guidance and Control Technology applies to navigation, positioning, flight control, platform stabilization and midcourse and terminal guidance, including both active and passive systems. It is distinguished from and can be considered a subset of command and control systems for vehicles such as aircraft and ships which include many additional functions and additional technologies (e.g., data bases). Acoustic systems are covered under Undersea Warfare Technology.

Key Components:

o Sensors and Detectors which include infrared (IR) detectors, vidicons, charge coupled devices (CCDs), conventional and laser gyroscopes, accelerometers, gyrocompasses, gravity meters, cesium clocks, low noise Field Effect Transistors (FETs), parametric amplifiers, IR and RF radiometers and PIN diodes.

o Transmitters which include solid state and tube microwave and millimeter sources and laser sources.

o Signal Processing which includes computers and related key components such as analog to digital (A/D and D/A) converters, integrated circu s and memories, analog CCDs, surface acoustic wave (SAW) devices, and related special purpose software and firmware for signal processing.

o Feedback Control Systems which include high precision synchros, resolvers and potentiometers for analog systems and items included in signal processing for digital systems.

Military Applications: Guidance and Control Technology is the key to attainment of both precision guided and fire and forget munitions. For fixed wing aircraft it can provide major advances in simpler pilot controls, improved maneuverability, and reduced costs. For helicopters it can provide significantly improved nap-of-the-earth operations. The GPS systems can prove an unprecedented precision navigation and positioning capability.

Trends: The major trend is the application of signal processing in guidance and control systems to provide greatly improved target discrimination from clutter, noise and decoys. A related trend in control circuits is the use of digital systems instead of analog systems. Concerning sensors the trend is to electroptic, IR and millimeter wave active and passive systems and digital controls is paced by the availability of faster digital circuits. Processing throughput speed of guidance and control computers will continue to advance at the rate of about a factor of two annually.

MICROWAVE COMPONENT TECHNOLOGY

This technology is that of active generators, amplifiers, switches and detectors of microwave energy as well as of passive components for transmission and distribution.

Scope: Microwave component technology includes both active device technology (semiconductor and electronic vacuum tube circuit elements such as amplifiers, switches and modulators) and passive component and assembly technology (such as antennae, filters, duplexers and power dividers).

Key Aspects: For active semiconductor devices the key aspects are precision control of impurity levels and doping profiles over dimensions that are smaller than one micrometer; contact metallurgy to provide low microwave loss and long life at high power densities; and packaging methods to match impedances between macroscopic transmission lines and microscopic semiconductor devices while providing an inert environment to protect the semiconductor and metallization. For microwave electronic vacuum tubes the key aspects are preparation of long life (1000 to 10,000 hour) cathodes with emission current densities of greater than 0.5 ampere per square centimeter; glass-to-metal seal and ceramic-to-metal seal processing that provides 10^{-9} Torr vacuum envelopes without contamination of cathodes and circuit structures; precision machining and assembly of circuit structures with tolerances of 0.0001 to 0.0005 inch. For passive components the key aspects are precision machining, finishing and assembly of metal and dielectric parts. Computer aided circuit design and computer aided microwave measurement equipment are key aspects of all microwave component technology.

Military Application: Microwave components are used in radar, communications, electronic warfare receivers and jammers, munitions guidance, fuzing and fire control. Wide bandwidth in both active and passive components is critical in jamming equipment to allow many threat frequencies to be countered with the same hardware. Low noise field effect transistors are important to ELINT receivers and microwave communications links. Small size solid state sources and microstrip circuit components that can withstand shock and vibration are critical to fuzing. High speed frequency division and microwave analog-to-digital conversion is critical to surveillance receivers.

Trends: Increased power at higher frequencies with solid state amplifiers and sources will occur, with tens of watts per device at 10 GHz and one watt per device at 100 GHz in the next few years. Low noise field effect transistors are now available through 20 GHz and will become available to 40 GHz within five years, but progress beyond that will require new material capabilities. Mixers will dominate over low noise FETs at frequencies above 40 GHz and will reach 300 GHz through quasi-optical techniques. Power tube efficiency will increase about 10% at frequencies below 40 GHz through the use of multiple depressed collectors within the next five years. New power generation techniques will be needed before tube technology can achieve 10 KW levels at 100 GHz, but significant effort will be directed toward this goal. Dielectric waveguide and quasi-optical circuits will be used above 100 GHz, but conventional stripline and waveguide components will dominate below 100 GHz.

UNDERSEA SYSTEMS TECHNOLOGY

Definition: Undersea systems technology is that of system and systems components designed to operate in the sea, or to obtain information about the water column, or about objects therein from locations on shore, in space, on the sea surface, or on the ocean floor from fixed, tethered, or mobile platforms, (including free floating or drifting unmanned, manned, or living platforms.)

Scope: Systems and systems components that are supported by undersea systems technology include:

- o Undersea vehicles, including vehicles that move along the ocean floor.

- o Systems for research, exploration, and understanding of the undersea environment.

- o Communications and control systems, including undersea sensor and instrumentation systems, as well as undersea navigation systems.

- o System for economic exploitation of the undersea environment, including the ocean floor. Examples are undersea mining, aquaculture, fishing, fish farming and salvage.

- o Life support systems.

- o Underwater weapons systems, including those designed to be used against targets in the water or to originate in the water but directed against land, air, or surface targets.

Dominant (but not exclusive) discipline - orientations of undersea systems technology components are[1]:

- o Underwater acoustics:

  Sensors, transducers, instrumentation
  Transmissions
  Propagation
  Information processing
  Display

- o Materials (shock, pressure, corrosion, and temperature resistent or compliant).

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[1]This is not an exhaustive list.

- o Hydrodynamics

- o Medical physics

- o Magnetic, infrared, and microwave

- o Mathematical simulation and modeling of undersea environments on micro and macro scale.

- o Underwater propulsion and energy storage and conversion.

End Products:

- o Undersea vehicles

  Submarines
  Bottom crawlers
  Torpedoes
  Craft to aid swimmers

- o Research and Exploration

  Seismic profilers
  Acoustic transducers and transponders
  Acoustic receiving arrays
  Magnetic survey equipment
  Microwave radiometry receivers
  Infrared mapping equipment
  Acoustic and electromagnetic signal processing and display equipments
  Compilations of geophysical data and mathematical analyses and simulations
  Chemical and radiological test equipment

- o Communications and Control Systems, Including Undersea Sensor Instrumentation, and Navigation Systems

  Underwater communications systems - acoustic and electromagnetic
  Mechanical guidance and control systems
  Passive and cavitation sensors
  Sonars - active and passive
  Towed arrays
  Optical systems - periscope TV
  Echo sounders
  Inertial navigation systems
  Satellite navigation systems
  Satellite instrumentation for sea surface and ice-cover condition measurement
  Submarine - infrared
  Submarine electro-optical system
  Computer (network) for internal command and control of underwater vehicles

Acoustic classification equipments
Acoustic quieting and noise reduction

- o Systems for Economic Exploitation of the Undersea Environment

  Cable laying equipment
  Fault-finding equipment
  Underwater positioning devices
  Submerged stable platforms
  Underwater tools

- o Life Support Systems

  Hypobaric chambers
  Protective clothing and equipment
  Underwater reserve (deep submergence) equipment

- o Underwater Weapons Systems

  Mines
  Torpedoes
  Acoustic and Magnetic Countermeasures
  Electro-magnetic countermeasures
  Communication security
  Submarine time control system
  Remote targeting system

Many of the above products exist in different versions for application from satellite, surface, submarine, or fixed platforms. Design, fabrication and packaging to meet the constraints imposed by the intended application constitutes, in many cases, the real technological lead. The principles that govern undersea warfare are well understood.

- o Key Technology Components

The following are some examples to illustrate the process. The Navy and DARPA are the sources of definitive information on critical technology components and keystone equipments.

- o Undersea Vehicles

  Drag reduction technology
  Thick-wall welding technology
  Quieting of flow and propulsion technology
  Sound isolation technology
  High power density energy storage

- o Keystone equipments in each case

  Design
  Technical data
  fabrication equipments

- Research and Exploration Systems and Communications and Control Systems, Including Sensors, Instrumentation, and Navigation Systems

- Acoustic Transmission Techniques

  Integrated circuits
  Piezo-electric ceramics
  Magneto-strictive metal
  High-power audio amplifier design
  Transducer-dome material
  Noise reduction and control

- Keystone equipments

  Design
  Data
  Fabrication

- Acoustic Propagation

  Mathematical simulation
  Acoustic signal processing

- Keystone equipments: Simulation models of the environment in specific frequencies and locations. Processing codes and techniques.

- Towed Arrays

  Signal processing
  Materials
  Hydro dynamics
  Fiber optics

ATTACHMENT 3

ILLUSTRATIVE LIST

CRITICAL AND NON-CRITICAL TECHNOLOGY COMPONENTS
FROM THE
STRUCTURES, MATERIALS, AND PROCESSES
MILITARY CRITICAL TECHNOLOGY AREA

This list illustrates one possible identification of critical and non-critical technology components in this one Military Critical Technology area.

SUMMARY OF MILITARY CRITICAL AND NON-CRITICAL TECHNOLOGY COMPONENTS

TECHNOLOGY SUB-AREA	CRITICAL COMPONENTS	NON-CRITICAL COMPONENTS
Fracture Control Design Processes (10)	Damage Tolerance/Durability/ Fail Safe Design Methodology - Metal Structures - Composite Structures - Drive Systems	High Fracture Toughness Materials/ Processes Improved Fatigue Resistant Materials/ Processes Non-Destructive Evaluation/Inspection Techniques as Related to Damage Tolerance/Fatigue Resistance (see also #26) Structural Life Management
Diffusion Bonding and Other Advanced Joining Methods (15)	Superplastic Forming/Diffusion Bonding (SPF/DB) Laser Welding Plasma Arc Welding Laser Surface Enhancement	Diffusion Bonding Narrow Gap Welding Gas Metal Arc (GMA) Welding Explosive Welding Ion Surface Alloying Ion Surface Treatment Brazing Weld Brazing Adhesive Bonding Electron Beam Welding
Inspection of Advanced Composite Structures (25) and Non-Destructive Evaluation Technology (26)	Ultrasonic Spectoscopy X-Ray Image Enhancement Acoustic Fingerprinting	Ultrasonic Reflection/Through Transmisn Resonance Ultrasonics Holographics Radiography - X-Ray; Neutron Accoustic Emission Thermal - IR; Liquid Crystal Thermography Radiation Penetrants Hole Shapes/Finishes Surface Waves/Shear Waves Chemical Footprinting Photogrametry Penetrants Magnetic Particles Exo-Electron Emission Eddy Current Ultrasonic Holography Thermal Emission

SUMMARY OF MILITARY CRITICAL AND NON-CRITICAL TECHNOLOGY ELEMENTS (Cont'd)

TECHNOLOGY SUB-AREA	CRITICAL COMPONENTS	NON-CRITICAL COMPONENTS
Vacuum Casting (Especially Air-Cooled Turbine Blades) (31)	Investment Shell Molds and Cores Directional Solidification (Including Eutectics & Single Crystals)	Superalloys Titanium Alloys Aluminum Alloys High Strength Steels Stainless Steels Melting
Corrosion, Erosion Resistant Coatings (35)	Corrosion/Erosion Resistant Coatings	Corrosion Resistant Coatings - Plating - Cadmium & Tire - Cadmium - Vacuum Deposited Metallic Coatings - Spray & Baked Aluminum-Alumazite Z
and		
High Temperature Coatings for Superalloys and Titanium (38)	MCrAlY Coatings Thermal Barrier (Metal/Ceramic) Titanium - Various High Temp. Coatings Eng Pts	Superalloy Coatings: - Diffused Aluminide - Pack Cementation - Vapor Deposition - Slurry Premeat (Incl. Electrophoretic) - Co [illegible]
Metal Matrix Composites (Including Carbon-Carbon, Organic) (39) - Metal Matrix Composites	Boron/Aluminum Silicon Carbide/Aluminum Silicon Carbide/Titanium Graphite/Aluminum Graphite/Magnesium Selective Reinforcement Borsic/Aluminum Borsic/Titanium	Tungsten/Superalloys In-Situ Composites Graphite/Lithium Graphite/Copper Graphite/Lead Alumina/Aluminum Beryllium/Titanium

SUMMARY OF MILITARY CRITICAL AND NON-CRITICAL TECHNOLOGY ELEMENTS (Cont'd)

TECHNOLOGY SUB-AREA	CRITICAL COMPONENTS	NON-CRITICAL COMPONENTS
- Carbon-Carbon Composites and - Ceramic Matrix Composites	Fiber Reinforced C-C Composites Thermochemical/Thermostructural/ Erosion/Ablation Analysis Quartz/Silica	Carbide Loaded Graphite Graphite/Ceramic Tantilum Carbide/Silicon Nitride
- Organic Matrix Composites	Graphite Epoxy Graphite Polymide Kevlar Epoxy Hybrid Composite Designs (Mixed Fiber/Metals)	Advanced Thermoplastic Matrices Selective Reinforcement
Powder Metallurgy (e.g., High Cooling Rate) (43) and Hot Isostatic Processing (24)	Rapid Solidification Particulate Composites (Dispersion Strength of Materials) Powder Processing (Metals, Ceramics) Component Rejuvenation/Repair Advanced Alloys	Hot Isostatic Pressure (HIP) Vacuum Hot Pressure (VHP) Shock Compaction Explosive Compaction Powder Composition Specifications Parameters/Sizes Cold Isostatic Pressing Casting Followed by HIP Metal Matrix Composites (See Also #39) Isothermal Forming/Forging Superplastic Forming Explosive Forming

ATTACHMENT 4

TECHNOLOGY TRANSFER MODES AND MECHANISMS

Technology can be transferred between individuals or companies by any one of a number of mechanisms. In this sense a transfer mechanism is any specific vehicle or means for conveying technology whether consciously or unconsciously. In most cases technology is transferred through a contractual or organizational framework involving more than one mechanism. We call this a transfer mode, that is, a framework, with an economic incentive, to provide an orderly procedure or way of teaching the recipient how to do something. Thus, the key distinctions between transfer modes and mechanisms are: (1) that modes involve a contractual or organizational framework, with an economic incentive and a conscious orderly procedure to effect the transfer; and (2) that transfer modes probably involve more than one mechanism. Most technology transfer modes also involve or require an active rather than a passive relationship between the transferrer and the recipient whereas mechanisms can be completely passive. A listing of the major modes and mechanisms used for international technology transfer is provided below:

Major Technology Transfer Modes and Mechanisms

Modes - contractual or organizational frameworks, with an economic incentive, within which technology transfers occur.

1. Transfers of technology from the U.S. to a foreign controlled organization.

    a. Turnkey factories
    b. Licenses with technical assistance (anything beyond an arms length transaction)
    c. Joint ventures
    d. Management or technical service agreements
    e. Coproduction agreements
    f. License agreements without technical assistance (arms length transactions with no personnel training or support)
    g. Trade shows, industrial exhibitions, symposia, and technical meetings

2. Multinational corporation internal transfers

3. Foreign direct investment in the U.S.

Mechanisms - specific vehicles or means for conveying technology.

1. Processing equipment transfers.

2. End product transfers.

3. Unpublished design information transfers.

4. Unpublished engineering document transfers.

5. Operations and maintenance data transfers.

6. Other technical data transfers.

7. Foreign citizens employed, trained, educated in the U.S.

8. Exchanges of personnel and visits of foreign personnel to U.S. facilities, or visits of U.S. personnel to foreign facilities.

9. Transfers of published documents with design, engineering or other technical data and information.

In a number of studies the importance of sustained enterprise-to-enterprise relations or continued personal interactions to best effect the transfer of technology has been emphasized. These studies show that technology is most effectively transferred through close and continual contact by individuals or firms. Thus, transfer modes and mechanisms involving extensive training or teaching efforts are more effective than exporting hardware or documents with little or no subsequent involvement of technical personnel on the part of the donor. While there may be some cases where the export of a product, or some set of information, would permit the recipient to make a revolutionary versus an evolutionary advance, these should be exceptions to the general case and handled as such.

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-8