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Report to the Chairman, Committee on Armed Services, House of Representatives

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DEFENSE TECHNOLOGY BASE

Risks of Foreign Dependencies for Military Unique Critical Technologies

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National Security and
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The Honorable Les Aspin
Chairman, Committee on Armed Services
House of Representatives

Dear Mr. Chairman:

In response to your request, we are reporting on the impact of U.S. dependence relating to foreign state-of-the-art technologies on maintaining U.S. leadership in critical technologies considered by the Department of Defense (DOD) to have principally a military application. This report updates the information we provided to your office during our March 17, 1992, briefing.

Based on information we obtained from DOD, we identified (1) the DOD critical technologies that principally have military applications, (2) the capabilities of other countries relative to the United States in selected key areas of those technologies, and (3) how the capabilities of other countries in those technologies affect U.S. national security.

Background

In an interdependent global economy, foreign sources of technology abound in both the commercial and defense sectors. There are sometimes economic, political, and military advantages to using foreign sources of supply for technology. The concern over foreign sourcing relates to whether a dependency constitutes a risk, or vulnerability, to the United States.[1] Such a risk would exist if the United States were to become so dependent on a foreign source that its ability to secure the most advanced technology for the development of a future weapon system were to become compromised. Although foreign sourcing does not necessarily mean dependency, many experts agree that the trend toward increasing foreign sources should be closely monitored to reduce potential national security risks.

[1]The November 1987 National Defense University Report, U.S. Industrial Base Dependence/Vulnerability, defines three elements of foreign sourcing: (1) a foreign source is a source of supply, manufacture, or technology that is located outside the United States or Canada; (2) a foreign dependency refers to a source of supply for which there is no immediate available alternative in the United States or Canada; and (3) foreign vulnerability, related to foreign dependency, refers to a source of supply whose lack of availability jeopardizes national security by precluding the production, or significantly reducing the capability, of a critical weapon system.

DOD's May 1991 Critical Technologies Plan (the 1991 plan) described 21 technologies considered essential for maintaining the qualitative superiority of U.S. weapon systems. This was the third annual DOD critical technologies plan. DOD uses its list of critical technologies to plan investment strategies for future research and development. According to the 1991 plan, the defense critical technologies represent the leading edge of DOD's science and technology program and are those likely to set the pace of innovation in developing advanced weapon capabilities and modernizing today's systems.

Results in Brief

At least 15 of the 21 critical technologies identified in the 1991 plan have significant commercial applications or potential, in addition to contributing to DOD missions, while 6 have principally a military application. These six technologies are (1) sensitive radar, (2) signature control, (3) weapon system environment, (4) pulsed power, (5) hypervelocity projectiles and propulsion, and (6) high-energy density materials. According to DOD officials, these six technologies principally have military applications, although in most cases they are not solely for military applications.

According to the 1991 plan and the DOD lead agents responsible for the six critical technologies, the United States is generally considered the world leader in those fields; however, other countries have broad achievements and possible leadership in some niches of those fields. U.S. and other countries' capabilities in high-energy density materials illustrate this. In addition, the United States is the recognized leader in developing signature control, cited by DOD as one of the most important of the six technologies; however, the technology available from other countries continues to advance.

DOD's lead agents for four of the six critical technologies with largely military applications said there were no major national security concerns in those fields even though other countries were ahead of the United States in niches of those critical technologies. However, the DOD lead agent for signature control stated that the capabilities of other countries in this field could have some adverse effect on U.S. national security, but there was no way of really knowing. The lead agent for weapon system environment said there is some potential for concern.

Six Critical Technologies Largely Unique to Military

DOD's 1991 plan describes 21 critical technologies considered essential for maintaining superiority of U.S. weapon systems and identifies 6 of them as largely military unique. These six military critical technologies are:

(1) Sensitive radar: those radar sensors capable of detecting low-observable targets, or capable of non-cooperative target[2] classification, recognition, and/or identification. Sensitive radars include wideband radar, synthetic aperture radar, bistatic radar, laser radar, and advanced over the horizon radar.

(2) Signature control: the ability to control the target signature (radar, acoustic, optical, or other) and thereby enhance the survivability of platforms[3] and weapon systems. This technology area includes the reduction of the wakes[4] created by moving any vehicle through water or air, and by emissions, such as rocket plumes. According to the lead agent, current weapon systems and systems under development that are supported by signature control include the B-2 bomber, Advanced Tactical Fighter, AX airplanes, Army helicopters, and Navy submarines.

(3) Weapon system environment: a detailed understanding of the natural environment (both data and models) and its influence on weapon system design and performance. That is, a clear understanding of the limitations and potential leverage of environmental factors is needed to increase existing system capabilities and performance, or to optimize the design of new systems. According to the lead agent, weapon systems supported by this technology include all strike aircraft with smart weapons, such as the F-15, F-16, and A-6, and antisubmarine warfare efforts.

(4) Pulsed power: the generation of repetitive, short duration, high-peak power pulses with relatively light weight, low volume devices for weapons and sensors. The technology encompasses techniques for conversion, storage, pulse-forming, and transmission of electrical energy. Pulsed power technology is required for directed energy weapons, kinetic energy weapons, and ground and space-based identification and surveillance systems. The directed energy weapons (lasers, microwaves, and particle beams) provide speed-of-light operations with high-firing rates at long

[2]A target that either cannot or will not identify itself; thus, it could be an enemy, friendly, or neutral target.

[3]A platform is something that can carry a weapon system, e.g., an aircraft, ship, satellite, or truck.

[4]Wakes are turbulence caused by the movement of a vehicle through a given medium.

ranges, capable of destroying or disabling missiles and other targets. The kinetic energy weapons use hypervelocity projectiles for long-range engagements, rapid fire rates, and deep magazines for antimissile and anti-armor defense.

(5) Hypervelocity projectiles and propulsion: the capability to propel projectiles to greater than conventional velocities (over 2.0 kilometers per second), as well as understanding the behavior of projectiles and targets at such velocities. Propulsion systems that are being investigated include electromagnetic guns, electrothermal guns, traveling charge guns with liquid or solid high-energy propellants, hypervelocity rockets, and explosively driven shock tubes.

(6) High-energy density materials: compositions of high-energy ingredients used as explosives, propellants, or pyrotechnics. They provide the means of getting most ordnance items (whether a bullet, missile/rocket, or kinetic energy vehicle) to a target, and once the ordnance item is near the target, the means to kill it, either by fragments or blast.

U.S. Capabilities Compared to Those of Other Countries

Information prepared by the Defense Intelligence Agency (DIA), in coordination with the military services and other organizations, indicated that foreign countries had possible leadership in some niches of the six technologies. For example, regarding signature control, DIA indicated that Japan had possible leadership in the structural radar absorbing materials niche, while the Soviet Union had possible leadership in the helicopter signature reduction niche. DIA also concluded that both foreign capabilities were increasing at a rate similar to that of the United States.

The lead agents told us that the DIA comparisons are still considered valid, although some updating is needed based on recent events in the former Soviet Union. Some lead agents expect that the next publication of DOD's Critical Technologies Plan will incorporate changes attributable to the world situation and national budgets.

On April 8, 1992, in testimony before the Subcommittee on Defense Industry and Technology, Senate Committee on Armed Services, the Director, Defense Research and Engineering, stated that DOD will revise its previous method of developing the Critical Technologies Plan when it submits the next one.[5] The Director also stated that (1) a newly defined set of critical technologies will be an integral part of DOD's science and technology strategy, which will supersede DOD's previous plans; (2) many of the technologies critical to achieving goals established for DOD's science and technology initiatives will be similar to those technologies identified in the 1991 plan; (3) the revisions are attributable to the changes in the world and U.S. defense posture, and the revolution that has occurred in the information sciences and associated computer technologies. A DOD official involved in developing and coordinating this effort told us he expects the DOD science and technology strategy to be available to the Congress in June 1992, and the associated critical technologies plan 2 or 3 months later, after formal coordination within DOD.

Appendix I provides summary comparisons of the U.S. and other nations' capabilities in key areas of DOD's critical technologies that principally have military applications.

Impact on National Security

According to lead agents for four of the six critical technologies (sensitive radar, pulsed power, hypervelocity projectiles and propulsion, and high-energy density materials), other countries' leads in niches of the critical technologies have no significant impact on U.S. national security. However, the lead agent for signature control indicated that there are hints of possible adverse effects on U.S. national security in some niches of signature control. However, the lead agent was uncertain about their significance. It was the lead agent's opinion that if nations are willing to sell such technology to anyone, this could affect U.S. national security. The lead agent for weapon systems environment said there is some potential for concern if other countries become as adept as the United States in weapon system environment, especially in the antisubmarine warfare area.

The lead agents for the six technologies stated that they relied on DIA intelligence assessments for the comparison tables presented in DOD's 1991 technology plan. The lead agent for high-energy density materials

[5]Section 2522 of title 10, United States Code, as amended, requires the Secretary of Defense to submit to the Senate and House Committees on Armed Services not later than March 15 each year a plan for developing the technologies considered by the Secretaries of Defense and Energy to be most critical to ensuring the long-term qualitative superiority of U.S. weapon systems. DOD's official responsible for developing and coordinating the 1991 technology plan, informed us that the 1992 Critical Technologies Plan is late because it is still being coordinated with the new science and technology strategy that is being developed.

and hypervelocity projectiles and propulsion said (1) he considers himself more knowledgeable about technology developments of North Atlantic Treaty Organization (NATO) allies than the other countries because of the many contacts he has in the NATO countries and (2) his knowledge was limited regarding the former Soviet Union and other countries; therefore, he has to rely more on the intelligence assessments in these cases. This lead agent stated that he was concerned that U.S. participation in joint cooperative efforts with foreign countries, including allies, could result in the United States giving away technology without getting anything in return.

DOD officials said they do not know exactly how the changed conditions in the former Soviet Union will affect critical military technologies. For example, the lead agent for signature control said that some scientists from the former Soviet Union are looking for jobs and that selling information on technologies could occur in a very clandestine way. In the lead agent's opinion, this could affect U.S. national security, but it cannot be assessed at this time.

In a January 15, 1992, testimony before the Senate Committee on Governmental Affairs, the Director of the Central Intelligence Agency, stated that the Agency is closely watching for a "brain drain" of scientific experts from the former Soviet Union to weapon programs abroad. He said, however, that the Agency has found no independent corroboration of rumors regarding the recruitment of former Soviet scientists by certain third world countries. In addition, the Director said leakage of highly sophisticated, but less controlled, conventional military technologies and weapons from the former Soviet republics may also occur. Areas of concern that he cited included stealth and counter-stealth technologies, thermal imaging, electronic warfare, fuel-air explosives, precision guided munitions, and advanced torpedoes. The Director said that the brain drain causes the greatest concern, rather than a loss of specific materials or weapons, and the intelligence community is following this issue very closely.

Scope and Methodology

We reviewed DOD's 1991 plan and the March 1991 Report of the National Critical Technologies Panel[6] to identify those critical technologies that principally have military applications. We interviewed DOD officials, including the lead agents responsible for the six critical technologies identified as having principally military applications, to obtain (1) the current status of those technologies and (2) how the capabilities of other countries in those technologies affect our national security. We also interviewed the DIA official that was responsible for DIA's efforts to collect and analyze information regarding the competitive status of foreign countries vis-a-vis the United States on critical technologies that principally have military applications.

Our review was performed between November 1991 and April 1992 in accordance with generally accepted government auditing standards. As requested, we did not obtain DOD comments on this report. However, we discussed the information in this report with program officials and have included their views where appropriate.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from its issue date. At that time, we will send copies to the Secretary of Defense and to other interested congressional committees. Copies of the report will also be made available to others upon request.

[6]The National Critical Technologies Panel's first report, released on March 22, 1991, described 22 technologies considered essential for U.S. long-term security and economic prosperity. The National Critical Technologies Panel was appointed by the Director, Office of Science and Technology Policy, Executive Office of the President and included representatives from six federal agencies: DOD, Commerce, the National Aeronautics and Space Administration, the National Institutes of Health, the Department of Energy, and the National Science Foundation. The purpose of this report is to increase government and industry awareness of the crucial role of technology in achieving national goals.

Please contact me at (202) 275-8400 if you or your staff have any questions concerning this report. Other major contributors to this report were Michael Motley, Associate Director; Kevin Tansey, Assistant Director; Rosa M. Johnson, Assignment Manager; and Edward D. Cole, Evaluator-in-Charge.

Sincerely yours,

Paul F. Math
Director of Research, Development,
Acquisition, and Procurement Issues

Status of U.S. and Other Nations' Efforts to Develop Six Critical Technologies

Figures I.1 through I.6 provide a summary comparison of U.S. efforts and those of other nations for selected key aspects of the technology. The figures deal respectively with sensitive radar, signature control, weapon system environment, pulsed power, hypervelocity projectiles and propulsion, and high-energy density materials. These figures were prepared by the Defense Intelligence Agency in coordination with the military services and other organizations. The figures refer to the former Soviet Union as the USSR (the Union of Soviet Socialist Republics).

Figure I.1: Summary Comparison of Sensitive Radar

Selected Elements	USSR	NATO Allies	Japan	Others
Development of extremely wideband radar, wideband microwave sources, and antennas	□□□□ ○	□□□ ○	□□□ ○	
Beam steering, application of coherent laser diodes, laser radar	□□	□□□ ○	□□□ ○	□□ [a] Sweden
Active element arrays conformal antennas	□□	□□□ ○	□□□ ○	
Overall[b]	□□	□□□ ○	□□□ ○	□□ Sweden

[a] While not predominant in any key aspect of this technology, Sweden has reported some interesting research in target characterization with high-resolution laser radar.

[b] The overall evaluation is a subjective assessment of the average standing of the technology in the nation (or nations) considered.

LEGEND:

Position of other countries relative to the United States:

- □□□□ broad technical achievement; allies capable of major contributions
- □□□ moderate technical capability with possible leadership in some niches of technology; allies capable of important contributions
- □□ generally lagging; allies may be capable of contributing in selected areas
- □ lagging in all important aspects; allies unlikely to contribute prior to 2000

Trend indicators – where significant or important capabilities exist (i.e., 3 or 4 blocks):

- + Foreign capability increasing at a faster rate than the United States
- ○ Foreign capability increasing at a similar rate to the United States
- – Foreign capability increasing at a slower rate than the United States

Source: The Department of Defense Critical Technologies Plan, May 1, 1991.

Figure I.2: Summary Comparison of Signature Control

Selected Elements	USSR	NATO Allies	Japan	Others
Improved modeling and measurement of broadband scattering characteristics of complex shapes	□□	□□	□□	
Structural RAM components and ferrites/polymer composites	□	□□	□□□ O	□□ Israel
IR signature reduction, (propellants and plume)	□□	□□	□□	
Acoustic signature reduction in marine platforms plus, techniques for dynamic balancing of complex rotating machinery	□□	□□	□	□ Israel
Helicopter acoustic signature reduction	□□□ O	□□□ –	□	
Overall[a]	□□	□□	□□	

[a] The overall evaluation is a subjective assessment of the average standing of the technology in the nation (or nations) considered.

LEGEND:

Position of other countries relative to the United States:

- □□□□ broad technical achievement; allies capable of major contributions
- □□□ moderate technical capability with possible leadership in some niches of technology; allies capable of important contributions
- □□ generally lagging; allies may be capable of contributing in selected areas
- □ lagging in all important aspects; allies unlikely to contribute prior to 2000

Trend indicators – where significant or important capabilities exist (i.e., 3 or 4 blocks):

- \+ Foreign capability increasing at a faster rate than the United States
- O Foreign capability increasing at a similar rate to the United States
- – Foreign capability increasing at a slower rate than the United States

Notes: The acronym RAM in the above figure refers to radar absorbing material.

The acronym IR in the above figure refers to infrared signature.

Source: DOD Critical Technologies Plan, May 1, 1991.

Figure I.3: Summary Comparison of Weapon System Environment

Selected Elements	USSR	NATO Allies	Japan	Others
Undersea acoustic research, especially that correlated with pathymetry data	□□□ ○	□□□ ○	□□	
Accurate predictions of localized weather conditions	□□	□□□□ ○	□□	
Effective integration of remote sensing data	□□	□□□ –	□□	□□ Various nations
Improved modeling and simulation of scene dynamics	□	□□	□	
Overall[a]	□□□ –	□□□ ○	□□	□□ Various nations

[a] The overall evaluation is a subjective assessment of the average standing of the technology in the nation (or nations) considered.

LEGEND:

Position of other countries relative to the United States:

- □□□□ broad technical achievement; allies capable of major contributions
- □□□ moderate technical capability with possible leadership in some niches of technology; allies capable of important contributions
- □□ generally lagging; allies may be capable of contributing in selected areas
- □ lagging in all important aspects; allies unlikely to contribute prior to 2000

Trend indicators – where significant or important capabilities exist (i.e., 3 or 4 blocks):

- \+ Foreign capability increasing at a <u>faster</u> rate than the United States
- ○ Foreign capability increasing at a <u>similar</u> rate to the United States
- – Foreign capability increasing at a <u>slower</u> rate than the United States

Source: DOD Critical Technologies Plan, May 1, 1991.

Figure I.4: Summary Comparison of Pulsed Power

Selected Elements	USSR	NATO Allies	Japan	Others
Reduce size of power systems and components by order of magnitude	□□ [a,b]	□□	□□	
Development of photo-conductive solid-state switch	□□	□□	□□	
Develop HPM sources	□□□□ +	□□□ +	□□	
Overall[b]	□□□□ [a,b] O	□□	□□□ [b] O	□□ [c] Various Countries

[a] The Soviets have developed a number of alternative technology approaches; overall, they are on a par with the United States.

[b] Strong in primary power sources that may prove adaptable to pulsed power systems.

[c] The overall evaluation is a subjective assessment of the average standing of the technology in the nation (or nations) considered.

LEGEND:

Position of other countries relative to the United States:

□□□□	broad technical achievement; allies capable of major contributions
□□□	moderate technical capability with possible leadership in some niches of technology; allies capable of important contributions
□□	generally lagging; allies may be capable of contributing in selected areas
□	lagging in all important aspects; allies unlikely to contribute prior to 2000

Trend Indicators – where significant or important capabilities exist (i.e., 3 or 4 blocks):

+	Foreign capability increasing at a faster rate than the United States
O	Foreign capability increasing at a similar rate to the United States
–	Foreign capability increasing at a slower rate than the United States

Note: The acronym HPM in the above figure refers to high power microwaves.

Source: DOD Critical Technologies Plan, May 1, 1991.

Figure I.5: Summary Comparison of Hypervelocity Projectiles and Propulsion

Selected Elements	USSR	NATO Allies	Japan	Others
Accurate characterization of projectile flight in atmosphere	□□□ –	□□□ –	□□	□□ Australia, Italy
Effective use of advanced propulsion systems	□□□ –	□□	□□	□□□ Israel
Application of advanced materials to kinetic penetrators	□□		□□	
3-D characterization of material reaction to warhead effects	□□□ [a] O	□□	□□	
Overall[b]	□□□ –	□□	□□	

[a] Computation deficiencies may be offset by empirical experimentation.

[b] The overall evaluation is a subjective assessment of the average standing of the technology in the nation (or nations) considered.

LEGEND:

Position of other countries relative to the United States:

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- □□□ moderate technical capability with possible leadership in some niches of technology; allies capable of important contributions
- □□ generally lagging; allies may be capable of contributing in selected areas
- □ lagging in all important aspects; allies unlikely to contribute prior to 2000

Trend indicators – where significant or important capabilities exist (i.e., 3 or 4 blocks):

- + Foreign capability increasing at a faster rate than the United States
- O Foreign capability increasing at a similar rate to the United States
- – Foreign capability increasing at a slower rate than the United States

Note: The acronym 3-D in the above figure refers to three-dimensional.

Source: DOD Critical Technologies Plan, May 1, 1991.

Figure I.6: Summary Comparison of High-Energy Density Materials

Selected Elements	USSR	NATO Allies	Japan	Others
Improve properties of insensitive high explosives	□□	□□□□ +	□□□ +	□□ China
Reduce observable signatures of propellants while maintaining or improving performance	□□	□□□ +	□□□ +	□□ China
Improve modeling of energetic material reactions (3-D, combined mechanical/ chemical reaction properties)	□□	□□□ +	□□□□ +	□□ China
Application of energetic materials to ballotechnic processing	□□□□ +	□□	□□	
Overall[a]	□□□ +	□□□ +	□□□ +	□□ China

[a] The overall evaluationi s a subjective assessment of the average standing of the technology int he nation (or nations) considered.

LEGEND:

Position of other countries relative to the United States:

- □□□□ broad technical achievement; allies capable of major contributions
- □□□ moderate technical capability with possible leadership in some niches of technology; allies capable of important contributions
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Trend indicators – where significant or important capabilities exist (i.e., 3 or 4 blocks):

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- O Foreign capability increasing at a similar rate to the United States
- – Foreign capability increasing at a slower rate than the United States

Note: The acronym 3-D in the above figure refers to three-dimensional.

Source: DOD Critical Technologies Plan, May 1, 1991.

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