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Directorate of Intelligence

The Soviet Defense Industry: Coping With the Military-Technological Challenge

A Research Paper

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The Soviet Defense Industry: Coping With the Military-Technological Challenge [redacted] 25X1

A Research Paper

This paper was prepared by [redacted] 25X1
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The Soviet Defense Industry: Coping With the Military-Technological Challenge [redacted] 25X1

Summary

Information available as of 21 October 1986 was used in this report.

[redacted] the Soviets by the early 1970s were becoming increasingly worried about the growing military-technological challenge posed by the United States. Circumstantial evidence suggests the defense leadership was persuaded that its traditional approach of relying on superior numbers of weapons to offset Western technological advantages would not meet this challenge. [redacted] 25X1 25X1
[redacted] key defense planners believed if the USSR was to compete effectively with the military power of the United States, the weapons industries required extensive and sustained modernization. [redacted] 25X1 25X1

Before the 1970s, the Soviets had paid greater attention to expanding production capacity than to improving manufacturing technology. Throughout the 1950s and 1960s, roughly two-thirds of capital investment in industry as a whole was devoted to construction, leaving on average less than one-third for the acquisition of machinery and equipment. [redacted] 25X1 25X1
[redacted] the defense industry applied its investment funds in a similar manner. 25X1 25X1
This policy, together with low replacement rates for obsolete machinery and equipment and the fact that even new defense plants were often equipped with machinery designed years earlier, resulted in a largely outdated manufacturing capability. [redacted] 25X1

The Defense-Industrial Modernization Program

In the early 1970s, the Soviets began a comprehensive modernization of their defense industry. [redacted] 25X1 25X1
[redacted] an upgrading of the entire tank industry, including the construction of modern manufacturing facilities and the installation of state-of-the-art machinery and equipment. [redacted] major capital improvements in 25X1 other defense industries. Our analysis of the Soviet machinery sector—responsible for the production of consumer durables, investment goods, and military hardware—suggests that between the early and late 1970s the share of investment in the defense-industrial ministries increased substantially. [redacted] 25X1

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The USSR also embarked on programs designed to support this upgrading of the defense industries:

- There was a step-up in the development of advanced machine tools, computers, and microelectronic devices—equipment needed to produce advanced weapons and improve productivity. Much of this work was undertaken within the defense industry itself.

- As legal imports of Western plant and equipment soared in the early 1970s, 25X1
  Access to Western manufacturing equipment, processes, 25X1
  and know-how has enabled Soviet defense plants to introduce some advanced weapons into production up to five years earlier than would have been possible with indigenous capabilities.

- The Soviets improved the coordination between weapon designers and producers and tried to involve more than one ministry or plant in the co-operative production of a given weapon system, measures which have helped reduce unnecessary duplications of effort. 25X1

This commitment to defense-industrial modernization appears to have been helped by the rise of Dmitriy Ustinov, who had been gaining favor, position, and power since the mid-1960s. He had long advocated Western-style management techniques, and the policies he implemented clearly indicate that he believed general economic growth and modernization to be the bedrock of the USSR's defense potential. His appointment to the position of Minister of Defense in 1976 and the subsequent appointment of like-minded subordinates probably signaled a coalescence of views on the broad guidelines of defense-industrial modernization policies. 25X1

Results of the Program

The pace and scope of the defense-industrial modernization effort to date have been uneven. Much of the effort has been in the form of new plant and equipment rather than major retooling of existing facilities, suggesting that considerable renovation still needs to be done in older facilities. Moreover, the level of technology even in new production facilities often lags well behind the overall level in the West. Nevertheless, the expansion of manufacturing facilities and selected improvements in production technology have given the defense industries the plant and equipment needed to produce 90 percent of the hardware that the Intelligence Community is projecting will be deployed by the end of the decade, as well as the advanced weapons that we expect to be fielded through the early 1990s. Attesting to the progress the Soviets have made in modernizing their defense industries is the number of new systems already in production that demand relatively advanced manufacturing technology and equipment

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to meet requirements for miniaturized componentry, new materials, and complex surface geometries. These include T-80 tanks; MIG-29 and SU-27 interceptors; Sierra-, Oscar-, and Akula-class attack submarines; and SA-12 surface-to-air missiles. 25X1

The introduction and widespread application of more costly equipment sets and integrated production lines require more time than modernizing with the less sophisticated technology used in manufacturing earlier weapon systems. 25X1

was not—as had been the 25X1
case in earlier periods followed by ar25X1
upturn in the growth rate of military hardware production. A larger number of defense-industrial facilities were producing at lower rates or not producing at all. 25X1

The rising dependence of the defense industries on materials and components produced by civil industry probably provided added impetus to Soviet efforts, begun in the late 1970s, to upgrade the increasingly antiquated civilian production base. Leonid Brezhnev introduced measures to share defense management expertise with the civilian sector, to apply the military model to spur scientific and technological progress, and to reorient the Academy of Sciences and universities to applied research. At the same time, growth in investment in the defense hardware ministries was scaled back and investment in civilian machine building accelerated. In 1985, Mikhail Gorbachev not only endorsed these measures but also further stepped up the provision of resources to civilian machine building (investment planned for civilian machine-building ministries in 1986-90 is 80 percent higher than the actual investment in 1981-85). His program singles out advanced machine tools, robotics, microelectronics, computers, automated management systems, and telecommunications for greater funding. In each of these areas, he has initiated technology development programs with extensive defense-industrial participation. 25X1

Outlook for Defense Industry

Over the next decade, Soviet defense industrialists will have to deal with a mixture of old and new challenges:

- We estimate that the costs of Soviet weapon systems have increased appreciably with the introduction of each new, more capable system within a given weapon class. Although modernization has helped the Soviets to increase productivity in the defense-industrial sector and to limit cost increases, the growing costs of technological development and exploitation will continue to drive up weapon costs, confronting designers and producers with pressures to economize.

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- More capable weapon systems probably will allow replacement of certain older military equipment on a less than one-for-one basis, easing the production burden but increasing the need for exacting tolerances and strict quality control.

- Retrofits of older equipment, now under way for a large portion of the Soviet arsenal, ease demands on weapon assembly plants; but suppliers of radioelectronic components and subsystems, computers, and advanced materials will be hard hit as they must support both new and retrofit programs.

The USSR probably will produce and deploy larger numbers of less capable weapons than the United States when doing so compensates for technological shortcomings or is a more cost effective way to meet military requirements. Moreover, the Soviets have often succeeded in translating technological achievements into weapon systems more rapidly than the West does. Thus, the technological levels of deployed Soviet and Western systems are more comparable than are the general levels of technology. Over the longer term, however, the Soviets are almost certain to place even greater emphasis on the development and manufacture of sophisticated weapons that require upgraded industrial technology.

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This will be a tall order. Gorbachev must contend with increasing resource constraints, a government hobbled by organization and systemic barriers to quick progress, and an incentive system that still retards industrial innovation. He also faces an increasingly sophisticated and reinvigorated military challenge from the West, including the Strategic Defense Initiative. And his civil-industrial modernization program will compete for machinery and equipment resources with the ongoing modernization of the defense industries. Many defense plants, for example, need further upgrading with more precise and flexible computer-controlled machine tools, special equipment to process new structural materials, and sophisticated, nondestructive testing equipment.

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Gorbachev's strategy seems directed in part at providing the requisite breathing space to give his investment policy a chance to work. Domestically, he apparently has convinced most of the leadership—at least for now—that the modernization of civil industry ultimately will benefit the defense industries and the military. In foreign policy, his recent arms control initiatives, summit diplomacy, and efforts to mend fences with Western Europe, Japan, and China are reminiscent of Soviet foreign policy leading up to the detente period of the 1970s. An improved East-West relationship—particularly if formalized by an arms control agreement—would buy

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Gorbachev more time to implement his domestic economic agenda. Even so, the competition between defense and those components of civil industries not directly supporting military-related production is likely to grow in the late 1980s and early 1990s as the Soviets begin to tool up for production of the next generation of weapons. If the performance of the civilian machine-building sector has not improved sufficiently by then, the Soviets will have to choose between delaying continued retooling of the defense industry or cutting back the ambitious goals for upgrading civil industry.

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Scope Note

This paper analyzes Soviet efforts, which began in the early 1970s, to prepare the defense industry and its support base for the military-technological competition in the 1980s and 1990s. It also assesses the political, military, and economic implications of this modernization program. 25X1

Our analysis is based on evidence from Soviet policy statements, investment trends, and weapon programs and draws from substantial research on the Soviet military-industrial complex undertaken over the last few years in the Office of Soviet Analysis and other offices of the Directorate of Intelligence. 25X1 25X1

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The Soviet Defense Industry: Coping With the Military-Technological Challenge

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Background

To offset their lower level of technological sophistication and economic performance, the Soviets (and the Russians) historically have relied on a three-track strategy in their military rivalry with more technologically and economically advanced Western powers. First, they have devoted very large amounts of high-quality material and human resources to the military-industrial complex and its programs, often at the expense of other economic sectors. Second, they have developed a program for weapons research, development, and production that plays to the strengths of their industrial base. Third, they have extensively exploited Western military-technological advances.

Massive Military-Industrial Complex

By sheer political will and enormous allocations of investment and manpower, the Soviets have created the world's largest weapons industry.[1] Nine industrial ministries—including the leaders in most industrial technologies—dedicate most of their efforts to the provision of military materiel (see table 1). At any one time, more than 1,500 development and test facilities are engaged in the development of 150 to 200 new weapon and military support systems or major modifications of existing systems. Concurrently, about 150 major assembly plants, supported by thousands of component and material production facilities, are engaged in the production of about 300 major weapon systems. These combined efforts have allowed the Soviets to field, on average, about 140 major new systems and 200 to 400 major upgraded systems during each of the past two decades.

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Table 1
Soviet Ministries Primarily Engaged in Defense-Industrial Production

Ministry	Products
Aviation Industry (MAP)	Aircraft, aerodynamic missiles, defensive missiles (both tactical and strategic), tactical air-to-surface missiles, and antisubmarine warfare (ASW) missiles.
General Machine Building (MOM)	Liquid- and solid-propellant ballistic missiles, including submarine-launched missiles (SLBMs); SLBM fire-control systems; space launch vehicles; spacecraft; surface-to-surface cruise missiles; and high-energy lasers.
Defense Industry (MOP)	Conventional ground force weapons, mobile solid-propellant ballistic missiles, optical systems, antitank guided missiles, tactical surface-to-air missiles, lasers, and ASW missiles.
Shipbuilding Industry (MSP)	Naval vessels, naval electronic and support systems, mines, torpedoes, submarine detection systems, acoustic naval systems, and radars.
Radio Industry (MRP)	Radars, communication and navigation equipment, special-purpose computers, guidance and control systems, lasers, and airborne fire-control systems.
Medium Machine Building (MSM)	Nuclear weapons and high-energy lasers.
Machine Building (MM)	Conventional ordnance, munitions, fuses, and solid propellants.
Electronics Industry (MEP)	Electronic parts, components, and subassemblies.
Communications Equipment Industry (MPSS)	Communication equipment, radar components, electronic warfare equipment, military computers, and facsimile equipment.

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Aging Production Technology

Soviet leaders have long relied on massive infusions of plant and equipment to transform the economy and spur economic development. In every ministry they have created large staffs and institutes charged with promoting advances in production technology. They have developed massive systems for technical information to inform managers and workers of new production technology. They have tried variously to induce or require such advances by manipulating plan targets and incentives, including adopting "certification" procedures to force machinery and equipment producers to meet "world standards."

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These approaches have yielded incremental modernization throughout the economy, with the defense industry—by virtue of its favored position—having achieved a more rapid pace of modernization. Soviet literature indicate that each new defense plant has been equipped with at least some of the best available machinery and tooling. The modernization of production technology for new weapon programs has had a high priority; the decree governing each program specifies in detail the obligations of all contributors, including machinery and equipment suppliers. Defense industry has also had priority access to suppliers, including not only foreign and domestic civil industry but also its own in-house support base. Indeed, the realization in the 1950s that future weapon systems would require new technologies probably led the Soviets in the late 1950s and early 1960s to begin development of solid-rocket production technology, advanced metallurgy, composite materials, and a modern semiconductor industry directly under the control of one or more of the ministries principally engaged in defense production of military hardware.

Nevertheless, most Soviet weapons were manufactured by an industrial base that was antiquated by Western standards. The expansion of defense-industrial capacity—for example, in the aerospace industry—was accorded higher priority than measures designed to encourage technological innovation and increase productivity. The limited technical demands imposed on the manufacturing base by the weapons of that era and a relatively plentiful labor supply encouraged—or at least permitted—such a policy. Throughout the 1950s and 1960s, the Soviets devoted little more than one-third of their capital investment in industry to the acquisition of machinery. By comparison, in the mid-1970s nearly three-fifths of US industrial investment was directed toward reequipping and modernizing the manufacturing facilities. As a result, the level of technological sophistication of Soviet machinery inventories grew slowly. Indeed, the average service life of Soviet industrial equipment has been estimated at 20 years, compared with average lives of 10 years in France, Germany, and Italy, and 12 years in the United States.

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this low retirement rate—and its negative effects—also prevailed in the Soviet defense industries. Signs of high-level concern over lagging efficiency in the defense industry began to appear in the 1960s, and in 1963 then First Party Secretary Nikita Khrushchev complained that although "the defense industry is coping successfully with creating and producing modern weapons . . . these tasks could have been carried out more successfully and at a lower cost."

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Soviet statements indicate that defense managers preferred to retain old, yet reliable equipment and to build new plants rather than to suffer downtime associated with the startup of new equipment and plant renovation.[2] In addition, Soviet developers of production technology and equipment worked in relative isolation from weapon designers and producers, frustrating efforts to coordinate the advances in production technology needed for some new weapon systems. In contrast, US defense industry since at least the late 1960s typically has planned on replacing equipment every eight to 12 years.

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Functional Weapon Design and Performance

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Taking into account this production base, the Soviets took a pragmatic approach to weapons development,

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stressing predictable, low-risk development programs and weapons that could be readily produced in large numbers. Designers consciously avoided the use of technically unproven materials and components. most weapons could be manufactured with general purpose machinery and equipment operated by a semiskilled work force. Although this design approach limits the pace of technological advance, the Soviets were able to achieve a combination of large-scale deployment and sufficient overall system performance to mitigate the technical deficiencies of individual subsystems and components, while allowing easy operation and maintenance in the field by a conscript force with minimal technical skills.

Moreover, during the late 1960s and early 1970s, the Soviets made considerable progress in developing and proving new weapon technologies while exploiting the positive aspects of their weapons acquisition process. In particular, the Soviets emphasized technical areas such as electronics and communications that supported many of the advances in weapons performance that took place in the 1970s. Simultaneously, we saw a premium placed on those features of their acquisition process that encouraged program stability and predictability. These longstanding practices were set forth in the Unified Military-Technical Policy (UMTP), which first appeared publicly in the 1974 edition of Marshal Grechko's book *The Armed Forces of the Soviet State*. It is essentially the codification of a number of practices that date back to the 1950s and calls for a "systematic approach" to weapon development, including:

- Selective but preferential development of those technologies that have the greatest potential for enhancing future military capabilities.
- Weapon development criteria that seek both the highest tactical-technical characteristics and the lowest possible cost.
- Monitoring the systematic improvement of the weapons of all branches of Soviet forces, using systems analysis and forecasting, and keeping a close eye on Western achievements in science and technology.
- Creation of weapons and equipment that are easy to operate or that can permit reductions in military labor, especially through automation and mechanization.
- Improvements in command, control, and communications.

As a result of the design philosophy, the weaker technology base, and the industrial constraints described above, Soviet weapons generally have been inferior to US weapons in terms of performance and mission capabilities. To compensate for these deficiencies, the USSR has relied on numerical superiority, strong management of the weapons acquisition and assimilation process, crash programs, and access to Western technology:

quantitative superiority, particularly in land arms, has often been judged to be the most feasible way to counterbalance the generally higher level of performance and reliability of US systems. Soviet experience in World War II have indicated that the USSR expects even heavier losses in a nuclear conflict. Thus, the Soviets have produced large numbers of comparatively unsophisticated, specialized systems to counter the more capable, multimission weapons of the West. Indeed, even in the mid-1980s, when US force expansion and modernization peaked in many areas, Soviet production of major types of weapons almost invariably exceeded US production (see table 2).

- To help speed the production and deployment of new weapon systems, the Soviets have developed a centralized weapons forecasting and planning process, managed by a powerful government agency—the Military-Industrial Commission (VPK). The

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Table 2
US and Estimated Soviet Production of Major Weapon Systems, 1974-84

System	US	USSR
ICBMs and SLBMs	980	3,400
Intermediate- and medium-range ballistic missiles	116	735
Surface-to-air missiles	24,000	130,000
Long- and intermediate-range bombers	6	340
Fighters	5,600	11,700
Helicopters	3,000	10,000
Submarines	40	121
Major surface combatants	90	110
Tanks	8,795	31,500
Artillery	5,250	30,000

Note: Where sufficiently large to express order of magnitude, the numbers have been rounded.

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Soviets attempt to minimize the time for the formulation of requirements and for development approval, maintain stable design teams, and strictly adhere to program schedules.

- Analyses of weapons indicate that the Soviets move quickly to incorporate newly proven technologies—even if behind Western research and development (R&D) advances—into deployed systems. In most weapon areas, programs to develop new or significantly modified systems have been authorized about every five to 10 years. The Soviets have modernized forces by steadily upgrading proven weapons when new subsystems—such as fire control—become available and can be adapted.

- When revolutionary military technology advances have been necessary, the USSR has spent lavishly and established high-level oversight bodies to develop fundamentally new systems—such as ICBMs, nuclear weapons, and possibly, more recently, directed-energy devices.

- Where possible, the Soviets have acquired and exploited cost-saving Western technology to upgrade their research, development, and production base.

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This approach worked well for most of the postwar period. The USSR was able to field enough weapons of sufficient quality to erode or eliminate the US lead in key strategic and general purpose mission areas.

The Challenge: Developments in US Technology

Even by the early 1970s, however, the Soviets had become increasingly concerned about the ability of the United States to shift the military balance decisively in the West's favor by exploiting its superior technology. military writings during the early-to-mid-1970s catalogued a long list of future US weapons that worried the Soviet military leadership.

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the Soviets viewed the eventual deployment of these systems, then slated for the 1980s and 1990s, as a direct threat to their hard-won military gains during the first three postwar decades:

- *Strategic offense.*

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the USSR was lagging behind the West in terms of the size-weight characteristics of warhead materials and guidance systems. The highly accurate MX, Trident II, and Pershing II missiles placed fixed, hardened strategic forces at risk; improved submarine sensors and the ever-increasing quietness of US attack submarines increased the vulnerability of relatively "noisy" Soviet ballistic missile submarines; and space-based weapons would pose a potentially serious threat to Soviet overhead command, control, communications, and intelligence systems. Other US developments—including a comprehensive upgrading of command, control, and communications, and deployment of the Trident SSBN—promised to increase the survivability of US forces.

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- *Strategic defense.* The anticipated capability of the US B-1B, strategic cruise missiles, and future stealth aircraft to evade radar detection and the expected deployment of the Pershing II missiles threatened to overwhelm Soviet strategic defensive forces.

- *General purpose forces.* The M1 tank—expected to engage three to four opposing tanks—represented a significant improvement in firepower, fire control, and armor. Smart munitions threatened both Soviet ground weapons and naval surface vessels. And the F-15, already by the early 1970s a proven air-superiority fighter scheduled for widespread deployment in the US and NATO arsenals, was unequaled by Soviet aircraft on the deployment horizon.[3]

The Soviet defense leadership could have chosen to offset the increasingly superior performance characteristics of Western weapon systems by relying on its traditional approach of fielding ever-increasing numbers of relatively less advanced weapons. Events of the early 1970s, however, argued against such a strategy. The Soviets had begun to make advances in basic weapons-related technologies—advanced materials such as composites and titanium, and components such as microelectronics—that were making major improvements in weapons performance possible (see inset). At the same time, operations research in the United States and other Western defense establishments was beginning to show that the numbers of weapons required to overcome major performance gaps and effectively balance force capabilities were too large to be feasible. These findings were consistent with the results of the 1973 Middle East War in which Soviet-armed Syria and Egypt suffered heavy losses of weaponry relative to their Western-equipped adversary, Israel. In addition, Soviet demographic

Improving Weapon Capabilities: The Need for Advanced Materials

The increasing use of sophisticated new materials is supporting advances in the technical characteristics of weapons:

- *Titanium—heralded as the space-age metal because of its high strength-to-weight ratio, excellent ductility, and high heat and corrosion resistance—is used in aircraft, submarines, and missiles, with secondary uses in spacecraft, surface ships, armored vehicles, and body armor.*

- *Composite materials are widely applied in Western aerospace systems. Like titanium, composites—generally formed from a combination of resin and boron, graphite, or aramid fibers—are lighter, stronger, and more resistant to corrosion than conventional structures and are ideal for increasing the performance of aircraft.*

Manufacture of these materials requires clean production environments and relatively high production sophistication. Production machinery must therefore have increased tolerances, and manufacturers must use computers extensively.

Although the Soviets have experimented with these advanced materials since the early 1950s and used titanium successfully on the MIG-25 Foxbat in the mid-1960s, widespread application was delayed until the mid-to-late 1970s. Titanium is used widely in submarine production, and composites are used in the AN-124 transport, the MIG-29 Fulcrum, and several other aircraft in development.

trends confronted the defense leadership with a decreasing manpower pool from which to recruit the necessary personnel to operate and maintain an expanded arsenal.

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The USSR therefore pushed harder on the weapons modernization front in the 1970s. Overall, the system adapted fairly well to these new demands. *Development* times for some new advanced systems did not increase significantly:

- New-in-principle systems, incorporating advanced technology in a number of subsystems, have generally continued to take nine to 14 years.
- Modernized systems, incorporating advances in selected subsystems, have continued to take five to nine years.
- Other minor modernizations—where an improved component or subsystem is developed and incorporated in an existing weapon in production, or sometimes in the field—have still required less than five years.

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Nonetheless, the adjustment in design approach to emphasize increasing technological sophistication did begin to lengthen development times for some advanced new systems, particularly in the final stages when the weapon undergoes tests and series production facilities are readied. These instances appeared to increase in frequency through the 1970s, culminating in a number of unusually drawn-out programs for major systems:

- The MIG-31, MIG-29, and SU-27 interceptor aircraft, as a group, were in testing roughly two years longer than earlier, less advanced fighters.
- The T-80 and T-64B tanks were in testing about two years longer than the average for previous main battle tanks.
- The SS-NX-21 and SS-NX-24 cruise missiles probably will require about five years in testing compared with the four-year average for earlier cruise missiles.

Furthermore, the Soviets also began to face difficulties in moving advanced systems into *production,* as the weapons-driven requirements for advanced production technology were levied on a relatively antiquated production base. Traditional Soviet responses—applying more labor, materials, and general purpose equipment—could not compensate entirely for the lack of sophisticated production equipment.

Problems began to arise in the late 1960s (see inset). These difficulties persisted through the 1970s, as the Soviets sought to produce advanced systems in plants that we believe were not extensively modernized:

- The *SA-10*, which incorporates phase shifters, phase shifter controls, computers, and digital signal processors.

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many of these components—and the missile itself—could not be fabricated in large quantities with the labor-intensive approaches used for the earlier SA-2, SA-5, and SA-6. This probably has contributed to the slow deployment of the SA-10, a pace well below that of the SA-2 and SA-5 and well below our estimates of production capacity.

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- The *SA-12*, which uses similar advanced components.

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We estimate that series production will reach 36 batteries per year, one-half the peak deployment rate of the SA-4, which it will replace.[4]

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- The *MIG-31 Foxhound*, which is the USSR's first true lookdown/shootdown interceptor and uses a pulse-doppler radar, computers, and automated data links. These subsystems require high-tolerance components with reliable performance over a wide range of severe environmental conditions. The slow production rate of approximately two Foxhounds per month, we believe, is a result mainly of delays in manufacturing the radar and perhaps one or more other electronics-based subsystems.[5]

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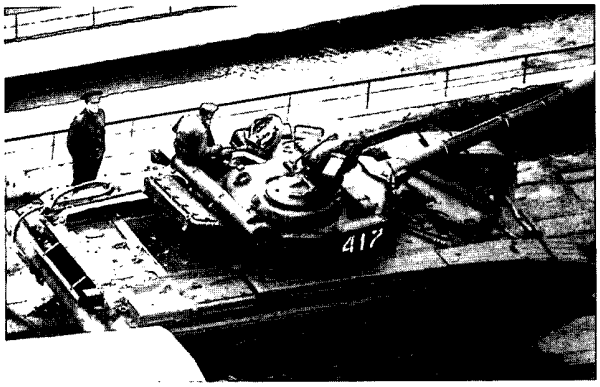
Reaching the Limits of Production Technology: The T-64 Tank



The T-64 medium battle tank, which entered serial production in the mid-1960s, was considerably more advanced than earlier Soviet tanks. It incorporated a radically different engine and power train, a Western suspension system, laminated armor, and an automatic ammunition loader.

The T-64 was plagued, however, by poor performance and unreliability—we believe in part because it was produced largely by an aging manufacturing base. in the mid-1960s production technology in the Soviet tank industry had not advanced beyond the level it attained at the close of World War II. Although the Soviets employed some advanced fabrication and welding techniques, major investment in plant and equipment for the T-64 startup was slow and often concurrent with production. Indeed, some facilities were pressed into production with little investment in equipment. Thus, the level of industrial sophistication was below that needed to properly produce the advanced components incorporated into the tank.

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In 1969, as problems with the new subsystems grew more pronounced, the Soviet leadership created a special committee to investigate and study the problems of the T-64. This committee was headed by the chief of Tank Troops, Marshal Babadzhanyan, and included military-technical and industrial experts. The work of the committee probably resulted in the improved production performance for the T-64A variant beginning in 1970. Its findings also may have contributed to the eventual decision to return to the proven V-12 engine for the T-72 and probably called for improvements in manufacturing technology.

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- The *SU-27*, which employs advanced engines and a substantially upgraded avionics package. After several redesign efforts, the Flanker entered production in 1983. By mid-1985, however, only 20 of 50 identified aircraft had engines, and nose radars have been missing from several of the new aircraft. These observations suggest problems in engine and radar development or outfitting.

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The problems exemplified in these weapon programs have typically centered on developing and producing reliable advanced subsystems called for by the designs—high bypass turbofan engines, phased-array radars, advanced sensors, sophisticated guidance and navigation systems, onboard computers for several functions, and a variety of complex parts made from advanced composites and other materials. Production of these subsystems required high-quality components—especially electronics—as well as advanced manufacturing know-how and equipment equivalent to that in use in US industry in the mid-1960s to early 1970s.

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Dmitriy Ustinov: Defense Industrialist of the Modern Age

Dmitriy Ustinov was the preeminent Soviet military industrialist.[a] After holding senior management positions in defense industry since 1937, Ustinov was considered in 1967 for the position of Defense Minister during the two-week period after the death of Defense Minister Malinovskiy, Politburo elements proposed Ustinov for the job three times. The military, however, was unyielding in its demands for the appointment of a professional, uniformed soldier, and the post was given to Marshal Grechko. In 1976, military elements reportedly again opposed the selection of Ustinov on largely the same grounds, but the top leadership—concerned about economic performance and enamored with Ustinov's expert managerial skills—quickly and decisively promoted him to the post.

Defense Industrial Modernization

We believe the Soviets were stretching the limits of existing production technology. Because of this, they embarked on an intensified and systematic modernization of their defense industry aimed primarily at ensuring that defense plants could produce new generations of weapons designed to meet the qualitative challenge of advanced Western weapon systems in the 1980s and 1990s. The modernization also offered the benefit of enhanced production efficiency. Weapon production facilities were expanded and—to a lesser extent—renovated with new, more sophisticated equipment, and the management and organization of defense industry were upgraded.

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Although we have no direct evidence of any sweeping Politburo decision, we believe the drive to modernize defense industries gathered momentum in the early 1970s. We base this judgment primarily on the rise in influence and eventual accession to power of a new cadre of Ministry of Defense leaders that advocated rationalization of weapon acquisition and industrial modernization and on evidence of intensive modernization efforts.

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New Defense Leadership

In April 1976, Dmitriy Ustinov was appointed Minister of Defense (see inset). We believe his appointment signaled that a consensus had been reached at the highest levels of the political leadership on the broad guidelines of weapon acquisition and defense-industrial modernization policies. In this connection,

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Ustinov was less inclined than Grechko to look at military demands—both for hardware and personnel—solely from a military perspective. His background as an economic manager and the policies he implemented indicate Ustinov believed general economic growth and modernization provided the bedrock of the USSR's defense potential. This position was consistent with his recognition that the military competition with the United States was increasingly a qualitative rather than a quantitative one, and that the USSR had to upgrade its military and industrial technology.

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Ustinov's elevation—effectively consolidating oversight of weapon acquisition policy and defense-industrial support—probably was meant in part to ensure the smoother implementation of these policies. Indeed, Ustinov had long pushed for improved efficiency and performance in the defense sector, and

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fragmentary evidence suggests that he and his views [6] were gaining influence: [7]

- In 1965, while under his control, the defense industrial ministries were among the first to adopt the new system of economic accountability, designed to encourage innovation and efficiency in production.
- In 1967 Ustinov apparently advocated the adoption of Western-style management techniques for the Ministry of Defense.
- In 1970 the Soviets reorganized their structure for military procurement, recreating the post of Deputy Minister of Defense for Armaments. The new deputy minister acquired many of the functions previously handled in a less coordinated fashion by the services. Ustinov, as party secretary for defense matters, probably actively participated in the decision to create this position.

- After he became defense minister in 1976, Ustinov oversaw the appointment of talented people whose concerns for military modernization and efficiency appeared to coincide with his own. In 1977, Nikolay Ogarkov was promoted to First Deputy Minister of Defense and Chief of the General Staff, and the following year Vitaliy Shabanov was brought over from the Radio Industry to become a deputy minister of defense, assuming the armaments portfolio (see inset)

[7] In 1968 the Ministry of Defense published a major work entitled *Military-Economic Problems in a Political Economy Course*, which maintained that the paths toward raising the effectiveness of the defense sector were the same as those for production in general: "the use of more productive equipment and technology, the use of less expensive supplies and energy, improved design, higher quality output, total mechanization and automation, improvements in organization of production, and improvements in the planning and management system." The book also indicated, however, that the defense industry must adapt more quickly to changing requirements than the civilian industry.

Vitaliy Shabanov: An Efficiency-Minded Armaments Chief [a]

From 1949 to 1974 Vitaliy Shabanov held various positions within the Radio Industry. In 1978 he was appointed Deputy Minister of Defense for Armaments. When he assumed this post, Shabanov—the only civilian to be appointed to this key position—brought with him firsthand knowledge of both advanced technologies and defense-industrial production processes. As evidenced by his military writings, his views on military-economic issues are similar to those of Ustinov. In a 1982 issue of Military Thought *he wrote:*

> *. . . the economic resources of our state are not unlimited, everything must be directed so that every ruble from spending on the provision for the country's means of defense is expended rationally, with maximal efficiency, and to the greatest advantage of the armed forces. . .*

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During most of his tenure as Minister of Defense, Ustinov probably retained direct control over the defense industries, and so was in a strong position to push through measures to improve efficiency in both sectors. Although Yakov Ryabov succeeded Ustinov in 1976 as party secretary for defense matters, after Ryabov was transferred to the State Planning Committee (Gosplan) in early 1979 Ustinov probably was assigned nominal responsibility for this area, which normally is not the responsibility of the Soviet Defense Minister. Thus, from 1979 until 1983, when Grigoriy Romanov became party secretary for defense matters, Ustinov was the only member of the political leadership to hold simultaneously the positions of Politburo member, government minister, and—at least on a de facto basis—party secretary.

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Modernizing Weapons Production

ties. Typically, the advent of new weapons at weapon assembly and composite facilities had meant the provision of tooling, jibs, and fixtures. The new programs appeared to be broader in scope and to be coordinated with efforts to upgrade a large array of support facilities.

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Spurt in Investment in the Defense Industries. The most comprehensive evidence of the increased attention to defense industries has recently appeared in open sources. Our calculations show a big jump in the level of investment in the defense-industrial ministries between the periods 1971-72 and 1976-80 (see table 3). Estimated average annual investment in the military machine-building ministries climbed by 3.5 billion rubles, or by 83 percent, between these two periods. The corresponding rise in investment in the civil machine-building ministries was only 1.5 billion rubles, or 45 percent.

Reflections of these investment trends at a more disaggregated level were observed in the tank and aircraft industries, areas where advancing weapons technology dictated substantial improvements in both existing and new production plant and equipment.

Table 3 *Billion 1984 rubles*
USSR: Estimated Average Annual Investment in the Machine-Building and Metalworking Sector, Selected Periods [a]

	1971-72	1976-80	1981-85
Civil ministries	3.3	4.8	6.1
Defense ministries [b]	4.2	7.7	8.4

[a] The estimates were obtainable only for the years indicated.
[b] The Soviets do not publish statistics on the defense industries. They do, however, report annual investment in the machine-building and metalworking (MBMW) sector, which encompasses the nine defense industrial ministries (shown in table 1) and which produces almost all the hardware procured by the Soviet military. These data, however, also represent investment in 11 other machine-building ministries that predominantly produce machinery and equipment for civilian use (such as machine tools, refrigerators, and cars). Through an analysis of published Soviet economic information we have been able to isolate the level of investment in the civil ministries for 1971-72, 1976-80, and 1981-85. Subtracting this estimated amount from the published data on total investment yields a residual level of investment. This residual is not simply investment in the nine defense machine-building ministries. It probably includes, for example, investment in machine-building enterprises belonging to non-machine-building ministries (transportation, construction, etc.) and excludes the investments that the defense machine-building ministries make in non-machine-building activities under their jurisdiction (everything from steel and aluminum plants to worker housing). Nevertheless, we believe that the defense machinery portion of the residual is dominant and that therefore movements in the residual can be taken to represent the changes in investment in the defense machine-building ministries.

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we have been able to document a major program for the aircraft industry beginning in the early 1970s. Many airframe plants were expanded and upgraded. New milling machines capable of machining materials such as lightweight, high-strength titanium were installed, as well as plant and equipment for manufacturing aircraft parts out of composite materials

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Direct evidence of modernization programs in the missile and shipbuilding industries is only fragmentary. Analyses of the new systems entering production in the late 1970s and early 1980s and their supporting production facilities, however, indicate these required at least a selective upgrading of manufacturing technology. For example, new aircraft, surface-to-air missiles, and submarines make more extensive use of high-strength materials like titanium and composites, which require special machining capabilities. New materials, complex shapes, and the miniaturization reflected in many advanced systems, such as strategic cruise missile guidance and propulsion systems, generally demanded more sophisticated equipment than was in place in Soviet industry in the early 1970s.

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- An increased emphasis on modernization—compounded by the supply bottlenecks characteristic of the late 1970s and early 1980s[8] and an intensified drive to gear up for the production of advanced systems—probably meant that a greater-than-usual number of Soviet defense-industrial facilities were producing at lower rates or not producing at all.

- The introduction and widespread application of new, more sophisticated, and more costly equipment sets, integrated production lines, and automated management systems for new weapons production very likely required longer periods of assimilation. Indeed, although the time required to build and equip plants for new weapons has varied greatly,

construction and tooling time has been longer than average for several recent advanced systems. For example, production preparation for the T-80 tank and the TU-160 and AN-124 aircraft—each manufactured in massive new facilities—required over two more years than preparation for comparable earlier systems.

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[8] These bottlenecks are discussed in the section "Shifting the Focus Toward Civil Industry."

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Rising weapons costs and a faltering economy probably also encouraged Moscow to hold down procurement growth and introduce more efficient new equipment. Despite ongoing efforts to introduce resource-saving technology, we estimate that the costs of Soviet weapons have continued to increase (see figure 2). Moscow, therefore, was preparing to execute a major costly and technologically more difficult phase of the military competition without overburdening a strained economy.

Upgrading Management. Ambitious production targets, combined with the frequently unreliable industrial supply system, have led Soviet enterprise managers—particularly defense industrialists—to try to become as self-reliant as possible. For example, in the early 1960s the Ministry of the Aviation Industry was reported to have plants for producing sheet aluminum, magnesium alloys, shaped metal, and plaster and rubber products. About 90 percent of all aviation production (airframes, air-breathing engines, instruments, and avionics) was concentrated in the ministry's enterprises. This high degree of self-sufficiency created unnecessary duplication of effort, problems in standardization, and production at inefficiently low rates

Defense-industrialists appear to be making greater efforts to pool their talents and avoid duplication of effort, although the evidence is too fragmentary to make a definitive judgment

To improve enterprise management, the USSR launched a major effort in the 1970s to establish automated management systems (ASUs) in both the civilian and defense sectors of the economy. ASUs are computerized systems used for the management of a variety of production and planning operations, including accounting analysis, organization, process control, and design. The automated process control system (ASUTP) may include direct numerically controlled machine tools, industrial robots, and flexible manufacturing systems. According to the Soviet press, by 1980 Soviet industry had established more than 4,400 ASUs, which included more than 1,600 ASUTP applications.

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this kind of automation has begun to pay dividends for the defense industry, at least on a limited basis. In 1985, General Secretary Gorbachev claimed that use of automated design systems in the aircraft industry made it possible to raise productivity to three times the previous level and to reduce the time taken in planning production by two and a half years.

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Modifying Building Designs. Although the concentration of many operations at a single plant typically has led to wasteful duplication in Soviet industry, bringing together final assembly and major fabrication subassembly operations in a single complex—if

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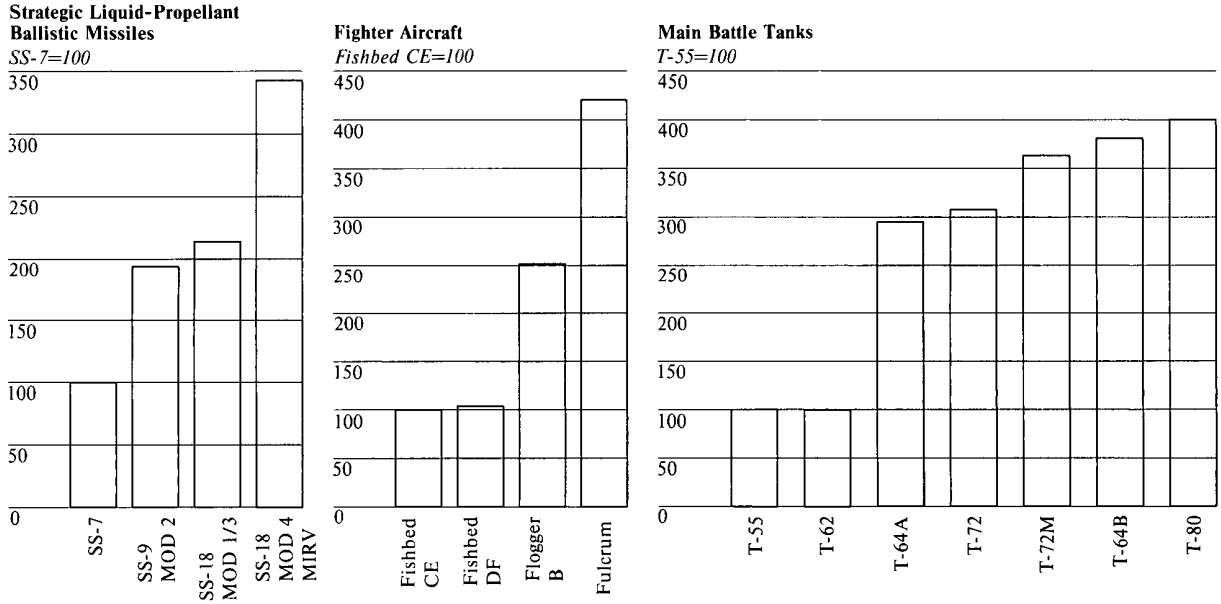
Figure 2
Note change of scale
USSR: Growth in Estimated Production Costs of Selected Soviet Weapon Systems[a]



[a] The indexes are calculated in constant 1982 rubles.

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organized around group technologies and flexible manufacturing processes—can help to increase efficiency in weapons production. To the extent the Soviets add or rebuild production lines with modern, integrated manufacturing processes, they will find it less necessary to continually expand or modify production facilities when they introduce a new weapon system or substantially modify an existing model. The resource savings could be substantial. According to a recent Soviet survey of 3,500 construction projects by the All-Union Bank of Financing Capital Investment, constructing new facilities is about 11 percent more expensive than expanding existing facilities and about 23 percent more expensive than renovating existing plants.

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beams whose added strength provides the more vibration-free environment required by precision equipment. They also provide the flexible workspace needed for modern manufacturing processes, allowing production lines to be rearranged, upgraded, or replaced periodically. For example, in such large buildings, all similar parts can be manufactured on one production line or in one area (group technology), while in another area a group of machines operating automatically from a central station can complete all machining operations on a single component moving from machine to machine (flexible manufacturing system). The buildings thus make possible integrated manufacturing operations not only in a single plant, but also in a single building.

Many new production facilities responsible for producing advanced weapons combine administration and engineering, small parts production, large component fabrication finishing, and final assembly. Examples include the Khar'kov and Omsk tank plants, producers of the T-64B and T-80 tanks; the Gor'kiy submarine yard, producer of the Charlie-class cruise missile submarine, the Tango- and Victor-II-class attack boats, and most recently the Sierra-class (titanium) and Kilo-class submarines; and the Ul'yanovsk aircraft plant still under construction (see inset). Some of the advanced components require highly specialized manufacturing facilities, and these are frequently being colocated with weapon assembly. For example, at least nine of the 22 airframe plants have added or are adding specialized facilities for producing nonmetal composite parts.

Upgrading Production Technology

Modernization of the weapon production base has required more and better production technology and equipment. For much of the necessary support, defense industry could look inward, since its ministries and plants produce many of the machine tools, robots, and computers and virtually all of the critical microelectronics and telecommunications components for advanced production equipment and systems.

We cannot precisely gauge the growth in key Soviet support industries or in total imports of Western technology attributable to the demands of defense-industrial expansion. Nevertheless, trends in the timing and pace of this upswing suggest that demands connected with modernization—which were especially strong in the late 1970s—played a role in increased imports. The party and government had already adopted (in May 1971) a resolution to increase the role of the KGB in the collection of the results of Western science and technology. The resolution stressed that a worldwide scientific and technical revolution was taking place and that, in the interests

The Ul'yanovsk Aircraft Plant: Advancing Production Capabilities on a Massive Scale

When faced with the challenge of producing the AN-124 aircraft, which from their perspective was significantly more complex than earlier models, the Soviets chose to erect a large and qualitatively different facility rather than retool or reequip an existing aircraft production plant.

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The plant will be extensively equipped with up-to-date manufacturing equipment and industrial processes, including computerized design, management, and information systems. According to Soviet statements, the complex is intended to be a "Western style" plant, incorporating the latest technologies for manufacturing wide-bodied planes. The Soviets have also said that the complex will not only manufacture airframes but also ultimately will produce the engines, avionics, and other components for aircraft produced at the plant. We believe the AN-124 Condor heavy military transport will be the first aircraft to be produced at Ul'yanovsk

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of national defense and the development of the national economy, it was necessary for the Soviet Government to obtain timely information on scientific and technological developments throughout the world. The KGB was authorized to focus on the military and industrial applications of these developments, and the collection program apparently gathered momentum in the aftermath of the Central Committee plenum in April 1973

Machine Tools and Robots. Sophisticated machine tools make possible advances in weapon design and increases in productivity—twin goals of the modernization program. In April 1968 a Politburo decree assigned responsibility for the development of advanced machine tools for the defense industry to the Ministry of the Aviation Industry. As shown in figure 4, nationwide production of both conventional and advanced machine tools grew steadily until 1977 when the Soviets cut back production of conventional machine tools to concentrate on expanding production of numerically controlled (NC) and computer numerically controlled (CNC) machine tools, automatic lines, robots, and manipulators.[1]

Soviet imports of machine tools from the West also climbed in the late 1970s (see figure 5). Although many conventional tools were imported, probably to compensate for the Soviet production cutback, many others were highly advanced. For example, since the late 1970s the Soviets have imported more machining centers from Japan than they have produced domestically. The Soviets also have entered into at least 36 scientific and technical agreements with West European companies for numerical control technology, and nine for flexible manufacturing systems.

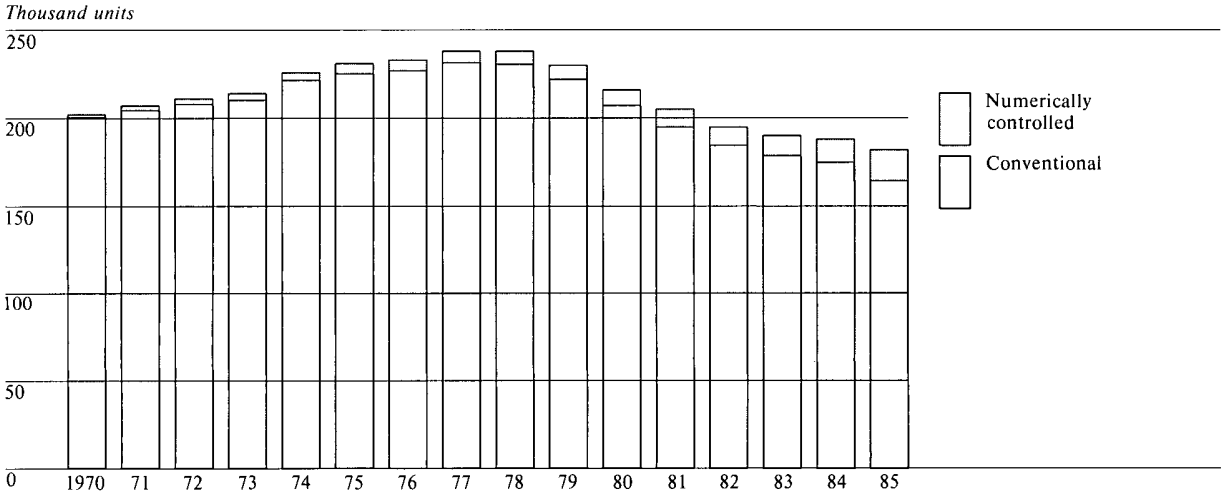
Although we cannot estimate the total number, many automated machine tools have been installed in the defense industry since the early 1970s, including NC machine tools, machining centers, automated welding systems, conveyers, precision casting equipment, and automatic robot-inclusive production lines. Extensive use of Western-origin equipment of this type has been documented in all defense industries.

Despite the assistance provided by the United States, Western Europe, and Japan, the technological level of Soviet computer-operated machine tools lags about three to four years behind Western models, and flexible manufacturing systems are five to six years behind. The USSR also lags the West considerably in both the production of advanced robots and their integration into computer-assisted manufacturing.

Microelectronics and Computers. Basic microelectronic devices, especially integrated circuits, are critical components in a wide variety of electronic systems for weapons and production equipment

[1] Conventional tools are general purpose metal-cutting equipment (lathes; drilling, boring, and milling machines; grinders; and sheet-metal-cutting machines) and metal-forming equipment (presses and forges). Advanced machine tools incorporate electronic controls and computers, enabling the machining of a part with a complex surface, the completion of successive machining operations on the same part, or the simultaneous machining of several workpieces with consistent accuracy and speed.

Figure 4
USSR: Production of Machine Tools, 1970-85



Sources: *Narodnoye khozyaystvo SSSR*, 1976, 1980; and *SSSR v tsifrakh*, 1985.

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Since 1975 the Soviets also have imported 2,500 pieces of major manufacturing equipment related to the microelectronics industry, most of it illegally, at a cost of about $400 million. Copying Western designs has sustained the industry: for example, the Soviets have developed at least 17 microprocessor families by copying US designs. Progress in Soviet domestic production, coupled with access to foreign technology, cut the West's lead in microelectronics from eight to 10 years in the mid-1970s to approximately four to six years in 1985.

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Soviet production of computers accelerated quickly beginning in the early 1970s (see figure 7). Although we are unable to identify production by model or specific application strenuous efforts were under way to apply computers in both design and manufacturing. Western technology has played a key role in Soviet computer development. In 1967 the Soviets adopted the architecture of the IBM System/360 computer for their standard mainframe computer, the Ryad, which became available in 1973. The second-generation Ryad—modeled after the IBM System/370—became available in the late 1970s. A parallel program produced the first minicomputers and microcomputers in the mid-1970s. In 1984, in an effort to promote greater computer literacy, Moscow started negotiations with several Western companies to build a turnkey plant for production of personal computers (PCs). To satisfy immediate requirements, the USSR, spurred by relatively relaxed COCOM trade controls on low-powered PCs, initiated negotiations with several Western and Japanese firms to buy PCs and related equipment.

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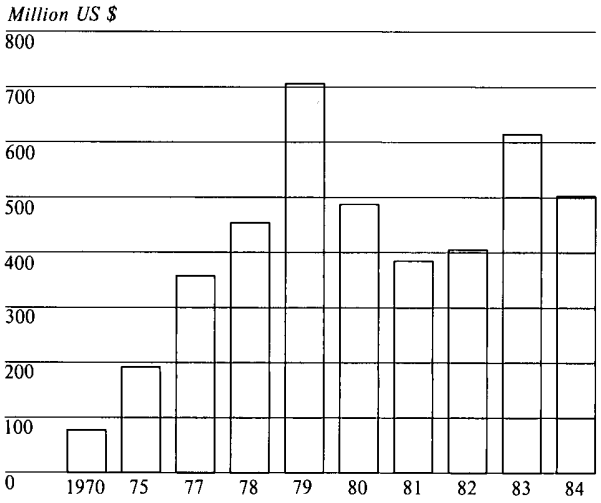
Figure 5
USSR: Imports of Machine Tools From the West, 1970-84 (Selected Years)



Note: These data represent the totals for metal-cutting and metal-forming machine tools and have been converted using average official exchange ratios for each year.

Sources: *Vneshnyaya torgovlya SSSR*, 1982-84

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The USSR, however, has been slow to apply computers to process control, stock control, machine tool control systems, and especially product design systems (computer-aided design, or CAD). According to analysis of open literature, only 8 percent of all Soviet industrial facilities had mainframe computers in 1984, including one-third of the facilities with over 500 employees. By comparison, nearly all US industrial facilities with more than 100 employees have computers. Shortages of sophisticated CAD manufacturing systems have contributed to the rising costs of the USSR's more advanced weapon systems and further stressed the taut supply of skilled manpower. In addition to equipment shortfalls, slow software development (especially for machining operations and computer-aided design) and severe shortages of programers and repair technicians have constrained applications.

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Although the USSR now has modern, unified computer systems, its progress in computer technology and production has been dwarfed by advances in the West and Japan. The Soviets lag the West by an estimated seven to eight years in mainframe technology and five to six years in the development of minicomputers and microcomputers.

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Shifting the Focus Toward Civil Industry

The campaign to modernize the defense industry was in full swing when the already slowing pace of the economy began to falter more dramatically. Believing

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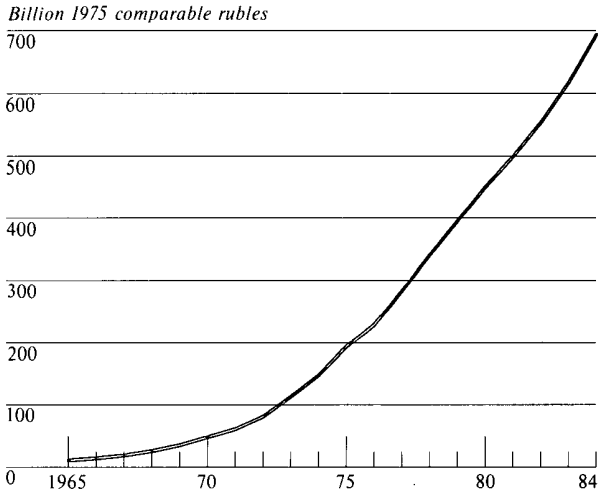
Figure 7
USSR: Production of Computers, 1965-84



Note: The values shown are based on 1975 "comparable" ruble prices, which allegedly represent the Soviet measure of industrial output in constant prices. However, because of the dubious pricing practices for new computer products – practices which lead to the adoption of prices higher than can be explained by improved productivity and/or technological enhancement – there is an unknown amount of inflation underlying the officially claimed comparable prices. As a result, the series depicted above overstates growth to some degree.

Sources: *Narodnoye khozyaystvo SSSR*, 1970-84

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better management (such as that practiced in the defense industries) and increased productivity (based in part on rising purchases of Western equipment) would offset slower growth in capital and labor, the Soviets planned and executed a marked slowdown of investment growth in 1976-80. But the upsurge in growth and productivity that the planners had envisioned never occurred as average annual growth of GNP fell to under 2 percent during the 10th Five-Year Plan (1976-80). In devising and implementing their growth strategy, the planners evidently did not deal adequately with three developing constraints that ultimately combined to slow industrial growth:

- A growing shortage of several key raw materials—iron ore, steel, lumber, and nonmetallic minerals.
- An increasing shortage of energy, plaguing the industrial sector.
- Rapidly developing bottlenecks in rail transportation.

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In addition, during the 1970s the planners had set a destructive process in motion in the investment sphere. Specifically, the concentration of investment on upgrading the production capacity of existing enterprises engaged more enterprises in the investment process, thus hampering the flow of production at least temporarily. In addition, the scramble among claimants for a share of the more limited investment allocations produced an investment mix that neither added proportionately to new capacity nor replaced much old technology with efficient new varieties.

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The leadership probably came to realize that the USSR would not recover its past economic dynamism without modernizing its civil economic base. At the same time, they probably also were greatly concerned about the drag that a technologically backward civilian industry was becoming for defense industry, which by the mid-1970s was supplied by at least 25 civil ministries producing materials, components, parts, and in some cases entire subsystems. As Gorbachev has said repeatedly, and as our investment calculations show (table 3), civilian machine building has been shortchanged in the allocation of investment, given the overall limits placed on investment and the competing demands of defense industry, agriculture, and energy.

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We believe that under General Secretary Brezhnev the Soviet leadership opted for measures that offered hope for improved performance at relatively little cost—sharing defense management expertise with the civilian sector, applying the military model for progress in science and technology, and orienting basic research and development organizations to

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applied research.[12] Shortly after assuming power in 1985, Gorbachev endorsed and extended each of these measures, but he also declared that a more basic restructuring of the economy would be necessary to restore vigor in the economy. His plans envision a large increment in investment and a substantial redirection of it—most notably in favor of civilian machine building.

This shift in focus toward civilian industrial modernization promises to both complement and compete with military modernization:

- *Complementarity:* catching up or even keeping up with Western military technology, as well as coping with defense costs, depends on raising the technological level and efficiency of civilian industry, especially the machine-building and metalworking sector.

- *Competition:* both the civil- and defense-industrial sectors must vie for investment, labor, and materials at the margin.

The Brezhnev Program: Modernizing on the Cheap

In their earlier efforts to modernize civil industry, Soviet leaders initially relied heavily on expanded imports of foreign industrial technology. They hoped that these imports would provide a relatively inexpensive shortcut to overcoming some of their most pressing industrial deficiencies. Although Western technology remains an important element in Moscow's drive to modernize its broad industrial base, emphasis shifted in the mid-to-late 1970s toward speeding domestic technological innovation. This reflected several developments:

- Soviet industry as a whole was making poor use of foreign manufacturing technology. Average lead-times for assimilating and diffusing imported technology are much longer in the USSR than in the West, almost always exceed the plan, and show no signs of diminishing.[13]

- Western technology has been a disincentive to pursuing new technological solutions. For example, Brezhnev at the 26th CPSU Congress complained that foreign purchases were causing industrial managers to relax their efforts to develop indigenous technologies.[14]

- Western controls on the export of key technologies to Communist countries were tightened in the early 1980s, making it more difficult and costly for the Soviets to acquire the quantity of technology used to modernize their industrial plant and increasing concern about becoming too dependent on Western suppliers.

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Meanwhile, Brezhnev stressed the need to make greater use of the experience in the defense sector to improve the civilian economy.[15] At the October 1980 Central Committee plenum he called upon the defense industry to make a greater contribution to the development of the national economy. He specifically directed military-production-related industrial organizations to help the civilian machine-building sector develop and apply critical new technologies, and he reiterated this call at the 26th CPSU Congress in February 1981.

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Although our evidence is sparse, we believe the Soviets acted on many of Brezhnev's initiatives.

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Defense resources and talent were transferred on a limited scale. For example,

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in late 1981 a major defense-related physics institute of the USSR Academy of Sciences was required to transfer 3 percent of its scientists to the

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[14] less than 5 percent of the technology developed in civilian institutes and industries was applied to commercial processes. Many processes developed by excellent civilian research were shelved because materials and instruments needed to convert the developments into manufacturing processes could not be obtained. Many civilian managers, therefore, preferred to purchase foreign products to avoid supply problems.

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[15] At the 24th CPSU Congress in 1971, Brezhnev declared that "considering the high scientific-technical level of defense industry, the transfer of its experience, inventions, and discoveries to all spheres of the economy acquires primary significance." Greater use of defense-industrial assets in the civilian economy, however, apparently did not become firm policy until late 1980.

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civilian sector to help raise productivity. Following Brezhnev's death in November 1982, top defense industry executives were reassigned to strategic posts in the civilian economy and central administrative organs. And, in 1984, all Soviet military and civilian hardware was to be given a uniform classification code designed to expedite the use of technologies and designs across ministerial jurisdictions.

More important, research programs were established in the 11th Five-Year Plan (1981-85) to develop technology, materials, and manufacturing processes that would support economic development and be useful in the design and production of sophisticated weapons. More than half of the programs dealt with technologies that have both civilian and military-industrial applications—composites, powder metallurgy, biotechnology, robotics, computers, microelectronics, fiber optics, industrial lasers, and anticorrosion protection. They were well funded and managed by powerful commissions functionally equivalent to the VPK. They appeared to be designed to draw military and civilian elements together in areas of mutual interest. Important military systems designers and defense-industrial managers were made commission members along with the Commander in Chief of the Strategic Rocket Forces, the Commander of the Moscow Air Defense District, and the Commander in Chief of the Baltic Fleet. Soviet military research and production facilities have been identified as participants (see inset).

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Meanwhile, the USSR—under Brezhnev's successors, Konstantin Chernenko and Yuriy Andropov—also took steps to reorient the Academy of Sciences to applied R&D and draw it into programs with dual military and civil benefits. Since September 1983,

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larger numbers of engineers have been brought into academy research institutes to help speed up the assimilation of technology into production. The academy also is admitting more applied researchers and industry-based engineers—particularly from the defense sector—as reflected in the 1984 elections of defense-industrial

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Major Research Programs With Both Civil and Defense Industry Applications

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Industrial Robots. *Several participants identified in the Soviet open press are known major research or development centers of defense-industrial ministries, including the associations Pozitron and LOMO (Ministry of the Defense Industry), Ritm (Ministry of the Shipbuilding Industry), and Svetlana (Ministry of the Electronics Industry).*

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Electronics and Computers. *The Soviet press reports that the Ministries of the Radio Industry and of the Electronics Industry are major participants in the dozen or so programs dealing with computer technology, microprocessors, and microelectronics*

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personnel to academy positions. The academy is participating more directly with the military in applied technology development programs and, with its participation in research programs, is being used to transfer technology from defense to the rest of the economy.

Perhaps the most significant shift affecting the defense industry during the 1981-85 plan period, however, took place in investment in the machine-building and metalworking sector. The plan for 1981-85 was never published, but statistics revealed during the past year show that investment in the civilian machine-building ministries in 1981-85 was 27 to 30 percent higher than in 1976-80. The implied corresponding growth in investment in the military machine-building ministries was only 9 percent—somewhat less than the growth planned for all investment in the 11th Five-Year Plan. The large increase posted in civilian machine building possibly reflected a leadership decision that modernization of the economy would require more than managerial and technical support from the defense industry or reforms in the scientific sector.

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The Gorbachev Agenda: Matching Rhetoric With Rubles

Since coming to power in March 1985, Gorbachev has made it clear that he wants to accelerate industrial modernization. Indeed, in a series of speeches and well-publicized appearances, Gorbachev reiterated many of the ideas advanced by Brezhnev, Andropov, and Chernenko, including the need to:

- Increase R&D efforts throughout science and industry and orient R&D work to address the needs of the economy.
- Accelerate the rate of replacement of outmoded plant and equipment.
- Appoint more technically competent managers and introduce planning and management techniques that place a premium on cost effectiveness.
- Reduce organization barriers to the application of scientific advances in industry.

Moreover, Gorbachev has strongly reiterated the earlier calls for civil industry to emulate the defense industries, citing defense management techniques.

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Unlike earlier leaders, however, Gorbachev has enunciated his ideas more vigorously and has made modernization the centerpiece of his domestic program. He has publicly called for:

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- Increasing the retirement of machinery in the machine-building sector from 2.2 percent in 1984 to 9.7 percent in 1990.

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- Increasing machine-building output by 43 percent between 1985 and 1990.
- Pushing capital investment in civilian machine building in 1986-90 to 1.8 times the 1981-85 level.

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The plan also calls for a tripling of the investment resources devoted to scientific programs to help promote rapid technological progress throughout industry.

In both Gorbachev's speeches and the 12th Five-Year Plan Directives, the emphasis is clearly on improving performance of the civilian machine-building sector. In mid-1986, he outlined the longstanding pattern of neglect:

> *Unjustified enthusiasm for the erection of new enterprises and neglect of the requirements of the existing ones became standard with the planning agencies and many ministries. The bulk of machinery and equipment went to the new facilities, whereas a timely replacement of the obsolete equipment in existing facilities and plants actually was not done. The process of asset renewal was too slow, and the age structure of the plant and equipment deteriorated.*

In the 1970s defense industry also was modernized mainly by the erection of new facilities rather than by renovation of old facilities, so a good deal of the plant and equipment in defense industry is also obsolete. Although the information available on the 1986-90 plan does not permit a calculation of the investment intended for the defense-industrial ministries, they probably are slated to receive substantially more than the 9-percent increase they were given in 1981-85 over 1976-80. But an analysis of investment targets suggests that the nine defense-industrial ministries will not receive nearly as much of an increase as the 80 percent slated for the civil ministries.

Gorbachev has insisted on a sustained increase in the quantity and quality of machine tools and tooling equipment; robots and flexible manufacturing systems; microelectronics and computers; automated management systems; and telecommunications. In addition, he has singled out the machine-building industries, which are likely to be the major beneficiaries of the increase in investment. The Ministry of the Machine Tool and Tool Building Industry—the primary manufacturer of machine tools and flexible machine systems—is to receive a 42-percent increase in investment in 1986 alone. The production of robots—primarily conducted in the Ministry of the Automotive Industry—is slated to increase at least 10 percent a year from 1986 to 1990. The major civilian producers of microelectronic components, computers, automated management systems, and telecommunications equipment have also been singled out for substantial growth and development. In addition, the Soviets have communicated through CEMA channels and high-level visits to East European countries that they look forward to increased industrial cooperation and larger quantities of high-quality machinery exports from Bloc countries. 25X1

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Implications and Outlook

During the last decade Soviet weapons industries made major strides toward improving their ability to produce advanced military hardware. The Soviets have largely overcome problems in producing a number of systems such as the T-80 tank, the MIG-29 and SU-27 interceptors, new transport aircraft, titanium submarines, and several new strategic and tactical missiles. In fact, according to our analysis, the Soviets currently have in place the requisite plant and equipment to produce more than 90 percent of the full array of military hardware we are currently projecting to be deployed through the end of the decade.

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The Soviets, however, need to make the experience of the modernization campaign routine. Gorbachev has acknowledged that industrial machinery and equipment must be replaced every eight to 12 years, and his plans for increasing the retirement rates in the machine-building sector imply an almost certainly unrealistic goal of recycling every 10 years. This cycle is typical of US defense industry, which also stresses the integration of new weapon systems with new production technology. In trying to move the USSR onto a similar path, Gorbachev must overcome resource and structural impediments, decide to what extent foreign technology will factor into his investment policy, and work hard to create the *peredyshka* (breathing space) he needs to implement fully his economic and investment strategy.

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Resource Allocations: Competition at the Margin

Despite somewhat improved economic performance since 1982, the USSR still confronts serious resource constraints. The ambitious civil-industrial modernization and consumer goods programs demand a major expansion of investment from an economy that is already stretched tight. Similarly, military requirements show no signs of abating. If the Soviets continue to seek qualitative improvements in weapon characteristics—as current development and production programs indicate—the costs of technological development or exploitation will continue to drive up weapons costs. The competition for resources between civil and military programs, therefore, will be intense.

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Although we have no clear indication that the weapons industries will suffer from this competition, Lev Zaykov, who is a full Politburo member and party secretary for defense industry and general economics, declared publicly in mid-1986 that the defense industry will step up its production of civilian goods and, more specifically, will devote resources to aid in the retooling of the light and food industries. Thus, we believe the Soviets will be hard pressed to increase military procurement outlays much beyond the high levels that have prevailed for the past decade and still meet Gorbachev's other goals. However, even maintaining procurement outlays at currently high levels would allow resources to be channeled to rebuilding civilian plant and equipment without sacrificing comprehensive force modernization. The greater the share of machinery devoted to nondefense purposes in the 1980s, the better the prospects that Gorbachev will succeed in improving the production capabilities of civil industry, which ultimately will benefit the defense sector.

We do not have any hard evidence on how military leaders and defense industry officials have greeted the civilian modernization program. In the mid-to-late 1970s, articles in the restricted military press suggested some disagreement over whether to reduce procurement in favor of increased allocations to military R&D and industrial modernization. This issue probably has not been resolved.

There are signs, however, that at least an important faction of the Soviet military realizes that long-term competition with the West demands development of Soviet high-technology support industries, including those in the civilian sector. For example, in October 1985 Soviet Major General Vasykov acknowledged in *Kommunist vooruzhenykh sil,* the journal of the main political directorate of the Soviet armed forces:

> *Today what is required for serial production of contemporary weapons and the newest combat equipment is not conventional or ordinary equipment but the most contemporary and frequently unique equipment, including fundamentally new instruments, computer-controlled machine tools, robot equipment, the latest generation computers, and flexible production systems. In other words, the present stage of the military-technical competition which has been imposed on us by imperialism requires a high level of development of those branches of industry with the best prospects, of the most contemporary technology, and a highly qualified work force.*

Moreover, Gorbachev reportedly has assured defense leaders that the military and defense industry will benefit from modernization advances.

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by late 1985 Gorbachev had committed himself to extensive modernization of military production facilities for aircraft, submarines, and other advanced items; had authorized major resources for the development of new, extremely powerful nonnuclear explosives, an area of strong military interest; and had approved other advanced research programs as well. In this way,

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Gorbachev has assuaged the military's fears that it would suffer from his efforts to revitalize the overall economy

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Gorbachev may be able to save resources by capitalizing on current developments in weapons production and deployment:

- More sophisticated and more capable weapon systems, such as the MIG-29 and the SU-27, probably will allow the Soviets to meet mission requirements with smaller numbers and possibly lower overall

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costs. 25X1

- The USSR and its Warsaw Pact allies are in the early stages of a program to improve the combat capabilities and extend the service lives of a number of their older weapons. For example, the T-54, T-55, T-62, T-64, and T-72 tanks are being upgraded with new fire control, ammunition, armor protection, and engines. We estimate that the cost of carrying out this program over the next 10 years will be only one-third of what it would cost to replace these tanks with the latest Soviet models. Soviet MIG-23 and MIG-25 fighters are also undergoing an extensive retrofit program that will add more capable avionics, radars, and self-defense systems.

- The number of types of weapons entering production is declining in those areas where technology advances afford greater mission flexibility (such as fighter aircraft and space launch vehicles) or where the Soviets have made substantial progress in satisfying mission requirements (such as ICBMs). Although much of the design and production resources freed as a result have been shifted to other military programs, the savings from future consolidation could be directed to civil usages. 25X1

If Gorbachev's investment strategy does not begin to pay major dividends in the 12th Five-Year Plan (1986-90), however, the Soviets will soon face some tough choices. They are already in the initial stages of identifying resource allocation priorities for the next five-year plan (1991-95), and key defense decisions probably will be made in the late 1980s. During this time period, the Soviets also will have to install machinery in the defense industry to support the production of new weapon systems in the 1990s. If Gorbachev's push to improve the performance of the machine-building sector and to increase imports from the Bloc fails to provide enough high-quality advanced tools and machinery for both defense and civil industry, the leadership almost certainly will be forced to either slow defense-industrial modernization or reduce the pace and scope of the civilian industrial program. Cutting back defense-industrial modernization probably would not have a significant effect on Soviet military capabilities until the mid-1990s, since the industrial capacity for producing most of the weapons scheduled for deployment through the early 1990s is already in place. Slowing civil-industrial modernization, however, would have a greater long-term impact because it would erode the defense industry's support base, which will be increasingly important to Soviet military competitiveness in the late 1990s and beyond. 25X1 25X1 25X1

Technology: Following the West

Importing Western (and Japanese) technology is one way of compensating for shortfalls in domestic R&D. The Soviets may have taken measures in the early 1980s to step up these acquisitions:

- called for an increase in the KGB's efforts to acquire technology abroad with more attention to obtaining hardware. 25X1

- the Soviets were putting pressure on the East European services to intensify their science and technology collection activities. 25X1 25X1

- In the 1981-85 plan Moscow reportedly allocated almost as much for "foreign technical assistance" as for total domestic R&D. 25X1

There are few indications so far of a major upsurge in the overall level of legal imports. Soft prices for the USSR's major export items—particularly energy—and obligations to client states suggest the Soviets will not have the reserves to sustain large increases in imports.[16] Also, there continues to be resistance in some quarters to importing Western technology because of the drag it is perceived to be on domestic innovation. For his part, Gorbachev has called for 25X1

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more "rational" concentration of imports on key projects. As in other aspects of his modernization program, Gorbachev apparently feels that much more can be obtained through improved use of indigenous resources.

Western export controls and enforcement policies—and trade policy generally—also argue for a more restrained import policy. Export controls have hit the Soviets especially hard in the high-technology areas of computers and microelectronics and in the use of this technology in advanced manufacturing applications that are crucial to the modernization program and the production of advanced weapons. The Soviets are concerned about their vulnerability to aggressive Western export controls and are trying to reduce it through greater technological self-reliance and expanded technological cooperation with Eastern Europe

On balance, we believe the Soviets will continue to rely on their strategy of selective reliance on technology from the West. Although the Soviets are clearly making greater use of technology developed in the East European countries—some of which is more advanced than that available in the USSR—this technology still lags well behind the Western state of the art in most key areas. Moreover, the East Europeans almost certainly cannot sufficiently increase exports of machinery and equipment to meet growing Soviet requirements over the next decade. It is likely, therefore, that Soviet reliance on Western innovations will increase in areas critical to modernization of both the civilian and defense industries—microelectronics, computers and software, telecommunications, robotics, and CNC machine tools (see inset). On the military side, taking into account Western programs such as precision-guided tactical weapons and the Strategic Defense Initiative (SDI) along with advances in such key areas as electro-optics, fire control, guidance and navigation, and signal processing, the Soviet covert acquisition program almost certainly will be at least as aggressive as it has been since the late 1970s.

Microelectronics: The Problem of Catching Up With a Moving Target

Because the Soviets will probably continue to depend on Western technical advances in the volume production of semiconductors, they are likely to remain at least three years behind in semiconductor technology and production capabilities. The USSR, however, could lose substantial ground if the US Department of Defense's VHSIC (very-high-speed integrated circuit) program is successful in creating VLSI (very-large-scale integrated) devices with improved military applications. VHSIC devices are intended to provide greatly increased capabilities in military applications. The USSR will have difficulty manufacturing more advanced VLSI or VHSIC devices unless it makes significant advances in production and clean-room technologies, material purity, and overall quality control. The Soviets have not yet demonstrated an independent ability to develop advanced production equipment for monolithic integrated circuit devices; thus they probably will become even more dependent on Western equipment to produce increasingly sophisticated devices.

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Structural Impediments

The impact of new domestic and foreign technology, however, depends on how well Soviet industry capitalizes on it. Systemic obstacles—including a cumbersome planning process, prices that do not adequately reward improved quality, and poor producer-consumer ties—have impeded the assimilation of technology. The defense industry is plagued by these same systemic problems, albeit to a lesser degree than the rest of Soviet industry. For example, although there is close cooperation between Soviet weapon design bureaus and producers, maunfacturing research and engineering usually are separated from production facilities, which creates a strong barrier to improving manufacturing processes.

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Gorbachev and the central leadership that he has assembled have shown that they recognize the systemic brakes on faster technological progress, but so far we have seen no signs that they have worked out a consistent set of policies to deal with them. The new Soviet leaders thus far have been unwilling or unable to make fundamental planning and management changes in either the defense or civilian industrial sectors. Moscow still places its highest priority on maintaining tight centralized control over all facets of the economy while continuing its efforts to carry out industrial modernization by the usual methods of political intervention and party control. The approach remains primarily "innovation by order." [18] This approach has inherent limitations: priorities cannot be extended too far without diluting their effectiveness, and high-level political intervention is similarly constrained.

Soviet history is replete with examples where special management techniques, abundant resources, and strong political backing were unable to prevail in a system generally inhospitable to innovation. Most, if not all, of the industries Gorbachev has targeted for priority attention are likely to prove equally resistant to political solutions. This, along with resource constraints, continuing dependence on Western technology, and accelerating Western advances, suggests that the Soviet lag behind Western production technology will not diminish appreciably over the next decade.

Playing for Time

Time may be one of the greatest constraints on Gorbachev's room for maneuvering. He needs time for his investment strategy to achieve enough progress in key high-technology industries to prepare the defense industry as a whole for the military competition from now to the 21st century. Whether he gets the time he needs could depend to a large extent on the overall East-West relationship, and particularly on the military competition with the United States. The Soviets may see themselves under considerable military pressure from Washington. Gorbachev, therefore, must reconcile a long-term industrial modernization program with an accelerating military-technological competition.

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His strategy seems directed in part at engineering the requisite breathing space. Domestically, he apparently has convinced the General Staff that his modernization program—given time—will help the defense industries. In foreign policy, his recent arms control initiatives, summit diplomacy, and efforts to mend fences with Western Europe, Japan, and China are reminiscent of Soviet foreign policy leading up to the detente period of the early-to-mid-1970s. East-West detente, even on a modest scale, could buy Gorbachev the time he needs. And he clearly is acting, in our view, with an appreciation that an arms control agreement could—especially in tandem with mounting US budgetary pressures—dramatically slow US military expansion. Detente would also make it easier for the Soviets to acquire the types and quantities of technology needed for the modernization program, probably on favorable credit terms.

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The implications for Soviet defense industry of shortfalls on either or both fronts vary from scenario to scenario:

- *Diplomatic failure/domestic success.* A failure to ease the pressure of Western military competition could be mitigated by a rebound in the domestic economy. Under such circumstances, more investment funds probably would be available for increased defense-industrial modernization and increased procurement. In addition, a modernized civil-industrial base could more effectively support the growing technological needs of the defense sector, although the Soviets probably would not be able to match the West in weapons sophistication.

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- *Diplomatic success/domestic failure.* If Gorbachev is able to affect Western military programs—either through direct agreement or unilateral US cutbacks in defense—but economic modernization fails, the outlook for the defense industry is mixed. Although

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the Soviets almost certainly will be able to field enough weapons to maintain parity, defense industry probably would be hard pressed to close the technological gap. The notable exception would be if the West relaxes its export controls on sophisticated machine tools and computers.

- *Diplomatic failure/domestic failure.* If Gorbachev's overtures to the West are unsuccessful, and if his modernization program fails, the impact on the defense industry would be more severe. Weapons plants would be called upon to both increase production and produce more advanced systems. Pressure to produce would be a disincentive for the defense industry to emphasize modernization. Defense industry probably would be further hindered by having to rely on lagging support industries for advanced technology and equipment. Soviet reliance on Western technology would continue under this scenario, and the Soviet technological lag probably would increase.

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The overall impact of any scenario, however, probably would be softened by several factors that have helped, and probably will continue to help, the Soviets to compensate for their overall technological inferiority to the West. First, there is no one-to-one correlation between a technological advance in production and an improvement in military capabilities. There is always a lag—often of considerable duration—between the attainment of a technological advance and its incorporation into a new weapon system. The Soviets have often succeeded in translating technological achievements into weapon systems more rapidly than the West. Thus, the technological level of deployed Soviet and Western systems is more comparable than is the general level of technology. Second, we expect the Soviets to continue to be able to surge ahead along a narrow front of military technologies—such as the exploitation of titanium—because they have chosen to place more emphasis on these areas than the West. Finally, strategy, tactics, and the number of weapons still count for a great deal in determining combat effectiveness.

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In sum, we believe Moscow has reevaluated and modified its traditional approach to weapons acquisition. The USSR probably will continue to produce and deploy comparatively larger numbers of weapons in areas where this approach to meeting mission requirements is mandated by technical shortcomings or is more cost effective. The Soviets, nevertheless, are placing greater emphasis on the development and manufacture of complex systems that require upgraded industrial technology. Their ability to meet future military requirements will require that a rapid pace of modernization be sustained to realize the dual benefits of cost savings and weapons improvement.

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