Director of Central Intelligence

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Prospects for Soviet Military Technology and Research and Development

National Intelligence Estimate
Volume I—Summary and Key Judgments

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NIE 11-12-83
14 December 1983

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THE DIRECTOR OF CENTRAL INTELLIGENCE

WASHINGTON, D.C. 20505

National Intelligence Council

15 February 1984

MEMORANDUM FOR: Recipients of NIE 11-12-83, Prospects for Soviet Military Technology and Research and Development

SUBJECT: Errata Sheet for Volume I, Summary and Key Judgments, 14 December 1983

1. Page 12, Table I-1: Insert boldface heading **Delivery Technologies** immediately above entry "Guidance and Navigation."

2. Page 18, Table I-2: Italicize the first entry of those grouped with Strategic Defensive Systems, "Space-based system for detection of bombers and airborne cruise missile carriers," to show that a significant advance in technology is required before system development can begin (as described in footnote b, page 18).

3. Page 23, tic on Soviet information-processing technologies: Correct the last sentence of that tic to read: "By the early-to-middle [vice late] 1990s they may introduce very-large-scale-integrated (VLSI) circuitry into military systems."

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NIE 11-12-83

PROSPECTS FOR SOVIET MILITARY TECHNOLOGY AND RESEARCH AND DEVELOPMENT

VOLUME I—SUMMARY AND KEY JUDGMENTS

Information available as of 14 December 1983 was used in the preparation of this Estimate.

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THIS ESTIMATE IS ISSUED BY THE DIRECTOR OF CENTRAL INTELLIGENCE.

THE NATIONAL FOREIGN INTELLIGENCE BOARD CONCURS.

The following intelligence organizations participated in the preparation of the Estimate:

The Central Intelligence Agency, the Defense Intelligence Agency, the National Security Agency, and the intelligence organization of the Department of State.

Also Participating:

The Assistant Chief of Staff for Intelligence, Department of the Army

The Director of Naval Intelligence, Department of the Navy

The Assistant Chief of Staff, Intelligence, Department of the Air Force

The Director of Intelligence, Headquarters, Marine Corps

PREFACE

This Estimate supersedes NIE 11-12-80. We have incorporated new information and refined or changed many of our previous judgments. We have a better understanding today than we had in 1980 of the scale of the Soviet commitment to military R&D, and of the significant role the Soviets have assigned to the acquisition of Western technology in their weapons development process.

Our principal focus in this Estimate is to identify and assess those technologies that are key to future Soviet military capabilities and to assess the likely impact of those technologies on Soviet military systems of the 1990s. To support the needs of the office of the Under Secretary of Defense for Research and Engineering, we have made comparisons of the relative standing of those technologies in the United States and the Soviet Union.

There are some gaps in our information and uncertainties in our analysis that impede our understanding of several important issues. We have an incomplete understanding of the relative standings now and of the rates of change in Soviet and Western technologies, of the interplay between technologies and systems performance, and of the full impact of technology transfer on Soviet science and technology.

Our understanding of specific Soviet technologies is not uniform. While we have been able to monitor Soviet progress fairly closely in some technologies, such as microelectronics, others have proved more elusive[redacted]

Our findings and analyses for this Estimate are in four volumes:

- Volume I : Summary and Key Judgments
- Volume II : The Estimate
- Volume III : Summary of Annexes and Future Military System Projections
- Volume IV : The Annexes
  - —Annex A: Soviet Military and Civilian R&D Processes
  - —Annex B: Soviet Military R&D Resources and Trends
  - —Annex C: Key Soviet Military Technologies

SUMMARY

Soviet political leaders recognize the role that technology plays in determining the extent of the USSR's military capabilities—their principal foreign policy asset. They are seeking to attain military-technical superiority over the West, and have given this goal a very high priority for at least the past two decades.

Progress to Date

The Soviets' resource commitment to military research and development is enormous by any measure. We estimate that, despite serious problems in the civilian economy, Soviet military R&D outlays have been about double those of the United States in recent years, and today amount to a significantly larger share of gross national product than in the United States. Leadership support for military R&D remains strong, facilities are still expanding, and the R&D program effort seems not to have been affected by economic difficulties in the civilian sector. If conditions worsen in the civilian economic sector, pressures against military outlays will surely grow, but the Soviets will almost certainly maintain their high level of commitment to weapons research and development. Also, requirements for R&D are increasing as the complexity of military threats facing the Soviets becomes greater.

The Soviets have narrowed the US lead in nearly all key technologies. In general, their technology available for application to future military systems [1] is now about five years behind the West—roughly comparable to that of the West in the mid-to-late 1970s. The relative Soviet position in the key military technologies ranges from world leadership in a few fields—but significant fields, such as chemical warfare and some areas of directed-energy research—to as much as 15 years behind the United States in some vitally important areas of computing.

Western technology has helped the Soviets considerably. They subsidize their military R&D programs through significant open and clandestine acquisitions of Western technology, most of which is of US origin. Their well-organized national program for acquiring and assimi-

[1] In this Estimate, projections about the *availability* of technologies mean that a particular technology would be ready to be incorporated in a weapons *development* program. Weapon system development times vary widely, but typically an additional five to 12 years is usually required before deployment is possible.

lating Western technology has been a major factor in the advances they have made since the early 1970s in significant areas, including microelectronics and computers, that are essential to the development of modern military systems. Their strategy of large-scale Western technology acquisition and use derives from their historic realization that it is to their benefit to take advantage of the advanced technology efforts of the West. Incorporating Western technology into their military programs, rather than relying on Soviet indigenous capabilities, yields a significant savings in program costs, thereby freeing indigenous R&D resources for efforts in other areas, and takes less development time, thereby producing more capable military systems at an earlier date.

The Soviets' weapons acquisition process helps them to overcome technological weaknesses and economic constraints. Relative to their US counterparts, Soviet military planners are better able to marshal, focus, and sustain the commitment and resources for developing weapon systems. Politburo-level weapons decisions carry force of law in the economy, and are the rough equivalent in US practice of combining a Defense Department program approval, a Presidential decision authorizing top priority, and multiyear Congressional funding. Strict schedules are enforced, resulting in essentially a *technology freeze* once a decision to develop a weapon is made. This reduces technological risk and affords a high probability of development success. *The weapons decisionmaking process offsets inadequate performance and the potential for technological stagnation in deployed weapons by an almost routine approval of follow-on improvement programs.* The Soviets field new or significantly modernized weapons on the average of every five to 10 years in each system area.

The USSR currently leads the United States in several key technologies, including chemical warfare agents and some aspects of millimeter-wave radar and sensor technology. These strengths, in conjunction with our limited understanding of some Soviet efforts, give the USSR a potential for deploying military systems we do not fully understand, and hence the potential for future military advantages. Such systems could prove extremely difficult to detect and to counter in combat. Soviet advanced research is also strong in directed-energy technologies, including that for development of high-energy laser weapons for possible application to space-, air-, ground-, and sea-based systems.

Soviet weaknesses are significant. The rate of return to the Soviets on decades of high-priority R&D investments—measured in economic terms—has been low relative to that in the West. While the payoff in

military output in absolute terms—numbers of new weapon systems, improved effectiveness, and the growth in overall military capabilities—has been quite good, on balance, productivity in the Soviet R&D sector, both civilian and military, has been notably poor. We expect this inefficiency to continue. The Soviet system does not—and probably will not—effectively stimulate advances in multidisciplinary efforts such as microelectronics and computers. While the Soviets have made important gains in recent years, serious shortcomings persist in some key areas of military technology, including the design, manufacture, and quality control of microelectronics. Moreover, in computer technologies, the Soviets will continue to lag the United States by five to 15 years; this lag will continue to hamper many programs, including those for ballistic missile defense, antisubmarine warfare, aircraft, and command and control systems. They also face major limitations in signal-processing technology and in automated production technologies and precision test equipment. In addition, their practice of heavily adopting Western ideas and designs will continue to reinforce their position of technological inferiority to and dependence on the West.

However, the Soviets' persistent modernization efforts help them to compensate for these weaknesses. For example, they have been able to move computer technology into deployed systems on the average of six years faster than the United States, enabling them to offset partially the US technological lead in computers. Similarly, frequent modernization of fielded weapon systems also helps the Soviets to offset the attendant technological lags that result from their reliance on Western technology for their military systems.

Prospects for Soviet Technologies

We think the prospects are, in general, low for an unanticipated major technological advance in the Soviet Union during the next 10 years that could lead to a revolutionary new capability posing a significant new threat to the West. For those technologies where we have an adequate understanding of Soviet achievements to date, the Soviets lag the United States in several areas critical to the achievement of military advantage. Moreover, about nine to 12 years are required to transform a major technological advance into a new operational weapon. The Soviets almost certainly will not be able to incorporate into systems deployed through 1995 advances much beyond their present technology levels.

We do not completely discount the prospects for technological surprise through 1995, particularly in several areas where the Soviet

efforts are already strong[ ]nonacoustic antisubmarine warfare, chemical weapons, directed energy, and optical processing are our greatest concern because of the strength and persistence of Soviet R&D in these areas. The growth and maturity of the Soviets' R&D sector, in conjunction with the scale of their military programs, could result in some unexpected advances either in the speed with which they are able to develop and field new weapon systems with higher levels of performance, or in the novel design of some of their systems.

For the 1990s the Soviets will be working from a strong and sizable base of military technologies, but the pace of their advances will be uneven:

- Developments in *information acquisition* technology will probably accelerate and be stronger before the end of the 1980s. The Soviets will increasingly emphasize advanced radar and electro-optical sensors in an effort to counter US Stealth technology.
- Soviet *information-processing* technologies, particularly microelectronics and computers, are not likely to keep up with Western developments; however, we expect the Soviets to adapt large-scale integrated circuitry for military applications by the end of the 1980s.
- We expect Soviet *weapons delivery* technologies, particularly in missile guidance and propulsion, to advance steadily and continue to provide a strong base for both tactical and strategic weapons development.
- The Soviets' most significant advances may occur in the area of *lethality/damage*. Their extensive efforts in chemical warfare and directed-energy technologies could result in some major advances. They are likely to keep up their large investment in conventional explosives technologies in order to maintain the excellent technological capabilities they now have.

Soviet prospects for gaining on the West in some military technologies, and keeping pace in others, will in large measure depend upon continued success in acquiring Western technology. Soviet dependence is especially important in computers, microelectronics, and automated production technologies.

Military Implications of Soviet Technologies

The decade of the 1990s will pose some new, major technological challenges to Soviet military planners. Western defense programs,

particularly US strategic force modernization, will lead to costly and technologically demanding Soviet efforts. The USSR's weapons development programs will continue to be vigorous.

The weapon systems that the Soviets will deploy through the mid-1990s will be based largely on the technology levels achieved—or obtained from the West—in the 1975-85 time frame. We estimate that the Soviets currently have under development between 150 and 200 new and major modernized weapon systems and support systems. We believe that the number of systems in development in the 1990s is unlikely to decline.

In *strategic offensive systems*, Soviet emphasis will be on greater survivability through deployment of mobile systems, as well as improved accuracy. The development of mobile land-based missile systems will serve to offset the increasing vulnerability of fixed intercontinental ballistic missiles to programed US strategic weapons.

In *strategic defense technologies*, the Soviets must make significant advances in several critical technology areas well beyond those now available for military applications. They will probably continue to lag behind the changing threat posed by programed US bombers and cruise missiles, particularly those employing Stealth, and by US ballistic missile submarines. They will nevertheless make major improvements in their defensive systems.

In *directed-energy* technologies, we expect development and prototype testing of several types of Soviet laser weapons. Laser technologies are already available for development of ground-based weapons capable of damaging satellite sensors and antisensor weapons for use in air defense. Technology for the development of destructive laser air defense weapons is expected to be available within the next several years. The Soviets are likely to be able to test a prototype space-based laser weapon for antisatellite application by the early 1990s. But the technology for space-based laser weapons for ballistic missile defense is not yet sufficient to support development of a prototype weapon. Operational laser systems for destruction of ballistic missiles or their reentry vehicles, if they prove feasible, probably could not be fielded until after the turn of the century.

Command, control, and communications systems, although effective, will continue to be limited by deficiencies in computer technology and computer networking. We expect a number of advanced *electronic warfare* systems in the 1990s, including highly capable jamming systems. In addition, we expect improvements in Soviet *technical intelligence collection* capabilities, including the deployment in the late 1980s of a network of space-based near-real-time reconnaissance systems.

Advanced technologies will allow the Soviets to improve many aspects of their *naval forces*. The deployment of a new class of aircraft carrier with accompanying combat and surveillance aircraft will support their efforts to expand their areas of sea control and sea denial. In antisubmarine warfare, they will remain unable to systematically detect and track Western ballistic missile submarines in broad ocean areas, but they may achieve improved capabilities against enemy attack submarines attempting to penetrate bastions for Soviet ballistic missile submarines.

Soviet *ground forces* and particularly supporting *air and air defense forces* will incorporate some weapons with advanced technologies. Western advances in armor protection and antiarmor weapons will reduce some of the present Soviet numerical advantages in the land-warfare area, and we expect the Soviets to have difficulties countering these advances. We anticipate advanced electro-optical and infrared sensors and imaging radars to be based on aircraft, remotely piloted vehicles, and drones. Introduction of small, guided, fire-and-forget weapons on helicopters is expected by the mid-1990s.

The Soviets have committed substantial R&D resources to support their *space programs*, with large increases in the early 1980s for the military manned space program and communications systems. The development of new systems, including the shuttle, space plane, heavy-lift launch vehicles, and near-real-time imagery relay systems, will offer the Soviets new military opportunities in space.

Soviet military research and development organizations have probably become more capable in developing high-technology weapon systems than Soviet industry has become in producing them. A combination of factors—more multipurpose weapons, higher costs, problems in production engineering and quality control, and more difficult and costly maintenance requirements—is likely to cause the Soviets to produce, in some areas, new and more technically advanced systems in smaller quantities than they have in the past. Thus, they are tending to rely somewhat more on technology, and somewhat less on quantity, to achieve their future military goals.

We believe that the Soviets will experience difficulties in manufacturing many of the sophisticated weapons projected for the 1990s. The Soviets are currently experiencing production rate limitations and technical problems that are disrupting the manufacture of several advanced systems—including the T-72 tank, the MIG-31 aircraft, the Backfire bomber, and the Typhoon ballistic missile submarine. The Soviets may partially overcome such difficulties through their present

efforts to expand their electronics-related industry, to press for advances in precision machining and other fabrication technologies, and to maintain their aggressive exploitation of Western technology.

Can the Soviets Catch Up in Military Technologies?

If the United States sustains a strong program of military research and development, we believe that the Soviet Union will not be able to match or overtake the United States in overall military technologies by the 1990s. In addition to the institutional impediments inherent in their system, the Soviets must also contend with uncertainties about their future successes in technology acquisitions. *Nonetheless, we expect continued advancements in all Soviet military technologies, and that the present overall gap between the United States and the USSR of about five years will be further narrowed.* The size of this gap, however, will depend also on US progress in military technologies. A larger number of the Soviet military technologies will be lagging by no more than two to three years—small enough to make the levels of technology nearly comparable for those military systems incorporating such technologies that will be introduced in the late 1990s and beyond. Moreover, the Soviet systems development process incorporates technology advances more frequently into deployed systems than does the US process.

The current and prospective upswing in US military R&D commitments, if sustained, will pose a major challenge to Soviet military R&D and make it more difficult for the USSR to close existing technology gaps. In certain areas of prospective US concentration, such as directed-energy technologies applicable to ballistic missile defense, existing Soviet strengths could be overshadowed. In these and other areas, however, Soviet military R&D will continue for some years to benefit from the increases in investment—and the larger total investment relative to that of the United States—that have characterized the past decade.

We caution, however, that there are numerous uncertainties associated with our assessments of the overall relative standing of US and Soviet military technologies by the 1990s. Our uncertainties stem from an incomplete understanding of the relative standings now and of the rates of change in Soviet and Western technologies, and from the difficulty in forecasting the contribution of technology transfer. In addition, while we assume a strong US commitment to military R&D, systematic comparisons of the future states of US and Soviet technological capabilities must also account for actual advances in US technol-

ogies—which we have not studied here, and which have yet to be realized, but which could significantly influence any projections.

We project that the Soviets will remain generally behind the West. However, their major commitment to technological advances will persevere into the next decade, their S&T and economic reform efforts may yield incremental but useful payoffs, and their military R&D will continue in any case to benefit for years to come from past investments.

KEY JUDGMENTS

How will the Soviet commitment to military R&D be characterized over the next 10 years?

The Soviet weapons acquisitions program in the next decade will be characterized by a continued persistence of effort and large resource allocations to military research and development. (See figure I-1.) The motivation behind this program is to achieve military capabilities that are at least equal, if not superior, to those of the USSR's potential adversaries. These elements will sustain the current momentum of military technological progress into the 1990s.

Despite serious problems in the civilian economy, the Soviet leadership continues to favor the military with generous funding and priority access to resources and foreign technology. Military research and development now account for approximately half the USSR's total R&D spending and manpower. The scope and magnitude of these programs, the Soviets' willingness to exact sacrifices from the civilian sector, their indigenous technological capabilities, and especially their extensive exploitation of Western technology will largely compensate for systemic inefficiencies, and permit them to narrow the US lead in military technologies and to develop increasingly complex weapon systems.

How ~~does~~ present Soviet military technology generally compare with that of the West?

The current level of Soviet military technology available for application to military systems generally is roughly comparable to that of the West in the mid-to-late 1970s. The Soviets have clearly made progress in recent years. In microelectronics, for example, the Soviets probably lagged the West by 10 to 12 years in the mid-1970s. Today, we judge this lag to be much smaller, perhaps only three to five years. The relative Soviet position in the key technologies of military significance ranges from world leadership in a few significant fields, such as chemical warfare technologies and some areas of directed-energy research, to as much as 15 years behind the United States in some vitally important areas of computing. Table I-1 (on pages 12 and 13) illustrates the relative standing of the USSR and the United States in the major technology fields that we believe will significantly influence future military capabilities.

How important is Western technology to Soviet military R&D?

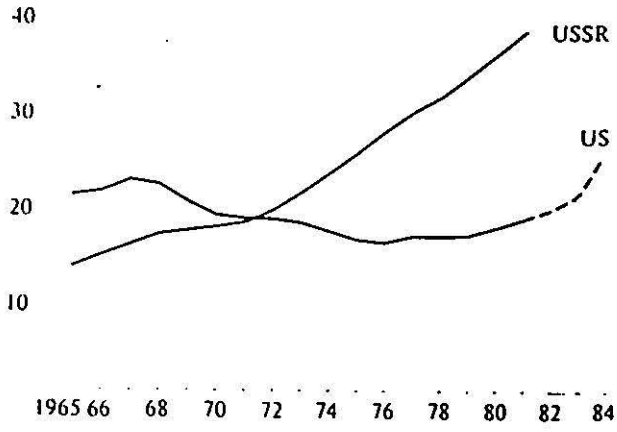
Competition with and acquisition of Western technology has been essential to many of the Soviets' military gains. They have successfully pursued some independent R&D paths such as in storable liquid missile fuels and some nuclear weapon designs, but in most areas have followed Western technological directions. In the overall technological competition, the United States sets the pace. The Soviets regard Western system characteristics as yardsticks against which their own technical capabilities are judged.

The Soviets' well-organized national program for the overt and clandestine acquisition and assimilation of Western—primarily US-derived—technology has been a major factor in the technological advances they have made since the early 1970s. Through technology transfer, the Soviets have significantly strengthened their technology capabilities in many areas, including microelectronics and computers, that are basic to the development of many modern military systems. Their strategy of large-scale Western technology acquisition and use derives from their historic realization that it is to their benefit to take advantage of the advanced technology efforts of the West. Incorporating Western technology into their military programs, rather than relying wholly on Soviet indigenous capabilities, yields a significant savings in program costs, thereby freeing indigenous R&D resources for other military areas, and reduces development time, thereby producing more capable military systems at an earlier date.

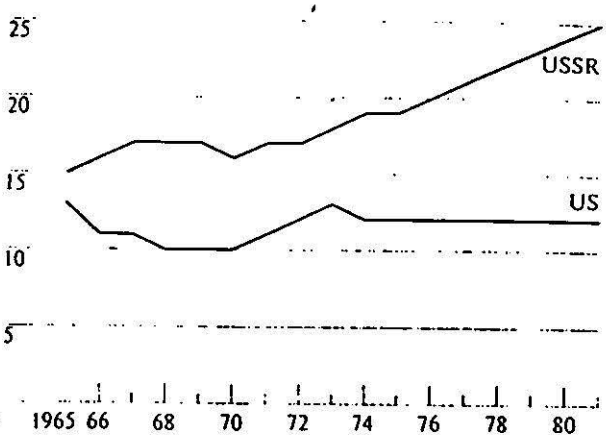
The Soviet Military-Industrial Commission (VPK) collects and prioritizes requirements for Western technology from the defense-industrial ministries. The Soviet intelligence services and their East European surrogates are the primary collectors of Western classi-

Figure I-1
Soviet and US Outlays for Military R&D

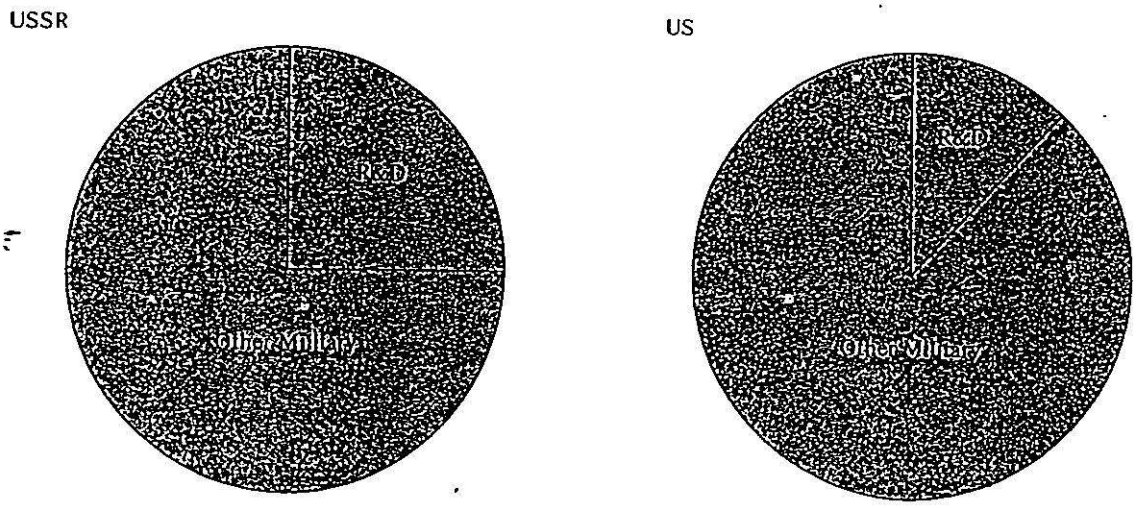
In Billion 1981 Dollars, 1965-84[a]



As Percent of Total Military Spending, 1965-81[b]



As Percent of Total Military Spending, 1981[b]



[a] The most recent data for the USSR are for 1981. The 1982, 1983, and 1984 US data are from Department of Defense projections based on total obligational authority.
[b] Percentages for the USSR are derived from data in 1970 rubles; those for the United States come from data in 1981 dollars.

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fied and export-controlled technology, as well as openly available technology. We believe that the majority of their significant military-related acquisitions are composed of export-controlled technologies and equipment, and technical literature in the public domain. The materials that can be acquired from the West are in turn fed to the requesting ministries, whereupon the VPK begins a followup program of monitoring their assimilation.

Soviet technology acquisition efforts have not been directed only at the United States but have been conducted on a global basis. The USSR has turned increasingly to other world technology leaders such as Japan. Technology acquired from the Japanese in critical areas such as microelectronics and computers could give the Soviets the potential to make important gains on the United States in military applications of these technologies, through their more frequent modernization programs.

Despite some dramatic gains from technology acquisitions, Soviet dependence on the West entails a risk that Western technology may be curtailed, and ensures a continued lag in many key technologies. The Soviets appear to recognize the disadvantages of this dependence and wish to reduce it, but they have not slowed their attempts to acquire embargoed Western technology. Their efforts continue to be comprehensive and to have a high priority. We believe that Soviet prospects for gaining on the West on a broad front in military technology will in large measure depend on continued success in acquiring Western technology. There will almost certainly be a continued dependence on Western technology for direction and leadership in many areas.

In what areas of key military technology is the Soviet Union either superior to the United States or particularly strong?

The USSR currently is judged to be superior to the United States in several key technologies, including chemical warfare (CW) agents and some aspects of millimeter-wave (MMW) technology. These strengths, [redacted] give the Soviets the potential for future weapons programs that could result in deployment of systems we do not understand or recognize, and hence result in military advantages:

[redacted]

Technological strengths in several other areas—such as conventional explosives, ramjet engines, titanium alloy fabrication, and liquid-metal-cooled nuclear propulsion systems—reflect design choices different from those of the United States and, although providing some unique weapons capabilities, do not necessarily provide clear-cut military advantages.

Advanced research in directed-energy technologies—laser, radiofrequency (RF), and particle beam—is also a strength of the Soviets:

- They have a priority program to develop high-energy laser (HEL) weapons. They are continuing to expand their test range facilities for HELs and are further expanding a facility we believe is intended for the design and fabrication of prototype laser weapons.
- They are continuing extensive efforts, begun more than 20 years ago, aimed at developing high-power microwave and millimeter-wave sources applicable to the development of RF weapons.
- We are uncertain about what progress the Soviets are making in particle beam technologies; their programs appear to be in an earlier phase and on a much smaller scale than those applicable to laser weapons. They appear to be conducting laboratory research applicable to space-based beam weapons, but we do not believe that they have built the accelerator they would need for feasibility testing of either neutral (for space) or charged (for atmospheric) particle beam propagation.

Table I-1

Relative Standings of the USSR and the United States in Major Technology Areas

Key: O Technologies in research and exploratory development.
X Technologies available for application.
← → Relative direction of future position where determination can be made.

Technology Area	US Ahead	US, USSR Equal	USSR Ahead	Comments	Caveats
Information acquisition/ denial technologies					
• Sensors and sensing systems					
— Electro-optical (EO) and infrared (IR)	O→X→			Soviets lag in fabrication of large arrays	Soviets have conducted research on more detector materials
— Radar [a]		OX			Soviets ahead in MMW component technology. US ahead in use of digital techniques
— Acoustic sensing systems	OX→			Soviets rely heavily on Western sonobuoy technologies. They lack broad area capability	Soviet active sonars compare favorably
— Nonacoustic sensing systems		OX			
• Nonelectronic countermeasures [b]		OX			
• Electronic warfare	X→	O			
Information processing/ transmission technologies					
• Microelectronics	X	←O		US advances in very-high-speed and very-large-scale integrated circuitry will sustain lead	
• Computing					
— Hardware	O←X			US has greater experience and readily available production equipment	
— Software	O←X				Soviet military use of analog, hybrid, or optical technologies may partially offset some present limitations
• Signal processing	←OX			US is advancing rapidly in digital technologies and device development	
• Command and control					
— Communications	OX			Reflects US lead in semiconductor technologies	Soviets lead in antenna hardening
— Automated control	OX			US networking experience is strong	Soviets have developed extensive research basis for algorithm development
• Guidance and navigation	O→X→				
• Power sources		OX			
• Structural materials [c]	O→X→			Soviets had late start in composites research; are limited by production capability	Some Soviet polymers equal to US. Large scientific base for ceramics research
• Propulsion [d]		OX		US strong in some technologies, Soviets strong in others	

Table I-1 (Continued)

Relative Standings of the USSR and the United States in Major Technology Areas

Key: O Technologies in research and exploratory development.
X Technologies available for application.
← Relative direction of future position where determination can be made.
→

Technology Area	US Ahead	US, USSR Equal	USSR Ahead	Comments	Caveats
Lethality/Damage Technologies					
• Directed energy					
— Lasers		OX			
— RF weapon technologies			OX		
— Particle beam weapons (PBW)			O	Neither country has developed the technology sufficiently for military applications	
• Nuclear technologies [c]		OX			
• Conventional explosives		X	O	Extensive Soviet research effort with lead in enhanced blast munitions	US ahead in insensitive explosives
• Chemical warfare			OX	Strong, persistent Soviet effort	US may be ahead in detector technologies and equal in prophylaxis
Environment technologies					
• Life sciences	OX				
• Ocean sciences	O→	X			
• Space technologies [f]		OX			
Production Technologies					
• Metalworking		OX			
• Computer-aided design/ manufacturing (CAD/ CAM) and automated assembly	OX			Soviet microprocessor technology limits numerically controlled machine development	

[a] Radar cross section (RCS) reduction and aerosol technologies emphasized in this comparison.
[c] Comparison based on metallic, polymeric, ceramic, and composite materials.
[d] Comparison based on rocket, air-breathing, naval nuclear, and a few ground propulsion technologies.
[e] Comparison based on nuclear warhead and isotope separation technologies.
[f] Comparison based only on space structures, space power sources, life support, and boosters.

Note: • The entries in this table are intended to convey the general pattern of accomplishments in each of the key technologies. Each entry represents a highly aggregated position comprising many detailed aspects—some of which have been objectively analyzed and others inferred—of the complex technologies represented. In the cases of the footnoted technologies, the table entry is weighted on the basis of those specified subtechnologies that are discussed in greater detail in annex C, "Key Soviet Military Technologies."

• US experts were consulted in assessing the US and Soviet states of the art in microelectronics, computing, guidance and navigation, and lasers. The assessments of the relative positions in the remaining technologies reflect the views of Intelligence Community analysts.

• These technology areas are not all equally important—some, such as microelectronics, are more pervasive than others and will affect the prospects of many future weapon systems.

• Technology comparisons do not necessarily equate to military capabilities. A lag in a technological field does not mean that military systems using that technology are inadequate for their intended mission. The assessments do not reflect Soviet judgments as to the adequacy or inadequacy of the resulting weapon system.

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Are there characteristics peculiar to the Soviet weapons acquisition process that ease the development of modern weapon systems?

Because of structural differences in the two societies, Soviet military planners are generally better able to marshal and sustain the commitment and resources for military R&D than are their counterparts in the United States. While the Soviet and US design cycles are similar in some respects—both are able to move promising ideas through a bureaucratic maze of development requirements into weapons production—the differences are also significant. The following aspects of the Soviets' weapons acquisition process, all of which stem chiefly from their political and economic systems, help to explain how they overcome important weaknesses and field modern weapon systems:

- A major weapons program in the Soviet Union is authorized by a Politburo-level (Defense Council) decision that has no direct counterpart in terms of authority in the United States. The decision is, in effect, the equivalent of combining a Department of Defense approval of a program, a Presidential decision authorizing top priority, and multiyear funding of the program by Congress.
- Under a Politburo decision, any state asset—that is, any individual or organization in the USSR regardless of formal affiliation—can legally be assigned a role in a weapons program. The Soviet leaders are thus assured that the best resources can be made available to the program.
- The Soviet emphasis on strict adherence to schedules results in what amounts to a freeze of most critical technologies once a decision to proceed with the development phase of a weapons program has been made, thus assuring a high probability of development success. The leadership offsets the inherent potential for obsolescence in Soviet weapon systems that could result from this practice by an almost routine approval of follow-on improvement programs.
- Because all aspects of Soviet weapons programs, including their very existence, are closely held state secrets, the regime prevents internal public debate and delays and hinders Western knowledge of the programs.
- The Soviet leaders, when making weapons development decisions, give only general consideration to expenditure estimates. They are more concerned about the integrated military requirements for weapon systems and the capability, in terms of men and material, to successfully carry them out.
- The Soviet system fosters continuity in the key organizations and personnel that conduct weapons development. In contrast to weapons acquisition in the United States, where weapons program managers and other key personnel are often in flux, individuals and organizations assigned to a program in the USSR normally stay with that program from inception to completion. Additionally, the organizations responsible for the initial version of a weapon usually retain responsibility for all follow-on versions.

What are the Soviet capabilities for quickly incorporating new technology into weapon system designs?

The Soviets can incorporate new technology in their weapon system development process in one of three basic time frames:

- *New* or *major modernized* weapon systems that incorporate advanced technology in a number of subsystems generally require nine to 12 years from program authorization to initial operational capability.
- *Modernized* weapon systems that incorporate one or a small number of new major subsystems (for example, missile guidance, avionics) generally require five or more years.
- *Upgraded* weapon systems already in production (or already in the field) are achieved by improving one or a small number of subsystems (for example, sensors, reentry vehicles, artillery tubes); these generally require less than five years.

The Soviets' practice of fielding new or modernized weapons on the average of every five to 10 years in each system area has contributed significantly to maintaining a high level of technology in deployed weapons. For example, because of their persistent modernization efforts they have been able to move

computer technology into deployed systems on the average of six years faster than the United States, enabling them partially to offset the US technological lead in computers. Similarly, frequent modernization of fielded weapon systems also helps the Soviets to compensate for the attendant technological lags that result from their reliance on Western technology for their military systems.

Are there significant weaknesses in Soviet technological or R&D management that impede military progress?

In spite of decades of high priority R&D investments, the return rate on these investments in the USSR, measured in economic terms, has been low relative to that in the West. While the payoff in military output in absolute terms—numbers of new weapon systems, improved effectiveness, and the growth in overall military capabilities—has been quite good, on balance, productivity in the Soviet R&D sector, both civilian and military, has been notably poor. We expect this inefficiency to continue. In general, the Soviet system does not—and we judge will not—effectively stimulate and coordinate indigenous, innovative advances in basic multidisciplinary technological programs such as computers or microelectronics. The Soviets' practice of heavily adopting Western ideas and designs illustrates, and tends to reinforce, their position of technological inferiority to and dependence on the West. While they have made important gains in recent years, serious shortcomings persist in some key areas of military technology:

- The Soviets remain weak in the design, manufacture, and testing of *microelectronics;* this will continue to impair the quality and limit the applications of microelectronic devices in many types of military systems.
- In *computer technologies*, the Soviets lag the United States by five to 15 years in various areas and may be falling further behind. This lag will hamper Soviet development programs in antiballistic missile (ABM), antisubmarine warfare (ASW), and command and control systems.
- Limitations in *signal-processing* technology will seriously impede Soviet capabilities to defend against US Stealth technology.
- In *production technologies and test equipment*, persisting inadequacies will continue to limit the quality and effectiveness of metallurgical processes, and generally hamper the reliability and availability of deployed military systems.

Strengths and Weaknesses of the Soviet Approach to Military R&D

Strong central management and high priority accorded the military in the USSR can expedite weapon development; if this leads to uneconomic diversion of resources away from basic science and civilian basic industry, however, it can hurt weapon development in the long run.

A conservative approach to design, combined with *early major technology freeze*, increases the probability that Soviet developers will meet program obligations; this approach has two disadvantages—discouragement of innovation and encouragement of development of single-mission systems—both of which can drive up the overall cost of meeting military mission objectives.

Maintaining stable design organizations and teams, shielded from significant program competition and relying on the same subcontractors for long periods, promotes continuity and minimizes startup problems; but such a policy can lead to stagnation, and extended commitment to suboptimal technical approaches.

Extreme secrecy helps to deny the West the leadtime necessary for timely response to Soviet programs; it also works to impair the free flow of information—and thereby innovation—within the Soviet R&D community.

Aggressive exploitation of Western technology can dramatically expedite technology advance and economize on resources. It can, however, lead to dependence or at least lags in certain areas, and it can render the Soviets vulnerable to Western countermeasures.

Greater weapon system complexity could also pose increasingly difficult management problems for the Soviets; the often overlapping demands on key subsystem organizations, such as those involved in the development and production of microelectronics, may tax their resources beyond their capabilities to deliver on schedule in future years.

What are the prospects for a major technological advance that would give the Soviets weapon systems that would provide an important military advantage over the United States?

In general, we judge as low the prospects for an unanticipated major technological advance in the

Soviet Union during the next 10 years that could lead to a revolutionary new capability posing a significant new threat to the West. We base this judgment—for those technologies where we have an adequate understanding of Soviet achievements to date—on the lag in Soviet technology behind that of the United States in areas most critical to the achievement of military advantage, and on the time—on the order of nine to 12 years—required to transform a major technological advance into a new operational weapon. The Soviets almost certainly will not be able to incorporate into systems deployed through 1995 technological advances much beyond the technology levels they have already achieved, or the technology now available to the United States. We cannot judge the potential for a major advance after 1995.

There are important gaps in our understanding of Soviet progress in several areas of technology and their currently achieved technology levels, where major advances could be militarily significant.

In addition, while we believe the Soviets lag the West in microelectronics, developments in this field are so rapidly paced and their applications so broad that we cannot foresee all possible military implications of advances in this technology area.

The Soviets' practices in technology application have become more aggressive and more responsive as their military technologies and R&D organizations have matured. While the Soviets have not been proficient as technological innovators, their substantial engineering capabilities have in the past used lower levels of technology to develop weapons designs which, in conjunction with high production rates, have resulted in weapon system effectiveness comparable to or exceeding some modern Western weapons. Thus, military advances could also occur through innovative applications of existing technologies. Such advances would depend more on present Soviet engineering strengths than on an unexpected technological breakthrough in an area of advanced research.

Finally, the growth and maturity of the Soviets' R&D sector, and the persistence of their military programs, could result in some unexpected advances either in the speed with which they are able to develop and field new weapon systems with higher levels of performance, or in the novel design of some of their systems.

How will the Soviets counter military technology advances in the West?

In several important areas, Soviet weapons requirements, and hence system performance in the 1990s, will be greatly influenced by the introduction of advanced military technologies by the United States and its allies. The US force modernization program, for example, will lead to costly and technologically demanding efforts by the Soviets to attempt to counter these major improvements, particularly in their defensive systems.

For defensive missions, the Soviets must make major improvements in several critical areas well beyond

those now available for military applications. For detection of US ballistic missile submarines and defense against Stealth penetrators, the Soviets also must contend with the limits imposed on the detection process by the physical environment. We doubt the Soviets will have the capability to deploy effective defenses against planned US ballistic missile submarines or Stealth penetrators, even by the mid-1990s. Further, Western advances in armor protection and antiarmor weapons threaten to reverse some of the Soviets' technical advantages in the land-warfare area. The Soviets will need to develop new antiarmor weapons because many of their current weapons cannot defeat the M1 tank's special armor. Also, greatly improved warheads for US antitank weapons should be able to penetrate the armor of Soviet T-64 and T-72 main battle tanks. The development of new tank armor and antitank weapons to counter these new, more powerful US weapons will place severe requirements on the Soviets, especially in the area of materials technology.

What new military systems, including those that will require new advanced technology, are likely to appear in the 1990s? Are there other systems for which we believe the Soviets lack the needed technology, which are therefore not likely to appear in the 1990s, but which could have major significance if the Soviets were able to produce them?

Some of the advanced systems that we project the Soviets will deploy in the 1990s are shown in table I-2. These systems will generally provide them with new capabilities that either fill existing needs or offer new opportunities. Also shown in table I-2 are systems that we believe are not likely to reach initial operational capability (IOC) in the 1990s; these judgments are based on our forecast of the technology that will be available to the Soviets. If these systems should be deployed in the 1990s or even later, however, they would give the Soviets important military advantages in the absence of appropriate Western responses.

The technology for nearly all of the systems that we expect the Soviets to deploy through the mid-1990s is probably now available to them, although we do not have evidence, in some cases, of what specific level of technology they have achieved. For some systems to appear by the late 1990s, the Soviets will require important technological improvements that we believe they have not yet achieved.

A key trend in the USSR's *strategic offensive systems* will be greater mobility and accuracy. The development of mobile systems will serve to offset the increasing vulnerability of fixed intercontinental ballistic missiles (ICBMs) to programed US strategic delivery systems. The Soviets have long perceived the benefits of such mobility and have had developmental efforts under way in small, solid-propellant ICBMs, for example, for over 20 years. Soviet technologies in propulsion, materials, and terminal guidance are currently sufficient to support the development of land-mobile ICBMs with hard-target kill capability. These technologies are also adequate for development and deployment of improved submarine-launched ballistic missile (SLBM) systems, some of which, in the late 1980s or early 1990s, could be capable of attacking hard targets by using accuracy MaRVs (maneuverable reentry vehicles). In addition, the Soviets could diversify their offensive forces further by developing new aerodynamic systems, perhaps including some with reduced observables.

Soviet *strategic air defense* technologies will very likely continue to lag behind the changing threat, if US penetrating aircraft and cruise missile programs result in deployments. The Soviets will be severely challenged in their capability to deal effectively with large-scale low-altitude attacks by cruise missiles, short-range attack missiles, and penetrating aircraft with low radar cross sections, and especially attacks by bombers and cruise missiles using Stealth technology:

- The Soviets are probably making an effort to develop the capability to destroy cruise missile carriers before they launch their missiles. They are about to deploy an airborne warning and control system (AWACS) aircraft for long-range search and surveillance, and may be developing long-range, long-endurance interceptors to counter standoff cruise missile delivery vehicles. Further developments, such as a spaceborne air vehicle detection system, will require Soviet advances beyond currently achieved levels in several technologies—signal processing, radiofrequency and electro-optical sensors, and computers.

Table I-2

Major New Soviet Systems for the 1990s
(Likely Systems and Those Unlikely But Significant)

System Area	Systems With Moderate-to-High Likelihood of Initial Operational Capability (IOC) in the 1990s [a] [b]	Systems Not Expected To Reach IOC in 1990s, But That Would Be Significant If They Did [b]
Strategic offensive systems	— Accuracy MaRV (maneuverable reentry vehicle) — Reduced-observable aircraft and cruise missiles	
Strategic defense systems	— Space-based system for detection of bombers and airborne cruise missile carriers [c] — Spaceborne laser antisatellite (ASAT) system — Ground-based radiofrequency ASAT weapon — Anti-cruise-missile missile — Satellite for detecting launches of submarine-launched ballistic missiles — Long-range interceptor	— *Ground- or space-based laser ballistic missile defense system* — *Orbital particle beam ASAT weapon* — *Orbital radiofrequency ASAT weapon* — *Stealth countermeasures systems* — *Space-based nonacoustic submarine detection system* [d]
General purpose naval systems	— Carrier-based airborne-early-warning aircraft — Naval conventional-takeoff-and-landing aircraft — Shipborne high-energy laser for ship defense	
General purpose ground forces systems	— Ground-mobile high-energy laser for battlefield air defense — *Fire-and-forget heliborne antitank missile* — New chemical warfare agents — Advanced (possibly turretless) tank — *New attack helicopter* — *Wide-band intercept and jamming systems*	
Command, control, communications, and intelligence systems	— *Automated intelligence integration-and-dissemination system*	— *Radar imaging satellite*

[a] Assumes that development will be fully successful and that Soviets will choose to deploy the systems. Not all Soviet developments lead to deployment.

[b] Italic type indicates programs identified as requiring significant advances in technology before system development can begin.

[c] This system could not appear until the late 1990s at the earliest.

[d] Low probability for a system capable of detecting ballistic missile submarines in the open ocean; low-to-moderate probability for detection of attack submarines trying to penetrate bastion areas for Soviet ballistic missile submarines. An airborne system for the detection of attack submarines is somewhat more likely.

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— Available technology will permit the Soviets to develop new low-altitude air surveillance and tracking systems, multimission fighters with multiple target engagement capability, surface-to-air missile (SAM) systems with phased-array radar using pulse-Doppler techniques, and anti-cruise-missile missiles.

— In the late 1980s and 1990s, Western Stealth cruise missiles and aircraft will severely stress the Soviets' defenses. We do not believe that they have the technology available to develop systems to effectively counter Stealth in the 1990s.

The progress made by the Soviets in *directed-energy* technologies has permitted systems development and prototype testing of some types of directed-energy weapons. The Soviet state of the art is not sufficient, however, to proceed with development of some other types of directed-energy weapons:

— The technology for ground-based laser weapons capable of in-band damage of satellite sensors has been available for at least a decade; the laser technology for a short-range space-based antisatellite (ASAT) weapon is probably now available. For tactical use, including air defense, the Soviets have had the technology for antisensor weapons for at least 10 years; technology for destructive air defense weapons is expected to be available within the next several years. The technology for longer range space-based ASAT weapons is also likely to be available within the next several years, to support prototype tests in space by the early 1990s. The technology for ballistic missile defense (BMD) weapons is not yet sufficient to support development of a prototype weapon. Ground-based and space-based BMD systems are likely to require another 10 years or more of technology development, and operational systems for destruction of ballistic missiles or their reentry vehicles probably could not be fielded until after the turn of the century.

— The Soviets now have the technology capable of supporting development of a prototype RF weapon for soft kill of electronics or for antipersonnel applications out to a distance of about 1 kilometer.

— The technology to support development of destructive particle beam weapons, if feasible, is not expected to be available for a prototype test before the mid-to-late 1990s.

The real-time performance of *command, control, communications, and intelligence* systems, including space-based systems, will continue to be limited by deficiencies in computer technology and computer networking. The Soviet lag in computer technology is greatest in software and peripherals, where the USSR is respectively 10 and 15 years behind the West. Still, we expect the Soviets to deploy, in the late 1980s, a network of space-based near-real-time reconnaissance systems, and an automated intelligence integration and dissemination system could be available in the late 1990s.

In *naval* technologies, the USSR will concentrate on those applicable to development of systems for protection of its nuclear-powered ballistic missile submarine (SSBN) forces and for detection of opposing submarines. The Soviets will achieve some success in protecting their own submarines by selection of operational areas and improved tactics, by employing multiple layers of ASW forces and—on the basis of technology now available—by increased SSBN quieting and by improvements in short-range detection systems. The Soviets will remain unable to systematically detect and track Western SSBNs in broad ocean areas. They may be able to deploy spaceborne nonacoustic systems in the mid-1990s with limited capabilities to detect enemy attack submarines attempting to penetrate bastions for Soviet ballistic missile submarines. An airborne system could be available by the early 1990s. We expect that current technology will enable the Soviets to be able to deploy conventional-takeoff-and-landing aircraft and airborne early warning aircraft in the early 1990s on attack carriers. They may deploy a first-generation shipborne high-energy laser for ship defense in the late 1980s.

Soviet *ground forces* and supporting *air* and *air defense forces* will also require some systems incorporating advanced technologies to meet their mission objectives in the 1980s and early 1990s:

— In tactical reconnaissance, high-quality near-real-time intelligence and targeting data will be

required to support strikes by aircraft and short-range ballistic missiles against dispersed and mobile targets. We expect development of advanced electro-optical and infrared sensors and imaging radars to be based on aircraft, remotely piloted vehicles, and drones, together with supporting ground-based processing and dissemination systems. The technology is now available for development of these systems; some programs, including one for a high-altitude reconnaissance aircraft [ ] are now well under way. It is doubtful, however, that the Soviets will be able to produce the necessary systems in the quantities required for effective tactical application before the mid-1990s.

— The introduction of small, guided, heliborne fire-and-forget weapons by the Soviets will require the development and introduction of advanced sensors, signal-processing techniques, and microelectronics and computing technologies. We expect the technologies to be available within the next few years to support initial deployments of such weapons in the mid-1990s.

— Soviet armor technology will need to make significant strides to counter Western antiarmor improvements. We expect the Soviets to have difficulties achieving these improvements rapidly. One approach, based on existing technology, could be the development of a turretless tank for initial deployment in the early 1990s. Such a tank would offer a reduced silhouette and increased armor protection.

— Soviet tactical air and air defense systems, using available technology, will probably emphasize improved survivability and operational efficiency. Soviet tactical fighters will be multimission and will probably resemble their current Western counterparts. We expect an emphasis on increased maneuverability with external ordnance in higher g-load conditions and an improved capability for out-of-plane attacks. A mobile ground-based high-energy laser weapon, which is now undergoing testing, could be deployed beginning in the late 1980s. It could be capable of structural damage at short range (1 to 2 km) under optimal conditions, and sensor damage out to a range of about 10 km. There is a moderate likelihood that an advanced system with higher power levels will be deployed in the late 1990s.

Given their maturing technology base, are the Soviets more likely to take technological risks in the weapons development program?

In their R&D practices, the Soviets will probably continue to restrict technological risk to the applied research phase prior to making a commitment for weapon system development. They will continue to reduce risk in actual weapons development by stressing the use of proven technologies and evolutionary improvements in system quality, with the intent of assuring a high probability that weapon systems will be delivered on time and achieve the desired performance levels. In addition, the continued infusion of technology from the West will serve to lower the technological risk in applied research, thereby helping the Soviets to build weapon systems with better performance capabilities sooner, and with fewer R&D resources, than would otherwise be possible.

Military requirements, together with the availability of new technologies, are the dominant factors in Soviet decisions to develop new military systems. Also, the satisfaction of future military objectives is a driving force behind Soviet military research. Although advanced technologies are often required for a new system, they are matured through separate technology development programs and, in almost all cases, must be available before the decision is made to include that technology in a weapon system development program.

Will the Soviets continue to develop a large number of military systems as they have in the past?

We believe that the Soviets will continue to maintain a high level of military systems development into the 1990s.

We estimate that, as of 1983, the Soviets have under development between 150 and 200 new and major modernized weapon systems and support systems, including military space systems. Over the past two decades, we estimate that 150 to 200 major weapon systems have been in development at any one time. We believe that the number of systems that will be in development in the 1990s is unlikely to decline.

Leadership support for military research and development remains strong, facilities are still expanding, and the R&D program effort seems not to have been affected by economic difficulties in the civilian sector. Also, requirements for R&D are increasing as the complexity of military problems facing the Soviets becomes greater.

The Soviets are increasing combat potential by exploiting advanced technology. In certain areas, this will lead to a smaller number of systems but a higher percentage of multimission systems than has been Soviet practice. We expect, for example, that tactical aircraft will be able to carry and employ larger mixes of high-technology weapons in the 1990s. In other areas, large numbers of many different types of systems will be developed for some established missions (such as the current trend for general purpose submarines) and to meet new requirements (such as for long-range land-attack cruise missiles and for directed-energy weapons). The Soviets will tend to maximize the development potential of their new weapons by continuing to design them to accommodate future modular upgrades after they are deployed.

However, Soviet military R&D organizations have probably become more capable in developing high-technology weapon systems than Soviet industry has become in producing them. A combination of factors—more multipurpose weapons, higher costs, greater quality control problems, and more difficult and costly maintenance requirements—is likely to cause the Soviets to produce new, more technologically advanced systems in smaller quantities than they have in the past. Thus, they are tending to rely somewhat more on technology, and somewhat less on quantity, to achieve their future military goals.

What problems will the Soviets have in producing the sophisticated weapons that we project for development?

We believe that the Soviets will experience difficulties in manufacturing many of the sophisticated weapons projected for the 1990s. The Soviets are experiencing production rate limitations and technical problems that are disrupting the manufacture of advanced systems—including the T-72 tank, the MIG-31 aircraft, the Backfire bomber, and the Typhoon SSBN. Current evidence of expansion in electronics-related industry, projected advances in precision machining and other fabrication technologies, and continued aggressive exploitation of Western technology suggest that some of their present difficulties are likely to be at least partially overcome. But some major deficiencies are expected to continue in the availability and quality of test equipment and instrumentation, in their logistics base, and in technical training of maintenance personnel.

Will the Soviets face resource constraints in producing and supporting these complex new systems for the 1990s?

Although we do not foresee a major diversion of resources away from military R&D, growing demands in the civilian sector will intensify the competition for resources if economic problems worsen in the late 1980s. Since the late 1970s, the annual rate of Soviet economic growth has been declining because of increasing resource scarcities, industrial and transportation bottlenecks, and persistent inefficiencies within the economy.

Manpower constraints, both in numbers and quality, might have an adverse impact on the ability of the defense industries to produce advanced weapons. Increases in productivity from more automated equipment have the potential to offset shortages of skilled labor in the industrial sector. In the armed forces, however, the relative decline in manpower quality, brought about by a growing number of less educated non-Russian-speaking Central Asians, may adversely affect operation and maintenance of complex weapon systems.

What are the Soviets doing to ensure a strong technology base for the 1990s?

In the past few years the party Central Committee and the Council of Ministers have initiated programs to improve the bureaucratic and economic aspects of the USSR's science and technology effort. A strong leadership commitment to this S&T policy is likely to strengthen the overall Soviet technology base necessary for satisfying both the needs of the civilian economy and the requirements for some of the high technology for weapon systems projected in this Estimate. This new policy has a stated near-term emphasis on

strengthening technology applicable to the civilian sector by relying on the defense sector to contribute expertise, technology, and limited resources. We believe that dramatic—and needed—advances in "civilian" technologies would require a substantial diversion of resources from military R&D, which we do not foresee. If the Soviets are successful in enhancing S&T through long-range programs, the future military benefits could be significant, particularly in those technologies that are common to both sectors, including computers, microelectronics, fiber optics, powder metallurgy and composite materials, and industrial lasers and robots.

Can the Soviets catch up with—even surpass—the West in overall military technology?

While the Soviets appear fully committed to achieving military-technical superiority, and have devoted significant resources toward this stated goal, we doubt that they currently possess the necessary capabilities to match or overtake the United States in overall military technologies by the 1990s. In addition to the impediments within the Soviet R&D system, they must also contend with uncertainties about their future successes in technology acquisitions, and with the current and prospective upswing in US military R&D efforts. These efforts, if sustained, will pose a major challenge to the Soviets and make it more difficult for them to close existing gaps. In certain areas of prospective US concentration, such as directed-energy technologies applicable to ballistic missile defense, existing Soviet strengths could be overshadowed. In these and other areas, however, Soviet military R&D will continue for some years to benefit from the increases in investment—and the larger total investment relative to that of the United States—that have characterized the past decade.

We also caution that there are considerable uncertainties associated with our assessments of the overall relative standing of US and Soviet military technologies by the 1990s. Our uncertainties stem from an incomplete understanding of the relative standings now and of the rate of change in Soviet technology, and from the difficulty in forecasting the contribution of technology transfer. In addition, while we assume a strong US commitment to military R&D, systematic comparisons of the future states of US and Soviet technological capabilities must also take account of actual advances in US technologies—which we have not studied here, and which have yet to be realized, but which could significantly influence any projections.

While we project that the Soviets will remain generally behind the West, we also caution that their major commitment to advances will probably not dissipate, that their military R&D will continue in any case to benefit for years to come from past investments, and that their S&T and economic reform efforts may yield incremental but useful payoffs. We expect continued advancements in all Soviet military technologies, and that the overall gap between the US and Soviet technology bases will be further narrowed. As a result, a larger number of the Soviet military technologies will be lagging by no more than two to three years, and the gap would be small enough to make the level of technology introduced into many military systems deployed in the late 1990s and beyond nearly comparable.

In general, what are the prospects for Soviet military technologies by the end of the 1980s?

We expect the Soviets to make continued progress in raising the levels of those technologies that are key to their advanced weapons development programs:

- At present the Soviets are strong across a broad front of military technologies, with the introduction of advanced microelectronics into military systems trailing similar technologies in the West by only about three to five years. At the same time the Soviets have achieved superior technological capabilities in several important areas that could provide the USSR and its allies with some military advantages in the 1990s.
- Support of military R&D and defense production by Soviet science also has improved noticeably over the last 10 years. The strength of Soviet efforts in several important areas—millimeter wave, electro-optics, directed energy, acoustic and nonacoustic ASW, and space—are directly attributable to large and extensive scientific research programs.

Progress in military technologies will vary by technology area:

- Soviet development of *information acquisition* technology will probably accelerate and be

stronger before the end of the 1980s. For example, the Soviets will need to emphasize advanced radar and electro-optics sensors, in an effort to counter US Stealth technology. (A key to their success in countering Stealth is whether they can develop better signal processing, a capability that depends on improving their ability to produce high-quality microelectronics and optical components or possibly making major advances in the linking of their analog, optical, and digital processing capabilities.)

— Soviet *information-processing* technologies, particularly microelectronics and computers, are not likely to keep up with Western developments; however, we expect the Soviets by the end of the 1980s will make innovative use of their microelectronics in designing large-scale integrated (LSI) circuitry for military application. Further, we believe Soviet use of digital signal processing based on microelectronics will be widespread for both ground-based and airborne weapon systems by the late 1980s. By the late 1990s they may introduce very-large-scale-integrated (VLSI) circuitry into military systems.

— We expect Soviet *weapons delivery* technologies, particularly missile guidance and propulsion technologies, to advance steadily and continue to provide a strong base for both tactical and strategic weapons development.

— Possibly the most significant advances in the Soviet military technologies will occur in the *lethality/damage* technology area. The Soviets are likely to keep up their large investment in conventional explosives technologies in order to maintain the excellent technological capabilities they now have. We are uncertain about what their vigorous chemical warfare R&D effort will produce in the next five to 10 years because of the lead they have now opened over the West. As Soviet research in directed energy, particularly laser and RF weapon technology, begins to yield results, the effects of even limited test success could stimulate even more R&D.

— Apart from some areas such as chemical and biological R&D, *life sciences* technologies in the USSR are generally less sophisticated and less well developed than those in the United States. Overall, genetic engineering techniques, for example, are somewhat less advanced than those of the United States and applications development efforts are smaller. We are concerned, however, about the potential that genetic engineering has for the development of biological warfare agents or toxins. Soviet research, development, and evaluation efforts involving human factors appear to be concentrating on improving weapon system performance through the optimal use of humans as controllers and decisionmakers. We also expect that the Soviet chemical warfare effort will continue, with emphasis on better protective suits and improved ability to detect CW agents, as well as more effective agents for offense.

— The Soviet *ocean science* research program—the largest in the world—continues to expand, with new advanced ships, instrumentation, and oceanographic satellites. One particular area of Soviet ocean sciences interest is the Arctic, where Soviet submarine under-ice expeditions and transfers have been conducted since 1961. Oceanographic scientific research expeditions, which also began then, are probably related to the development of submarine navigation procedures, to ASW operations and tactics, and to establishing the Soviet Navy's capability to operate its most modern submarines in its contiguous Arctic havens shielded from US acoustic surveillance systems.

— The Soviets have committed substantial R&D resources to support their *space programs*, with large increases in the early 1980s for their military manned space program and communications systems. The wide range of new space systems now in development stands in contrast to the 1970s, when most developments were for improved, rather than new, systems. Military systems and missions receive first priority, including a Soviet space shuttle, space plane, heavy-lift launch vehicle, and near-real-time imagery-relay systems. New capabilities will result, including those for quick-reaction military missions such as reconnaissance.

— The Soviets are gradually improving their *production* technology, with a trend toward greater industrial automation. The principal improvement from automated production will be in-

creased efficiency, and perhaps some alleviation of expected manpower shortages, especially of skilled labor. But Soviet industrial automation is not expected to result in the production of substantially larger numbers of weapon systems than are now being produced. Rather it is likely to be used to aid the production of more complex weapon systems by producing parts of higher reliability that are manufactured to more stringent tolerances and industry standards.

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