[redacted]

23469

Directorate of Intelligence

Secret

CIA|SOV----|88-10062-----

USSR: Organizational Measures Fail To Spur Technological Progress

A Research Paper

Secret

SOV 88-10062
August 1988
Copy

[redacted]

Warning Notice	**Intelligence Sources or Methods Involved (WNINTEL)**
National Security Information	**Unauthorized Disclosure Subject to Criminal Sanctions**

Dissemination Control Abbreviations	NOFORN (NF)	Not releasable to foreign nationals
	NOCONTRACT (NC)	Not releasable to contractors or contractor/co
	PROPIN (PR)	Caution---proprietary information involved
	ORCON (OC)	Dissemination and extraction of information controlled by originator
	REL...	This information has been authorized for rele:
	WN	WNINTEL-- Intelligence sources or method:

A microfiche copy of this document is available from OIR/DLB (482-7177); printed copies from CPAS/IMC (482-5203); or AIM request to userid CPASIMC). Regular receipt of DI reports can be arranged through CPAS/IMC.

Classified by: ...
Declassify: OADR
Derived from multiple sources

All material on this page is Unclassified.

Directorate of
Intelligence

USSR: Organizational Measures Fail To Spur Technological Progress

A Research Paper

This paper was prepared by
Office of Soviet Analysis, with contributions from
, SOVA, and
Office of Scientific and Weapons Research.

Comments and queries are welcome and may be
directed to the Chief,
SOVA

Reverse Blank

USSR: Organizational Measures Fail To Spur Technological Progress

Scope Note

This paper assesses the performance of interbranch scientific and technical complexes (MNTKs) in spurring and expediting the development and introduction of critical technologies in the Soviet Union. It describes briefly their organizational framework, how they operate, and what they are to achieve. The paper does not discuss the actual status of targeted technologies or specific prospects for their development. Such subjects are treated in the following DI papers: [redacted]; Intelligence Assessment SW 86-10062 (Secret NF), December 1986, *Soviet Microelectronics: Impact of Western Technology Acquisitions*; [redacted]

USSR: Organizational Measures Fail To Spur Technological Progress

Summary

Information available as of 1 July 1988 was used in this report.

In December 1985 the Politburo mandated the creation of a new organizational mechanism, the interbranch scientific and technical complex (MNTK), to spearhead the development of critical technologies for the industrial modernization program. Each complex was to link, under the overarching authority of a lead scientific institute, facilities that span the entire product development spectrum. The MNTKs were designed to bridge the gap between science and production to ensure that no new scientific discovery would fall through the bureaucratic cracks—a phenomenon that traditionally has impeded innovation within the Soviet Union. Similarly, the regime expected that the complexes—by exercising considerable authority over the production ministries—would both speed the development of new technologies and foster broader diffusion of new production processes.

The regime's strategy for accelerating product development is a conservative, top-down approach based on time-honed methods used to advance weapon technologies. The strategy has three elements: high-level party support; strong, centralized planning; and priority access to resources.

Disappointing Results

The complexes, now numbering over 20, are performing dismally. In general, they have not been successful either in increasing the volume and quality of new products or in shortening the research and development (R&D) process. In particular, the complexes have not met their time schedules for the development of new products and processes, and the regime has reproached them for spending too much time just getting organized. In fact, many of the MNTKs have not developed *any* new prototypes, and the leadership has complained that some of the complexes "exist on paper only" or are only in "embryonic form." Similarly, the results that they have been able to produce have not met the regime's quality standards

Placing the Blame: What's Wrong?

The MNTKs have encountered significant obstacles and resistance. Their efforts have been hampered most by their inability to obtain preferential status for resources. The MNTKs' inability to claim priority status points to a flaw in the strategy itself. The breadth and scope of the MNTK activities, especially when coupled with efforts outside the complexes to develop new technologies, are probably stretching resources too thin and generating competing claims for resources.

Much of the fingerpointing has been directed at the industrial ministries that were to participate in the complexes. The party and the MNTK heads have repeatedly complained that the ministries have either dragged their feet or refused to cooperate altogether.

Although the regime has patterned the MNTK after the model used by the defense industries for development and production, it did not duplicate the role of the defense customer—the Ministry of Defense. The military's precisely defined needs and demands for advanced technology to counter Western threats, coupled with its rigid quality control measures, has fostered technological advance within the defense industries. The MNTKs are also attempting to develop sophisticated technologies, but they have only limited ties to potential consumers. As a result, even when able to develop new prototypes, MNTKs usually are not able to find customers for their products and, therefore, are unable to convince series production plants to produce the new products

The dismal results of the MNTKs are largely due to the regime's focus on attacking the bureaucratic—rather than systemic—barriers to innovation. Although the MNTK heads have pointed to systemic barriers—the lack of incentives for enterprises to produce new technology and the aversion of producers to the risk associated with new products—as primary obstacles, the leadership, thus far, has done little to overcome these barriers. The regime probably thought that, by adopting the methods used by the defense industries to develop technologies, it could duplicate the latter's success without drastically disrupting the system

Looking for Help

The regime is tapping the defense industries to support the MNTKs. Most of the technologies targeted by the MNTKs have civil and military applications, and many of the complexes include organizations that are either directly subordinate to the defense industrial ministries or conduct R&D for them under contract. Further, many of the technologies targeted for attention by the complexes have been most fully developed within the defense industries. Moscow probably intended the MNTKs to serve as conduits for technology transfer between the two sectors, and the inclusion of defense industrial organizations within the MNTKs was probably designed to encourage broad diffusion of the MNTKs' achievements.

Reactions to the regime's solicitations for increased support have been mixed. A recent call by a defense industrial deputy minister to form an MNTK on composites indicates that at least some in the defense sector support the MNTK concept as a way to accelerate developments of special interest to defense. On the other hand, the head of the Personal Computers MNTK complained that ministries responsible for producing the computers—of which three are defense industrial—were resisting because they viewed the MNTKs as a "temporary campaign."

Since mid-1987 the regime has also turned increasingly toward the West to gain assistance for the MNTKs through cooperation agreements with foreign governments and businesses, joint ventures, and instrument purchases. We believe that the original MNTK blueprint had only a very narrow role for the West, with the primary emphasis on the USSR's indigenous R&D capabilities and an avoidance of dependence on Western assistance. Nonetheless, the Soviets have shown an eagerness to broaden Western contacts, especially as a way to overcome the barriers to R&D resulting from a deficient experimental test base. We believe their efforts to enlist Western assistance will intensify over the next year as the complexes become more desperate to meet 12th Five-Year Plan (1986-90) goals

Prospects

In the near term, the performance of the MNTKs is likely to fall far short of the objectives set for them. The impediments to progress are major and will not be easily or quickly overcome. Shortages of trained personnel,

deficient experimental test bases, bureaucratic resistance, and systemic deficiencies will weaken the impact of the MNTKs throughout the remainder of the present plan period.

Over the long haul, the MNTKs' ability to serve as a mechanism to advance key technologies rapidly will hinge on the regime's ability to resolve bureaucratic resistance, command priority status for the MNTKs, and refine the strategy to address the problems caused by the "absent customer." While Gorbachev has demonstrated his determination to address bureaucratic resistance, he has not succeeded in overcoming it. His prospects for success in other areas are similarly limited. MNTKs, however, may provide important benefits to the defense sector, which is likely to continue to claim a high priority on S&T resources and which has a powerful and knowledgeable customer in the military. The MNTKs may be particularly useful in transferring Western technology to the defense sector

Even in the unlikely event that these barriers are overcome and the MNTKs are ultimately able to operate as designed, we do not believe that they will be competitive with Western S&T in spurring broad-based technological advancement throughout the economy. The MNTKs' top-down, command approach to innovation relies on targeting specific areas for forced development, thus limiting spontaneity and flexibility. This approach orients the Soviet Union toward a "follower" or "catchup" role.

Beyond the MNTK

The Soviet leadership is becoming increasingly aware of the flaws in the MNTK strategy and is rethinking the role and structure of these organizations. It has begun to question whether the MNTK mechanism is appropriate as a catalyst for technological progress and whether it should be continued. Reforms now being considered could eventually result in a shift away from the MNTKs. Moscow is taking its first faltering steps to address the systemic features of Soviet R&D. Recent legislation aims at creating conditions and incentives for greater "technology pull" from below and expanding the autonomy of research and production collectives

Over the next few years the regime is likely to pursue both approaches—attempting to integrate centralized with decentralized methods. However, some of the new, decentralizing measures now being introduced—such as self-financing and increased competition between R&D organizations—are incompatible with the centralized strategy embodied in the MNTKs. Thus, although a shift toward a greater reliance on decentralized decisions on new products and processes is probably correct over the long term, in the short and medium term it creates the potential for conflict and disruption in Soviet technological development and could ultimately cause the leadership to abandon the MNTKs.

Contents

USSR: Organizational Measures Fail To Spur Technological Progress

Introduction

Gorbachev is holding the scientific community responsible for the rapid introduction of new production technologies into industry. In a December 1985 decree, the Politburo and Council of Ministers unveiled the organizational mechanism that is intended to play the pivotal role in this technology development effort: the interbranch scientific and technical (S&T) complex (MNTK). The complexes are designed to overcome what has traditionally been a major weakness within the Soviet S&T and industrial sectors: the disconnect between science and production. Each MNTK is to link, under the overarching authority of a lead institute, facilities that span the entire product development spectrum: from basic research to at least prototype production and—in some cases—series production

Table 1
Goals for Increased Use of Advanced Technology in the 12th Five-Year Plan

Percent

	1988	1986-90 [a]
Robots	NA	190
Industrial lasers	20	150-210
Powder metallurgy	20	NA
Composites	20	1,000-1,200
Membrane	20	150-200
Rotary automated lines	110 [b]	6,300 [c]
Personal computers	140 [b]	1.1 million [c]

[a] The 12th Five-Year Plan calls for the use of these technologies to expand by the totals indicated.
[b] The goals for rotary automated lines and personal computers refer to increases in production rather than increased use.
[c] The goal for rotary automated lines and personal computers represents the planned production in units.

What the Regime Expects To Achieve Through the MNTKs

It has become a matter of urgency to create organizational forms of integrating science, technology, and production, which will make it possible to ensure that scientific ideas are followed up precisely and promptly from their beginning right through to their extensive practical application. We are convinced that interbranch scientific and technical complexes must become one of these forms.

Lev Nikolayevich Zaykov,
Party Secretary and Politburo Member
March 1987

The Soviet leadership understands clearly that the key to long-lasting improvement of the country's economic situation is the continuous, rapid introduction of advanced production processes to produce high-quality goods using successive generations of increasingly productive machinery and equipment. The Gorbachev regime expects MNTKs to develop specific technologies critical for modernization and to shorten the time required to move from the laboratory to the shop floor. The regime also expects MNTKs to improve the efficiency of the research and development (R&D) process—that is, to ensure greater return from R&D spending. Finally, the MNTKs are intended to tap the defense-industrial sector for technology needed for civilian modernization and to create a reverse technology flow back into the defense sector

The regime has targeted for priority development the same advanced, high-technology areas that are critical to Western modernization—automation, computers, new materials, bioengineering, and energy. By 1991 the use of key technologies is to expand by "150 to 200" percent over that of 1986. The complexes are to ensure that the new technologies are developed and meet the regime's specifications for numbers of new products and standards of quality (see table 1). According to Soviet public statements, there are now 23 MNTKs focused on the targeted technologies listed in table 2

Secret

Table 2
MNTKs and Their Targeted Technologies [a]

	Automation	Computers	New Materials	Bioengineering	Energy
MNTK					
Welding	S [b]		P		
Rotor	P				
Personal Computers	S	P			
Fiber Optics	P				
Industrial Lasers	P	S	S		
Machine Reliability	P		S		
Biogen				P	
Catalysis				S	P
Robot	P	S	S		
Membranes			S	P	S
Oil Extraction					P
Metallurgy Machinery	S		P		
Powder Metallurgy			P		
Mechanical Processing			P		
Thermal Synthesis			P		
Anticorrosion			P		
Geological Prospecting					P
Textile	P		S		
"Radiotekhnomash"	P				
Energy Conservation					P
Other technologies:					
Eye Microsurgery					
Scientific Instruments					

[a] 22 MNTKs have been identified.
[b] P is principal focus.
S is secondary focus.

Note: MNTKs have been proposed, but formation has never been confirmed, in the following areas: composites, radiation hardening, micro-optics, computer-aided automation, and pulsed machinery.

Accelerate and Improve Returns From Investments in Science

The Soviet R&D base, although mammoth in size, is grossly inefficient (see inset); [ ]the rate of return on R&D has actually diminished since the late 1970s. One of the principal causes driving down the return on the regime's R&D expenditures is that very few scientific achievements are translated into actual applications or introduced into production. Many of the innovations developed by an institute are not picked up by design bureaus for use in new prototypes and are left to languish within an institute until obsolete and forgotten, or until discovered in the West and later reimported into the Soviet Union. According to official statistics, only one-third of Soviet inventions and discoveries are introduced into production, and only 15 percent of inventions are introduced into more than two enterprises. An even more dismal appraisal was given in a March 1987 *Izvestiya* article. According to an official from the State Committee for Inventions and Discoveries, only 10 percent of inventions ever find practical use, and only 3 percent of all inventions are introduced at more than one enterprise.

Similarly, Soviets writing in the open press complain that the country cannot expect to be competitive with the West as long as it takes seven to 15 years to transform an idea into a usable and marketable product. The regime has called for a "drastic" reduction in the duration of the process—in one instance, specifying 3.5 to five years as a goal. (Competition to trim the product development cycle is currently intense in the West. For example, the automotive industry is seeking to pare the process to 3.5 years, while [ ]is seeking to slash its four-year cycle for [ ]equipment by 50 percent.)

The regime expects that the MNTKs will be able to overcome the bureaucratic obstacles as well as appreciably improve communications within the R&D process. The MNTKs are to speed and improve technology development and problem resolution by bringing scientists and designers under one roof. Closer and improved communications should result because each

Bureaucratic Boundaries to Innovation

Yevgeniy Velikhov, Academy of Sciences Vice President and scientific adviser to General Secretary Gorbachev, has pointed out that: "The branch scientific institute became a barrier to the spread of certain scientific ideas that appeared in the Academy and the higher and specialized educational institutions."

In the Soviet Union, the different major stages of R&D—basic and applied research, prototype design, and testing—tend to be performed by different organizations with widely varying subordination. Soviet R&D facilities come under three broad organizational categories: the industrial ministries (referred to as sectorial or branch science), Ministry of Higher and Secondary Specialized Education (Vuzy), and the academies of sciences. Communications run primarily along vertical lines, with the individual actors reporting directly to central, superior administrative offices within the parent ministries in Moscow. The bureaucratic boundaries have acted as barriers that limit the development of new technologies and processes.

While the bureaucratic boundaries have created gaps within the scientific sector, they are also responsible for the gulf that separates this sector from production. The two sectors report to different superior organs—even within the same ministry. They also operate under different regulations and procedures for planning, financing, and incentives. What is an incentive to one sector can be a disincentive to the other. For example, plan fulfillment at a research institute has been based on project completion, not whether the results are suitable for introduction at the production enterprise. Consequently, new prototypes leaving the institute are frequently inadequately tested or have design flaws that prevent their series production.

MNTK will be able to link the various actors, permit at least some simultaneous research activity, and reduce the time required to develop the extensive documentation.

The MNTKs are expected to sharply increase the return on investment in science. Although to our knowledge no specific goal has been set for the MNTKs, the regime has cited the excellent returns achieved by the Paton Electro-Welding Institute and the Problems of Material Science Institute. Because each complex is to link the numerous participants within the R&D process, the MNTK is intended to ensure that no new scientific discovery is allowed to fall through the bureaucratic cracks. Similarly, the regime expects that the complexes, exercising their linkages and authority with the relevant ministries, will achieve broader and more thorough diffusion of new products and processes.

Facilitate Interaction With the Defense Industrial Sector

Most of the technologies targeted by the MNTKs have applications in both the defense and civilian industrial sectors, and we believe that the MNTKs are to serve as conduits for technology transfer between the two sectors. Although the regime has not explicitly cited such a role, the organizational network of many of the complexes shows substantial ties to the defense sector. Further, many of the technologies targeted for attention by the complexes—such as personal computers, robots, fiber optics, and testing equipment—have been most fully developed within the defense industries. For example:

- The lead organization of the Rotor MNTK is subordinate to the Ministry of Defense Industry.
- The MNTKs for Personal Computers, Robots, Industrial Lasers, Fiber Optics, and Machine Reliability incorporate research or production facilities that are subordinate to the defense industrial ministries.
- At least half of the MNTKs—although subordinate to civilian ministries or the Academy of Sciences—include research institutes in which a sizable share of research is conducted under military contracts.

Moreover, although the Soviets have announced that over 500 organizations are working within the MNTKs, they have identified fewer than 100 facilities. We assume that many of the 400 unidentified organizations are tied to the defense sector.

The MNTK Strategy

The MNTK mechanism is a typical Soviet top-down strategy. In fact, it uses the approach prevailing in the defense sector, which features three elements:

- High-level party support to overcome bureaucratic resistance.
- Strong, centralized planning and oversight to establish and meet goals on time.
- Preferential status and priority access to resources to avoid disruptions.

Borrowing From the Defense Industry

This strategy—which pushes technology from above—borrows heavily from the approach used within the defense sector to develop critical technologies for weapon programs. It emphasizes reliance on the USSR's indigenous R&D capabilities and an avoidance of dependence on Western assistance or inputs. Indeed, according to statements made by the leadership, the intent is to have the MNTKs apply, within the civilian R&D sector, those tactics that have been relatively successful for the military. In his June 1985 speech dedicated to S&T issues, Gorbachev outlined his plan for the formation of new organizations—units that eventually became the MNTKs—that would be responsible for developing critical technologies by emulating the methods used in R&D and carried out under the auspices of the defense industries. Gorbachev reemphasized, while visiting the Baykonur Space Center in May 1987 and praising Soviet achievements in space and rocket development, his expectations that the country's R&D community could duplicate these same successes without going "cap in hand abroad." Similarly, Academy Vice President Konstantin Frolov emphasized in a Soviet publication that the idea of the complexes and their formation was based on the experiences of the military-controlled space and nuclear programs. The regime probably believes that the successes achieved in these programs can be duplicated by the MNTKs by transplanting the management processes and tactics used in military R&D.

Earlier efforts to transfer defense-sector practices to the civilian side have not proved to be successful, however. During the late 1960s and early 1970s, scientific production associations (NPOs) were formed and employed many of the same measures. The NPOs, like the MNTKs, were an organizational mechanism designed to link the key actors in the R&D and production process. The NPOs did not provide the anticipated results—the accelerated development of new technologies—although about 500 of them were still in existence in 1987. Generally, the NPOs were defeated by many of the obstacles now confronting the MNTKs—supply problems, a deficient experimental base, and fragmented authority. Moreover, the NPOs suffered from an identity crisis. While on the one hand they were tasked with rapidly developing new technologies, on the other hand the parent ministries and enterprises looked to the NPOs for support in meeting current production quotas. Many of the NPOs eventually became prisoner to narrower, parochial interests at the enterprises, to the neglect of scientific research and technology development

Gorbachev's science planners most certainly analyzed the experience of the NPOs to find ways of avoiding the problems they encountered. From Moscow's perspective, the strategy of an overarching authority was itself sound, but the organizational implementation was too narrow. NPOs rarely—if ever—crossed ministerial boundaries. The steps that the leadership took to refine the strategy focused primarily on organizational adjustments. The scope was broadened to link—regardless of ministerial subordination—facilities to the capabilities necessary for the development of a specific, interdisciplinary technology. In contrast to the NPOs, the MNTKs include basic research institutes under the Academy of Sciences and facilities drawn from numerous ministries. Similarly, the MNTKs have been delegated greater decisionmaking authority

Party Support

The party has frequently demonstrated its support for the MNTK concept. The leadership has coupled visible support with public criticism in an attempt to overwhelm bureaucratic resistance from ministries and overcome the inertia and stagnation within the R&D sector. Gorbachev, in his speech to the January 1987 Central Committee plenum, expressed "great hopes" for the MNTKs and called upon the ministries to provide the complexes with all the assistance they needed and to facilitate their work in every way. "Second Secretary" Yegor Ligachev and party secretary Lev Zaykov have both praised the MNTK concept. Zaykov, when responsible for both the civilian and military industrial sectors, attended organizational meetings at some of the complexes to relay party support, but also displeasure at the obstacles the MNTKs have encountered. Ligachev, who we believe has had general oversight responsibility for science and education, warned: "The directors of the MNTKs and the leaders of ministries, agencies, and the Academy of Sciences . . . are personally responsible for effective utilization of this new-in-principle form of integrating science with production."

Strong Centralized Planning and Oversight

Each complex has theoretically been given responsibility for almost all aspects of developing its target technology, including forecasting future areas of research and developing comprehensive S&T programs—the principal tool used to plan Soviet R&D activity in key areas. The planning authority of the MNTK goes beyond the complex itself and includes all R&D facilities working on the technology. MNTKs are responsible for developing annual and five-year plans covering the activities of all these organizations. The complexes, working in conjunction with the Council of Ministers, are authorized to draw in additional participants—by compulsion, if necessary—to fulfill their mission. The MNTKs are to draw on the State Committee for Science and Technology for administrative support as well as leverage when coordinating across ministerial lines. They also are responsible for advising the State Planning Committee (Gosplan) on how and where their achievements are to enter series production. Gosplan, in turn, is to incorporate these results into the plans of production enterprises

Priority Access

The MNTKs have—in theory—also been given priority status when requisitioning resources. This right, rarely bestowed outside the defense industry sector, is

intended to avoid the bottlenecks that could retard the MNTKs' activities and progress. Besides materiel, the complexes are to have priority access to manpower and funds. The State Committee for Science and Technology (GKNT) is to maintain a special ruble reserve for disbursal to the MNTKs when necessary. Similarly, MNTK construction requirements are to be fulfilled expeditiously

What and How Are the MNTKs Doing?

Great hopes for the acceleration of the elaboration of new scientific ideas and especially for the large-scale introduction of newly efficient generations of equipment were connected with the establishment of interbranch scientific technical complexes. A little less than two years have passed [since their formation]. It has to be admitted that the hopes for new complexes did not entirely justify themselves.

Ekonomicheskaya gazeta
October 1987

The MNTKs are not meeting Moscow's expectations. There have been some successes, but these have been limited. Generally, the complexes have not succeeded in improving the volume and quality of new products, or in shortening the R&D process. They have encountered problems in getting themselves organized and operational. Indeed, the regime, according to recent open-source articles, is rethinking whether the MNTK mechanism can fulfill the leadership's objectives.

Some Successes

Over the past year the Soviet press has reported that some of the MNTKs are operating successfully. These claims, however, have been made by those complexes that were already successful organizations before they became MNTKs. Indeed, the regime, in a general appraisal of the MNTKs, acknowledged that the few successes could not be attributed to the MNTK strategy, but rather reflected their prior effectiveness. These "superstars" include only Paton Welding, Rotor, and Eye Microsurgery (see inset). Much of their success is a reflection of the capabilities of the MNTK general directors—B. Ye Paton, L. N. Koshkin, and S. N. Federov, respectively. For example, Paton and Koshkin both have a reputation for innovation and dedication to finding applications for their products. All three have high-level party contacts. (Federov is Gorbachev's personal eye doctor, and—according to a Soviet journal—former Minister of Defense Ustinov took a strong personal interest in Koshkin and his rotary technology and was instrumental in its diffusion throughout the economy.

The few achievements that have been identified tend to be single products and not new technological processes. For example, MNTK Biogen is supposed to have developed "more than 120 different items, including unique preparations and chemical reagents," but MNTK Membrane developed a paint recovery method, and MNTK Machine Reliability designed a test bench for a robot production facility.

Many Disappointments

With the exception of the examples noted above and in the appendix, however, few of the complexes can point to any achievements. Rather, the MNTKs have been rebuked strongly because they are "conducting their work unsatisfactorily . . . and many of them had failed to embark on the creation and introduction of a new generation of equipment and technology." President of the Academy of Sciences Guriy Marchuk complained in October 1987, for example, that the complexes "still have not become the structural units that are capable of substantially accelerating the development and introduction of new technologies."

Although our ability to assess the performance of the individual MNTKs is limited because we do not know all of their goals, nor the peformance of each, regime criticism indicates that the MNTKs have fallen short in several areas:

- *Timeliness.* According to the State Committee of Statistics' official report on 1987 plan fulfillment, the MNTKs have not met their time schedules for the development of new equipment and technologies. The regime has criticized the complexes for spending too much time just getting organized. For

Superstars: Thumbnail Sketches

Paton Welding MNTK

The Paton Welding complex was formed on the basis of the Ukrainian Academy of Sciences' Ye. O. Paton Electric Welding Institute, reportedly the largest S&T complex in the USSR. Paton's institute, which has its own massive experimental test base, six engineering centers, and pilot production facilities, is unique within the Academy system for having very successfully linked basic to applied research and for having developed extensive ties to industrial facilities. The institute has long been praised as a model for others to emulate. In his June 1985 speech laying out his S&T strategy, Gorbachev pointed to the Paton Institute as the prototype for new organizational structures—later named interbranch scientific and technical complexes—that were to spearhead technology development. The Paton Institute, now the MNTK, is a world leader in the develoment of welding and electrometallurgy techniques. According to one source, at least 80 percent of its work is done under contract for the military.

MNTK Rotor

MNTK Rotor is led by the Podolsk Design Bureau (KB)—generally called the Koshkin Design Bureau after its general director—and is subordinate to the Ministry of Defense Industry. Rotary technology has been the creation of, and under the total domination of, Lev Koshkin, who originally developed the technology during World War II for the production and handling of ammunition and who has pushed hard for its wider use in the economy. At its present state of development within the Soviet Union, it is generally "low tech" in nature. In its simplest forms, rotary technology consists of a variety of machine tools arranged around a large cylinder (hence the name "rotor" or wheel) that perform a series of operations on unfinished goods transported by conveyer belts. Its use has been suggested in many instances in place of robot technology; indeed, there appears to have been a long, competitive battle between the two technologies in the USSR. While rotary technology can be upgraded to "high tech" through the incorporation of sophisticated automated numerically controlled units, this has occurred only slowly—if at all—in the USSR. Koshkin is currently taking a very active role in adapting the technology for widespread use within the food-processing industry as part of the regime's overall effort to tap the defense industries for support in the agricultural sector.

MNTK Eye Microsurgery

This complex for eye microsurgery is unique in that it offers a service rather than a product. Its director, S. N. Fedorov, has essentially "automated" eye surgery. The surgical process incorporates practices common to assembly line work. An operation is conducted by a series of special teams, each performing its own function in turn. Fedorov claims that the process has led to a higher cure rate, increased "productivity," and lower patient costs.

example, MNTK Catalysis, even though it had new developments "on the shelf" when first created, was still slow to show any results. Similarly, MNTK Membrane was accused of lack of progress and "living off the scientific reserves" that it inherited.

- *Number of prototypes.* The complexes have not met the regime's expectations for numbers of new prototypes or products. On the basis of criticisms in the Soviet press, we believe that, as of mid-1987, at a minimum the Membrane, Personal Computers, Powder Metallurgy, Robot, Industrial Lasers, and Fiber Optics MNTKs were not meeting the objectives assigned to them within the one- and five-year plans. (We have no information on several MNTKs, although we assume that some of them also are falling short.) Many of the MNTKs have not developed any new prototypes. The leadership has complained that many of the complexes "exist on paper only" or are in "embryonic form."

- *Quality of results.* The MNTKs' R&D efforts, as well as their results, have not met the regime's quality standards. In 1987 MNTKs Personal Computers and Robot had to rewrite their plans because many of the projected activities would not have met world standards. Metal powders produced by the Powder Metallurgy MNTK were "unstable." The new laser developed by MNTK Industrial Laser was, according to the Soviet press, considerably inferior to foreign models. And even the "superstar" MNTKs have had problems: as of February 1987, Rotor was "not peforming to its full potential," and Paton himself complained that internal problems kept results of the Welding MNTK from going beyond "average quality."

The leadership appears impatient for the MNTKs to become fully operational and is intolerant of their shortcomings. The MNTKs have been in existence only about two years, yet the regime's criticism of their performance is particularly harsh. The leadership's unyielding—almost desperate—attitude reflects the critical role that the MTNKs and the technologies they are to produce are supposed to play in the industrial modernization effort. The regime is therefore hoping the MNTKs will produce quick results. Its attitude parallels the criticism levied against the machine tool ministry in the machine-building sector, which was also supposed to lead the way in producing new advanced equipment. The regime is banking on the MNTKs to have the new technologies in place for the start of the 13th Five-Year Plan (1991-95).

Placing the Blame: What's Wrong?

The initial reaction of those responsible for MNTKs' lackluster performance has been to place the blame elsewhere. It appears, however, that the mechanism's failure stems more from systemic factors and, despite leadership promises, low priority in obtaining supplies.

Fingerpointing

The principal participants in the complexes—the party, ministries, and MNTKs—are taking advantage of the regime's policy of *glasnost* (openness) to place or shift the blame for the MNTKs' dismal results

The regime has complained that MNTK directors, and the Academy of Sciences in general, have not been sufficiently diligent in eliminating obstacles. For example, MNTK Oil Extraction's slow progress was attributed to its weak and ineffective director. In another case, in December 1987 the director of one of MNTK Machine Reliability's principal organizations—O. A. Kaybyshev of the Superplasticity Institute—was censured for allowing the performance of his organization to worsen. The resignation in October 1986 of Academy President A. P. Aleksandrov may have been pushed, in part, by the regime because of his lack of wholehearted support for the MNTKs (see inset). When announcing his resignation at the October Academy meeting, Aleksandrov admitted that he had not been able to give the complexes his full attention. (It was at this meeting that Ligachev issued his strong warning that Academy and ministry officials would be held responsible for their support of the MNTKs.)

Most of the fingerpointing, however, has been directed at the ministries, which were to participate in the complexes through the inclusion of their scientific institutes, design bureaus, and experimental test facilities. The party and the MNTK heads have persistently publicized their grievances with the ministries, complaining that they have either dragged their feet—hence slowing the formation of the MNTKs—or have refused to cooperate altogether and have reneged on their commitments. For example:

- The director of MNTK Robot emphasized that he could "only influence with words" his many unwilling ministry partners.

- G. A. Abil'sitov, head of MNTK Industrial Lasers, declared that the ministerial organizations that belonged to his MNTK did so in name only, not in action. The complex's activities were "more and more taking on the character of bureaucratic warfare."

- Academician Koshkin, director of the top-performing MNTK Rotor, griped that many ministries were not cooperating or paying attention to his MNTK.

A Hesitant Academy

Both the members and leadership of the Academy of Sciences have not been strong advocates of the new complexes. Academicians warn that applied research and product development are not in the Academy's interest because they detract from its primary focus on basic research. Some of the Academy's top scientists have complained openly that the MNTKs would be a serious strain on the Academy's already limited resources. World famous theoretical physicist V. L. Ginzburg argued in the Academy's official journal that it was "inadmissible to carry out the strengthening of the contacts of science with production at the expense" of the Academy's responsibility for pursuing basic science. Ginzburg, contending that the Academy budget was already too small (4 percent of the state's expenditures on science), warned that, for "the Academy to be responsible for everything . . . means not be responsible for anything." Similarly, V. A. Trapeznikov—noted Soviet computer specialist, head of an institute participating in the MNTKs, and a strong advocate of the reform and revitalization of Soviet science—complained in a January 1987 Pravda *article that the once top-performing institutes were becoming "overtaxed, bogged down in administrative work, and turning into bureaucratic apparatuses" as a result of their role in leading the large amalgamations.*

Complaints leveled by Boris Naumov, director of the Personal Computers MNTK until his death in June 1988, indicate that—at least in his case—the defense industries have also been uncooperative. Naumov contended that, although he had attempted to assert control over the organizations involved in the development and production of personal computers, the four ministries responsible for producing the computers—of which three are defense industrial—were resisting because they viewed the MNTKs as a "temporary campaign."

Need for Greater Autonomy

The record so far suggests that the complexes do need greater autonomy from the overbearing control of the ministries and greater authority to enforce the rights granted to them by the regime. Ministerial conservatism makes it difficult to exercise the powers the MNTKs possess on paper. The MNTKs' inability to assert control over the ministries and to assume true leadership over the development of the targeted technologies is a result of a loophole in the regulations governing their activities. Although the lead institute for each MNTK is to have authority over all the participating organizations, each subunit retains its status as an independent legal entity and its subordination to its parent ministry. Each MNTK subunit continues to be responsible to its parent ministry for the fulfillment of its previous tasks and responsibilities. The MNTK subunits have, in essence, become dually subordinate organizations and are required to comply with the tasking of two masters who are levying competing, often conflicting, demands on the S&T organizations

Priority Status Only Illusory

Almost all of the MNTK directors have protested that they have not been given enough support. Although the MNTKs, by decree, were ensured priority access to resources, this has not materialized. MNTK heads often have stressed that no real progress can be made until "priority status" is a reality and not merely an illusion or rhetoric. They point to severe shortages that are hindering the full spectrum of MNTK activity:

- *Scientific instruments and experimental test base.* The lack of adequate experimental test facilities equipped with state-of-the-art precision scientific instruments is, by far, the most critical shortage confronting the MNTKs. At least 11 complexes have made known their need for design, experimental test, and prototype production facilities. Directors have charged that deficient or nonexistent test facilities are severely retarding—or blocking altogether—progress by the MNTKs. The head of MNTK Biogen stated that the lack of testing capability was impeding his ability to move new products into series production until the period 1995 to 2000. The head of MNTK Industrial Lasers protested that his organization was "in desperate need for priority placement on construction lists," but his pleas for preferential consideration were ignored.

- *Financial support.* Abel Aganbegyan, one of Gorbachev's economic advisers, has pointed to the continued practice of financing science separately from production as a major handicap. MNTKs Biogen, Catalysis, Machine Reliability, and Oil Extraction have stated that financial problems are hurting their activities. The Oil Extraction complex lacked any funding for its first full year. The complexes have called for funding methods to be reformed and for increased financial autonomy.

- *Specialists.* Most of the complexes have complained about a serious shortage of technically qualified specialists, especially designers. For example, MNTK Rotor alone needs 30,000 to 40,000 designers over the next five years. Instruction in some of the specialties within the higher educational facilities is, according to the complex heads, either deficient or nonexistent. MNTK Robot's director contended that there was such a demand for robot specialists he could not hold on to them; organizations able to pay higher salaries were drawing them away. Beyond the need for S&T workers, there was a shortage of trained personnel to install, operate, and service the new technologies produced by the MNTKs.

- *Supplies.* The complexes, which have not been granted priority access to general supplies, raw materials, or specialized subcomponents, have called for reforming the MNTK supply system. Rather than benefiting from preferential status, the complexes have encountered continued redtape and bureaucratic inertia. The MNTK for Scientific Instruments reported that it was having to wait two years to have its orders filled. The Membrane MNTK could not get access to vans or gasoline in order to market and service its new products. The Industrial Lasers complex had a critical need for sophisticated subcomponents such as optical units, electronic automated control equipment, and power systems. One of the participating organizations in the MNTK refused to produce custom-designed subcomponents and insisted that the complex adapt a model already in series production

As long as the Soviet supply situation continues to be characterized by pervasive shortages, it is essential for the success of the MNTKs that they receive preferential treatment. Priority is critical, not only to supply the MNTKs to operate, but also to maintain them as viable organizations for the long term. Soviet developers of new products cannot operate like those in the West, who can turn to alternative sources of financing, manpower, raw materials, and supplies. Without preferential treatment, the MNTKs will find it extremely difficult—if not impossible—to meet their goals within the established deadlines. Further, the complexes will increasingly limit the number of prototypes and tailor the design of products to avoid changes that would require the use of different inputs.

The MNTKs' inability to claim priority status, however, points to a flaw in the strategy itself. Priority status becomes meaningless if it is granted too broadly. The breadth and scope of the MNTK activities, especially when coupled with efforts outside the complexes to develop new technologies, are probably stretching resources too thin and generating contradictory and competing claims for resources.

In the near future, the supply situation for the MNTKs could get worse. Because of the political limelight focused on the MNTK concept, there have been calls over the past year to form yet more complexes. Some of those proposed are limited in their potential impact and do not represent key, interdisciplinary technologies. Rather, they are efforts to join the politically popular MNTK bandwagon. For example, during September 1987 there were calls in the Soviet press for the formation of MNTKs to develop videocassette recorders, training simulators for nuclear power complexes, and influenza vaccines. The unique nature of the complexes and their priority status risk overdilution as they become "economically faddish." If the complexes are allowed to proliferate, there will be even greater competition for scarce S&T resources

Systemic Factors

For the most part, MNTKs have been unable to move their developments beyond the prototype stage and into series production. Although Soviet press reports credit MNTKs with successful development of 160 new items of machinery and technologies that were ready for assimilation during 1987, only 78 of the

products were included in state orders for actual production under the 1988 plan. The regime and MNTK directors have identified two causes for the shortfall:

- Responsibility to oversee series production does not clearly come under the purview of the MNTKs.
- Ministries and their subordinate production enterprises are reluctant to tackle series production of new products

Linking Research to Production: The Gap Remains. The MNTKs, in most instances, are responsible for *producing* only prototypes, although, by decree, they are tasked with *overseeing* the development of the technology through series production. As a result of this ambiguity, there is no mechanism to ensure that the prototypes will ever be series produced, and the regime's goal of creating the MNTKs to bridge the gap between science and production is falling short. The late R. A. Belyakov, the head of one of the first and most successful NPOs, Kriogenmash, complained that the MNTKs provided only "half solutions." Belyakov pointed out that "the economy needs new series-produced equipment, not prototypes."

Many of the MNTKs—for example, Biogen, Catalysis, Metallurgy Machinery, Personal Computers, and Industrial Lasers—have indicated that they have encountered resistance from ministries and enterprises when attempting to arrange for series production based on new prototypes. The head of MNTK Industrial Lasers, one of the few complexes specifically responsible for series production, complained that the Ministry of Electrical Equipment had reneged on its commitment to produce components and perform assembly work. As of July 1987, the complex had satisfied only four of 990 requests for new industrial lasers that it had received from unspecified organizations. Even the successful Rotor MNTK has run into uncooperative ministries—including one of its principal customers, the Ministry of Machine Tool and Tool Building Industry—that dragged their feet and tried to avoid the production and introduction of rotary technology

The inability of the complexes to ensure series production of new technology—to close the gap between research and production—pointedly suggests that the MNTKs have not addressed the systemic obstacles that have consistently blocked the introduction of innovations throughout the economy (see inset). MNTK heads have pointed to the lack of incentives for enterprises to produce new technology and the aversion of producers to the risk associated with introducing truly new products. Indeed, the regime's objective for the MNTKs was to attack the bureaucratic—not systemic—barriers that have hindered the development and introduction of new technologies. The regime probably thought that, by adopting the methods used by the defense industries to develop technologies, it could duplicate the latter's success without drastically disrupting the system

Emulating the Defense Industrial Sector: The Missing Link. Although the regime sought to transfer the strategy used for developing technology within the defense sector, one critical element was not replicated: the military customer. The precisely defined needs and demands of the military for advanced technology to counter Western threats, coupled with rigid quality control measures, fostered technological advances within the defense industries. The MNTK mechanism is held back not so much by bureaucratic boundaries and ministerial inertia but by the absence of a customer who knows what is available technologically, has specific demands in terms of the product and quality, and is accountable for producing state-of-the-art goods.

To compensate for the lack of strong demand by a customer, it is up to the MNTKs to act aggressively to first identify the needs of their customers and then to convince them to buy the new products. Most of the technologies targeted by the MNTKs are embodied in products that do not "stand alone" and cannot be easily introduced onto the production floor. Rather, the new products must be integrated into new production processes and require extensive tailoring to the individual needs of the consumer. In the West, technically trained marketing teams go out and find applications and tailor their product to the customer's needs. On their own, the MNTKs may be able to meet goals for designing and developing prototypes, but

Systemic Obstacles to Innovation at Industrial Enterprises

Western specialists on Soviet industrial managerial practices have documented over the years the systemic obstacles discouraging the introduction of new technologies—both product and processes—at industrial enterprises. (One outstanding example is Joseph S. Berliner's The Innovation Decision in Soviet Industry, *MIT Press, 1976.) Although the Soviet leadership has sought over the past three decades to address the obstacles, numerous disincentives have discouraged industrial managers from actively seeking and encouraging the introduction of new, more technologically advanced products and processes. The primary objective for the manager is to fulfill his production targets assigned under the annual and five-year plans. Only through plan fulfillment can enterprise employees qualify for salary bonuses—the principal incentive that ensures enterprise compliance with central planning directives.*

To meet production quotas, managers seek to avoid decisions or actions that introduce risk or jeopardize plan fulfillment:

- *New technologies invariably reduce productivity initially and may even close down production lines altogether. Losses may not be recouped within the designated plan period, especially if the plan is even moderately taut. New products and processes that appear within a plan cycle are especially vulnerable to rejection.*
- *The more innovative the new technology, the more likely it is that enterprise will have to alter its supply requisitions or develop new supply channels.*
- *Increased costs incurred through the purchase or introduction of new technologies decrease an enterprise's profit, a principal indicator of plan fulfillment.*
- *Managers have sought to keep production targets relatively stable—hence predictable—allowing only for incremental increases. Innovations that hold out the prospect for significant productivity increases and substantial plan overfulfillment are avoided if they carry with their introduction sizable jumps in plan quotas.*
- *The introduction of new technology requires personnel shifts, wage and price adjustments, and, often, new facilities, necessitating extensive time and effort to provide documentation and get approval from numerous central organs. Enterprise managers lack the authority to act on their own; for example, centralized control of capital financing does not permit them to nurture promising R&D.*
- *The prices for new technology, or the rubles saved from its introduction, rarely reflect the degree of actual innovation. Only plan targets, not prices, are used by the enterprise manager to make decisions regarding the use of resources under his control.*
- *Material rewards for introducing new technologies at the enterprise are moderate at best and do not compensate for the risk, whereas penalties for failure—loss of bonus and possibly one's position—are stiff and immediate.*
- *State standards—official directives regarding product technical characteristics and performance—frequently serve as a straightjacket, stifling the rapid introduction of new technology or products that may not conform to increasingly obsolete standards. Enterprise managers will eschew introduction or production of new products or processes that violate standards, regardless of whether it represents an improvement.*
- *New technology may lead to loss of jobs, an unpopular phenomenon in Soviet society*

they have not developed a market for them. The regime risks storing expensive, but unwanted, designs and prototypes. The heads of MNTKs Membrane and Thermosynthesis have emphasized that, while they may be successful in meeting some of their production goals, they lack customers for the new technologies. Membrane's chief nervously pointed out that his 1987 production plan targets for membrane filtration systems and materials were three times higher than the confirmed demand for these products. The excess would have to be stored in the warehouse, where it would sit as "frozen capital."

Although the Soviet Union has a "planned" economy, chronic shortages have also made it a seller's market. Individual factories that produce according to a plan provided from a ministry do not have to worry about selling their product. But because of the tautness in the plans, there has almost always been more demand for products than available supplies. Within this environment, the premium has always been placed on "production" rather than "selling" and on staying with the proven product rather than risking experimentation with the new

Regime Response

Moscow has responded to poor performance by MNTKs with a variety of measures, most of which are Band-Aid remedies and none of which address the key, systemic problems noted above. Recent statements in the Soviet press, however, suggest that the situation has deteriorated to the point where the regime is rethinking the appropriateness of the MNTK mechanism as a catalyst for technological progress

Tightening the Screws Through Reorganizations

The regime has sought to improve the viability of the MNTKs through reorganizations and resubordinations. Such measures aim primarily at overcoming bureaucratic resistance to the MNTK mechanism and strengthening centralized control over their operation.

Moscow's original inclination was to give a leading role to the Academy of Sciences and its institutes. The regime probably believed that the highly respected Academy would be able to first develop new technologies and then to have the foresight to determine and guide their introduction into production. The leadership assumed that the "logic" of advanced technology and the predicted benefits would be sufficient to overwhelm conservatism within the industrial ministries.

As early as the spring of 1987, the leadership recognized that the Academy did not have sufficient experience or prestige to deal with the ministries. Of the eight MNTKs originally headed by a USSR Academy facility, three (Personal Computers, Fiber Optics, and Machine Reliability) were totally resubordinated to a ministry; three (Biogen, Catalysis, and Thermosynthesis) complexes will assume a "close affiliation" with ministries, and one (Industrial Lasers) will continue to be dually subordinate to a ministry and the Academy (we believe that this will also be the case with Scientific Instruments). While making the changes in subordination, the regime may be using the opportunity to increase the participation of the defense industries. For example, Machine Reliability MNTK will be more closely affiliated—perhaps subordinate—to the Aviation Industry Ministry. This closer alignment is indicative of the party's increasing effort to draw on the expertise of the defense industrial ministries. The regime probably expects that, by making the ministries, defense or civilian, directly responsible for the success or failure of the complexes, the ministries will more actively and willingly support the complexes.

The leadership has also sought to strengthen central control over the complexes and to increase the party's oversight of their activities. The GKNT, as a result of a recent reorganization and regime decree setting out its duties, is to assume greater responsiblity for the development and activities of the MNTKs and their targeted technologies. At the same time, the GKNT is to divest itself of involvement in R&D activity that is limited to the confines of a single ministry. On the basis of the 1987 decree, it appears that GKNT's performance will be evaluated in the future by how effectively it has supported the complexes and assisted them in meeting their objectives. The regime has also

strenghthened the role the party is to play directly in the MNTK operations. The complexes located in Leningrad, Novosibirsk, and Vladimir have been placed under the day-to-day control of the local party organs—presumably so they can exercise their leverage to obtain needed resources, housing, and construction, but also to monitor the complexes' R&D activities through the institutes' S&T councils and party organs.

Looking Outward

We believe that the original MNTK blueprint, although it included a limited role for East European participation, had a very narrow role for the West. (Many of the MNTKs serve as the "head organization" responsible for coordinating R&D activity under the Comprehensive Program for S&T Progress through the year 2000 formulated by the Council for Mutual Economic Assistance.) Gorbachev does not want to depend on Western sources for technology and has emphasized that the country must—on its own—develop a strong indigenous base capable of operating independently. At a January 1988 meeting with the Soviet media, Gorbachev complained that, during the 1970s, the foreign currency earned through oil exports had been used to "thoughtlessly buy equipment to solve production tasks [and to] purchase spare parts, without developing our own engineering and science properly. This import plague actually stifled the process of scientific and technical development. . . . We found ourselves literally in a corner." The regime is attempting to balance the national security imperative of technological independence from the West with its traditional reliance on information on Western S&T activities to advance Soviet technology

While the regime remains committed to indigenous technological development, it is not above seeking Western help in improving the R&D process. Since mid-1987 high-level delegations representing Soviet industrial ministries and the heads of MNTKs have approached Western governments and businesses to press for increased contact and exchanges between the West and the MNTKs. Although the Soviets have always demonstrated an interest in purchasing Western high-technology goods, their more recent efforts—those tied to the MNTKs and their targeted technologies—have tended to focus more on deriving assistance at the R&D stage. The Soviet leadership probably is seeking to use such contacts to help support and advance the complexes until they overcome current obstacles or until other measures recently implemented to spur technological development can have an impact (see below). In August 1987 the head of MNTK Personal Computers, Boris Naumov, told the Soviet press that he was seeking to establish a joint enterprise with a foreign firm as a way to bypass the bureaucratic resistance and inertia that was blocking the progress of his MNTK.

The regime wants to expand foreign contacts with the MNTKs through a variety of means:

- *Government-to-government exchanges.* During the October 1987 US-USSR preliminary negotiations for a new intergovernmental scientific cooperation agreement, the Soviets proposed the inclusion of several MNTKs as the lead organizations. Similarly, in early 1987 the Soviets proposed to expand the USSR-Greek agreement to include cooperation with the Industrial Lasers MNTK, as well as exchanges in new materials and biotechnology.

- *Cooperation agreements with private businesses.* Many of the MNTKs have approached foreign businesses—especially in the United States, West Germany, and Japan. Proposed cooperative efforts would include the exchange of specialists and joint testing of new ideas and product design.

- *Joint ventures.* Several complexes—for example, Welding, Membrane, and Personal Computers—are seeking to establish joint ventures in which Soviet and Western enterprises will combine forces within the Soviet Union to research, develop, and market new products. In exchange for their managerial expertise and investments, Western companies are to receive a share of the profits. The lead organization of MNTK Personal Computers reportedly has been negotiating a joint venture with a US software firm.

- *Licensing of Soviet technology.* MNTK Paton Welding has taken an aggressive approach to licensing its technology to Western countries

The defense industries probably support—and may have encouraged—the shift toward a greater role for the West in the MNTKs. In any event, they are well postured to capitalize on increased contacts with the West's R&D community and to use the MNTK mechanism as a way to channel benefits back into their own organizations (see inset).

We believe the regime expects numerous benefits for the MNTKs through increased contacts with the West:

- *Access to state-of-the-art experimental test bases.* Cooperation with the West is seen as a way to overcome limited domestic testing and experimental capabilities. Contact of this type would enable the complexes to test in the West theories developed within the MNTKs but blocked from further or quick development because of the weak test base.

- *Acquisition of scientific instruments.* MNTKs are seeking to purchase scientific instruments helpful in building a domestic experimental test base and for developing new products. [redacted] in October 1987 a French firm and an Italian firm were competing to win a sizable contract with a lead facility under MNTK Biogen for software, equipment, and engineering assistance. Earlier in 1987 the complex was reported to be placing contracts in excess of $180 million.

- *Assistance in identifying and developing potential applications and processes.* The Soviets have acknowledged that they expect to use expanded contacts with Western companies to help identify potential applications for new scientific discoveries and to aid them in overcoming their traditional difficulty of moving ideas out of the lab onto the production floor. [redacted] in some areas the Paton Welding MNTK has successfully developed new technologies and dedicated customers—including the military—but the complex has been less successful in developing an efficient process to apply the new product. Paton is willing to license technology to the West that has been used in the USSR for the construction of submarine hull rings, rocket motor casings, and armor plate. In exchange, Paton is seeking Western

MNTKs Pose Export-Control Concerns

The MNTK concept will complicate efforts by the United States and the Coordinating Committee for Export to Communist Areas (COCOM) to prevent the transfer of militarily significant Western technology to the Soviet Bloc. US and COCOM export-control guidelines provide for the approval of certain transfers of otherwise restricted technology to Soviet entities if the end use is purely civilian. Such a determination is difficult to make when the proposed end user is an MNTK: many of the numerous participating organizations conduct varying degrees of defense work as well as civilian research. Furthermore, some of the MNTK subunits are directly subordinate to the defense-industrial ministries, and approvals of high-technology sales to MNTKs raise the risk of internal diversion; that is, the diversion of the technology from the approved, civilian end use to a military one. As discussed in the text, the MNTK concept is intended, in part, to promote technology transfer back and forth between the defense and civilian industrial sectors.

COCOM concerns for technology transfer are not limited to direct equipment purchases and extend to all mechanisms currently pursued by the MNTKs to broaden exchanges with the West. Cooperation agreements including MNTKs will risk the involvement of Soviet scientists engaged in military research, and it will be difficult to fashion joint projects that exclude their participation. The licensing of technology under joint ventures with MNTKs, although subject to the same export controls, would also contribute to Soviet defense programs and industries represented within the individual complexes.

To make an informed decision on expanding contacts with the MNTKs, COCOM-member licensing authorities will require hard-to-get information on the complex members and the extent to which equipment, facilities, or knowledge are shared among complex subunits.

assistance to improve the production process for applying the technology and thereby overcoming the problem the complex has had in developing reliable production equipment.

- *Access to information.* An MNTK director as well as a Gosplan official complained at an early stage that, because of the lack of information concerning advances in the West, the Soviets had fallen behind. The director stressed that information on Western R&D activities was essential to drawing up realistic S&T forecasts and effectively directing the R&D effort. Both argued that increased contacts between MNTKs and the Western scientific organizations would facilitate access to the information.

Scaling Back Expectations

Although the leadership has continued to exert pressure on the MNTKs to fulfill their objectives, Moscow may be scaling back some goals. The evidence is fragmentary, however, and based on very limited—and sometimes contradictory—information:

- Although the Personal Computers MNTK was to oversee the production of 1.1 million personal computers during the 12th Five-Year Plan, Lev Zaykov, in a speech to the major producers, referred to the goal of 500,000 units for the entire economy (not just for educational purposes as had previously been the case).

- MNTK Membrane was to oversee the production and use of membranes that were to have a 1-billion-ruble impact within the economy by 1990. In April 1987 a Soviet newspaper reported that the target for economic impact now stood at 800 million rubles.

- MNTK Rotor initially was slated to develop 8,450 rotary lines by 1990. As of January 1988 the target had been trimmed to 6,300 lines.

These leadership actions stem from a growing awareness that its expectations for quick and significant returns from the MNTKs were not grounded in reality. During the last year, the leadership has complained on many occasions that the projected economic effect claimed by scientists and planners for new technologies has not materialized. Moscow's high expectations were probably based on the limited examples in which new technology prototypes were introduced under ideal conditions and benefited from priority status and leadership attention. Rotary technology, for example, had been reported to lead to as much as a tenfold increase in labor productivity, release hundreds of thousands of workers, and reduce by three or four times the space required for production. The director of one enterprise that installed rotary lines reported, however, that he had such difficulty in assimilating the lines that, without the constant, prolonged, close supervision of the developer (Koshkin's Design Bureau), his enterprise would not have been able to start up operations.

The development of robot technology in the Soviet Union is a classic example of a technology's failure to meet expectations once introduced. As has happened in the West, the problems encountered in introducing a new process technology often lead initially to disillusionment and later to a cautious pragmatism. Soviet publications indicate that such a reevaluation now is taking place with robotic technology and its broad introduction throughout the Soviet Union. Soviet statistics show that the economy cannot even absorb the robots that are produced. Of the 13,000 robots produced during 1986, only 8,000 were introduced. Ivan Silayev, head of the Machine Building Bureau, stressed in June 1987 that it was "not enough to just emphasize the number of robots produced, the country was already producing more transport robots than the economy could accept." According to a Soviet journal article, too many robots were being produced, and the technology incorporated into them had not yet "matured." Consequently, the introduction of robotic technology had not resulted in the anticipated release of sizable numbers of workers. Robot production needed to be cut back by one-third to one-half to permit significant improvement in speed and accuracy and to incorporate individual robots into integrated production lines.

Having Second Thoughts: Moving Beyond the MNTK

By October 1987 the leadership appeared to be rethinking the MNTK strategy and reevaluating the commitment to its continued use, especially after the

new State Enterprise Law came into effect in 1988. At a GKNT-sponsored conference, scientists, production workers, and party and government officials sought to determine what was hindering the complexes from reaching their objectives and what measures were needed to improve performance. According to the Soviet press, however, participants debated whether the MNTK mechanism itself was appropriate and whether it should be continued. Although the majority thought the MNTK mechanism to be "promising," a vocal element "denied the usefulness of the MNTK as a special organizational form." The meeting ended without drawing firm conclusions. Indeed, a Soviet reporter stated, "It has not yet been possible to find unequivocal answers to all these questions," and he acknowledged that "diametrically opposed" opinions were offered on what actions were required. Conference attendees were apparently unanimous in their view that the MNTK mechanism must be changed if it is to be more effective: "Neither the traditional mechanism of strict planning nor purely market relations are suitable for the assurance of the successful transition to qualitatively new levels of equipment and technology."

Currently, two very different approaches to the difficulties with the MNTKs are being considered: organizational fixes and systemic adjustments

Organizational Fixes. Some of the contemplated measures aim at creating yet more organizations—either larger or smaller than the MNTKs. Proponents of these solutions continue to operate under the assumption that bureaucratic boundaries are the principal barriers to innovation, and it is only a matter of finding the right organizational mechanism to overcome them

Both Academy President Guriy Marchuk and Academy Vice President Yevgeniy Velikhov have pointed to the use of small, temporary groupings of scientists and producers that would be flexible in their membership and comprised ideally of no more than 100 members. In December 1987 Velikhov evaluated small, flexible groups favorably when comparing them to MNTKs. He contended that the small groups allowed for greater contact between science and production and were able to avoid some of the MNTK practices that industry had found objectionable, especially the right of MNTKs, in conjunction with Gosplan, to dictate new production regardless of prohibitively high start-up costs. Velikhov implied that the decision to introduce new technologies at the production enterprise in order to be rational and to reflect economic concerns had to be made by producers, though with advice from the scientific community. To vest scientists and engineers with the decisionmaking authority risked irrational conclusions. In February 1988 a Soviet laser specialist and director of an Academy institute recommended the formation of small, regional laser centers outside the MNTK mechanism that could draw on newly formed production associations to supply them with needed components. The specialist thought that such action was necessary because the Industrial Lasers MNTK was encountering such stiff resistance from the bureaucracy that it had been rendered ineffective.

At the same time, the regime has announced the formation of State Production Associations (GPO), a new organizational mechanism that will dwarf even the huge MNTKs. The GPOs—to appear during 1988—will span research through series production, as well as through the installation and servicing of new technologies. It is not yet clear what role the MNTKs will have within the GPOs

Systemic Adjustments. The Gorbachev regime also is rethinking its science policy in general and may be stepping back from its heavy reliance on a top-down approach to developing key technologies. The leadership appears to be taking its first, though faltering, steps to address systemic barriers to the development and introduction of new technologies. Portions of the new State Enterprise Law, along with other legislation published during 1987, indicate that Moscow may be taking steps to create a more innovative scientific base—one not so dependent on the top-down approach to developing new technologies. In some cases, however, the regime's new measures are incompatible with its earlier strategy as incorporated within the MNTKs. Indeed, a Soviet journal in January reported that the changeover to the new methods had

taken the complexes "by surprise." There is the potential for increased disruption if both approaches are enacted simultaneously.

We believe that the regime may now recognize that overcentralization of decisionmaking authority within the complexes may actually retard or limit the development of new technologies. There appears to be a growing appreciation for the role that competition plays in advancing technologies. Encouraging competition among R&D organizations, however, relaxes the centralized control and runs contrary to the MNTKs' task of eliminating parallel and duplicative research

Although most, if not all, MNTK work will be financed by the state budget, over half of the scientific community in 1988 will switch to "self-financing," which requires the R&D organizations to cover their operating costs out of profits earned through research conducted under contract. Under the new arrangements, many of the individual MNTK subunits will switch to self-financing and will be granted increased autonomy entitling them to more independence in their decisionmaking. These organizations may find it more advantageous to perform work for customers outside the MNTK structure, circumventing the authority of the MNTK director to dictate who is to participate within the MNTK. The regime has not made it clear how it intends to resolve this potential conflict of interest. Meanwhile, the country's scientific leadership appears to be particularly apprehensive over what effect self-financing will have on the development of interdisciplinary—hence interbranch—technologies:

- "I think that, if the nuclear power industry had developed on a self-financing basis, it would not exist now." (A. P. Burdukov, director of a key institute and design bureau within MNTK Catalysis, October 1987).

- "As our practice shows, under the conditions of economic accountability, an enterprise is oriented toward the demands of the moment. For this reason the fate of developments designed for the long term becomes more complex: No one orders them from us. Today it is almost impossible to persuade some enterprise to finance the creation of future technology." (A. A. Deribas, head of a special design bureau, Academy of Sciences, October 1987)

While the leadership attempts to turn its scientific community toward the needs of production, it is also taking steps designed to stimulate keener interest on the part of industrial managers to acquire and introduce new technologies. For example, measures have been introduced addressing quality control, accelerated depreciation and replacement of machinery, and increased profit margins on technologically improved products. In his September 1987 speech to the Supreme Soviet, Premier Nikolay Ryzhkov emphasized: Under the new conditions, an enterprise will not be able to function successfully unless it relies on S&T progress. . . . In fact, making every collective as receptive as possible to innovations and giving it a vital interest in utilizing the achievements of S&T was put forward as virtually the main task of restructuring."

Over the next few years the regime is likely to simultaneously pursue both approaches—attempting to integrate centralized with decentralized methods—without committing itself. To do so, we expect it will use the newly created "state orders" to direct resources to priority projects and products. Soviet economists discussing the obstacles encountered by the MNTKs have proposed that state orders be issued by Gosplan and the GKNT for each MNTK, specifying the basic assignments for the research, development, and introduction of new products and processes. Further, each MNTK would be authorized to issue state orders to ensure an adequate and timely supply of needed resources and to levy mandatory assignments on participants. At the same time, however, MNTK directors are to seek to negotiate with their subunits mutually beneficial contracts for supplies and for research and design work

While we expect the regime to use state orders to protect the MNTKs during the disruptive period when reforms are introduced, their use will not serve as a panacea and, in fact, is likely to encounter stiff

ministerial resistance. On the basis of limited Soviet press reporting, it appears that state orders must be at least coordinated and probably approved by the participating ministries, not just Gosplan and the GKNT. It is precisely these ministries that are already resisting the erosion of their authority to the complexes. There will also continue to be conflicting demands placed on the MNTK subunits, because the ministries will still levy state orders.

As a part of its effort to delegate authority and responsibility to the enterprises, the regime is taking a strong stand against the abuse of the newly created state orders. The leadership is already complaining that, rather than being limited to the most important products, state orders have been distorted to serve as a substitute for the annual plans in order to fetter the entire production capacity of the enterprise and to weaken new measures intended to decentralize decisionmaking.

Should the Gorbachev regime increasingly rely on state orders to address the problems of the MNTKs, it will indicate that the leadership—at least on the issue of the development of critical technologies—continues to resist decentralization of decisionmaking.

Prospects for Success

Falling Short for the Near Term

The MNTKs have not fulfilled the regime's objectives to date, and we do not expect the situation to turn around in the short term—the remaining two and a half years of the 12th Five-Year Plan. Indeed, many of the MNTKs will fail miserably under the current conditions.

Although such an evaluation made on the basis of only two and a half years' performance by the MNTKs may appear particularly harsh, the obstacles blocking progress are major and will not be easily or quickly overcome. Personnel shortages, deficient experimental test bases, bureaucratic inertia and resistance, and systemic deficiencies will minimize the impact of the MNTKs throughout this five-year plan.

Developing New Technologies. We do not expect the MNTKs per se to enable the S&T sector to meet regime objectives. In those rare instances in which we know the specifics, MNTK plans appear unrealistic in terms of the number of new products or the impact they are expected to achieve. In situations in which complexes do develop a number of new prototypes, we expect that the MNTKs will be less successful in moving the prototypes quickly into series production. In many instances the new products will fall short of world-class quality. And the absence of an effective marketing strategy will result in products that will be difficult to introduce onto the factory floor, require extensive and time-consuming modification or adjustment when first reaching the enterprise, and perform at appreciably less-than-planned levels.

Shortening the R&D Process. The MNTK mechanism will not appreciably shorten the R&D-to-production cycle during the current five-year plan. A few products may be developed in a somewhat shorter period of time, especially as MNTKs struggle to show some success, but these successes will be attained only through a total focus of effort and resources to the potential detriment of broader, yet slower, progress across a whole technology.

Strengthening Exchange Between the Civilian and Defense Sectors. It is feasible—perhaps even likely—that the MNTKs will be successful in tapping the defense industries for support. Defense industry institutes and design bureaus are probably willing to give guidance and some resources to assist the MNTKs—especially in areas in which the industry stands to gain appreciably with only minimal expenditure of its own resources. A recent call by a defense industrial deputy minister to form an MNTK on composites indicates that at least some of the defense sector support the MNTK concept as a way to derive benefits for their interests. On the other hand, the resistance that the Personal Computers MNTK has encountered from the defense industry ministries indicates that the complexes are not receiving wholehearted support.

During the last year, we have seen the association between the defense industry and the MNTKs increase, especially as a result of resubordination of some of the MNTKs from the Academy to ministries, and the defense industry sector may be tapped yet harder to support the MNTKs. Especially as the complexes fall increasingly short of the regime's goals, the leadership will be tempted to turn to the defense industries for increased support—particularly in the case of those technologies in which they have acquired the most experience: rotors, computers, robotics, new materials, and machine reliability and testing. The defense sector probably will be looked to as a source of designers, experimental test facilities, and specialized production capabilities

Long-Term Prospects

The MNTKs' success in producing significant results and serving as a mechanism to rapidly advance key technologies over the long haul hinges on how the regime resolves bureaucratic resistance, whether it attains priority status for the MNTKs, and how it refines the model.

Overcoming Bureaucratic Resistance. The regime faces a long and uphill struggle to overcome bureaucratic resistance and inertia—especially within the ministries, but also within the relatively independent Academy of Sciences. Overcoming obstacles to innovation posed by bureaucratic boundaries is but one element of Gorbachev's efforts to redefine the role the ministries are to play within a more decentralized decisionmaking environment. The regime must move quickly to establish the MNTKs as the primary authority over the various subunits—at the expense of the industrial ministries—rather than continuing to let the subunits serve two competing and often warring masters. As evident by the complaints now being registered by the MNTK directors, continued divided authority could result in paralysis

Gorbachev stands a better chance of succeeding here than in other areas. While we believe the General Secretary has demonstrated the determination and dedication to break through the logjam of conservative managers, he has yet to demonstrate success. Assuming that he continues his pressure on the bureaucracy and policy of cadre renewal, a more supportive and capable bureaucracy could be in place by the early 1990s.

Staking Claim to Priority Status. For the MNTK mechanism to be even marginally effective, it must have priority access to scarce resources such as scientific instruments, new construction, experimental test facilities, specialists (especially designers) and specialized subcomponents, as well as financial assistance. The MNTKs will face competition from all sectors—including the defense industries—for these items, and we think the complexes are not likely to receive preferential treatment, especially as competition is heightened during the switch to a more decentralized supply system.

Refining the Model. The MNTK strategy contains weaknesses that, if not addressed, will severely limit the potential of the complexes to spur long-term technological development at the pace and quality dictated by the regime. These missing links will act to limit the viability of the MNTKs and will sharply curtail their effectiveness. As the MNTK charter now stands—stopping at prototype development—it does not connect research to production. Thus, even when the MNTKs have developed prototypes, there is no assurance that enterprises will assume series production. We believe, therefore, that the effectiveness of the MNTKs will be severely limited as long as the Soviet economic mechanism does not provide a strong, well-informed customer who has a direct interest in exercising his right to shape product design or quality. In the absence of such customers, the MNTKs would have to market their products aggressively to bridge the research-to-production gap. We believe that, if this issue is not addressed, the technological advances coming out of the MNTKs will not be disseminated widely throughout the economy. To date, Moscow has barely recognized this deficiency.

Failure on the part of the MNTKs to meet the regime's objectives does not mean that the Soviets will not be successful in developing the targeted areas. The

leadership may be able to achieve significant results—but they will be reached primarily in spite of (or outside) the MNTK mechanism, through steps decentralizing economic decision making. Much will depend on how these measures—self-financing, competition—are implemented. The new decentralizing measures, however, when coupled with the highly centralized strategy used by the MNTKs, have a greater potential to disrupt both efforts than to be mutually supporting.

If Gorbachev's decentralizing measures are more successful in spurring innovation, the regime may play down or even eliminate the MNTKs. In the interim, during which the measures are implemented, the MNTKs will continue to limp along, with the regime using state orders as a crutch to provide funds, scarce resources, and ministerial assistance. If the new measures are not successful, then MNTKs can be expected to be reemphasized with increased pressure put on ministries.

If current obstacles are overcome, and the regime successfully integrates and balances the effects of its numerous and, at times, uncoordinated reform measures, the MNTKs may make an impact by the mid-1990s. By that time, the MNTKs that enjoy strong directorship and moderate ministerial support should be able to show at least some limited technical advances and new products. The targeted technologies are not "blue-sky ideas" that would require a long and risky basic research effort to achieve a technological breakthough. The MNTKs should be able to modestly improve the rate of return on investment in their R&D efforts: product quality will be enhanced through prioritization of effort and improved feedback from producers and end users, and diffusion of results will be broader because of the numerous ministries drawn into the MNTK effort. Similarly, the MNTKs, benefiting from improved and shortened communication lines, should be able to shorten somewhat the lengthy R&D process

Implications for the West

As one way to overcome bureaucratic and organizational obstacles, the regime will probably make a concerted effort to gain whatever benefits and assistance possible by increasing contacts and scientific exchanges between the MNTKs and the West. As competition for scarce resources become fiercer, we expect that the MNTKs will turn increasingly to the West for scientific instruments to develop an infrastructure for testing their R&D results. We also expect that the MNTKs will pursue such contacts with the motive of gaining access to state-of-the-art test bases and expediting the development of prototypes. Such joint ventures would also allow Western market forces to be used as a proxy for consumers and competition and the role they play in directing and encouraging technological advance. The MNTKs will particularly look to joint ventures to help them identify and develop applications for their new scientific discoveries.

It is ironic that the defense sector probably will reap greater benefits than its civilian counterparts through the use of the MNTK mechanism. Defense interests are well represented in the long-range plans and S&T programs that the MNTKs have drawn up, especially in those complexes known to have direct ties to defense industrial organizations. Because it is a powerful and knowledgeable customer, the military will be able to capitalize on any achievements the complexes may develop. The defense industries have the well-developed infrastructure to identify, acquire, and rapidly assimilate technological advances, and the military will have the resources and the authority to ensure that products of interest to them are prioritized and nurtured until completion. Similarly, the defense sector stands to gain through technology transfer as MNTKs expand their contacts with Western countries through cooperation agreements and joint ventures

Even if the regime is able to resolve the numerous obstacles limiting the MNTKs, they will not be able to compete with R&D complexes in the West in spurring broad-based technological advancement. The MNTKs' top-down, command approach to innovation probably condemns the Soviet Union to perpetual follower or catch-up status. The practice of targeting and prioritizing specific areas for forced development, and placing control within one organization under one

director, limits spontaneity and flexibility—essential elements for innovation and creativity. Similarly, the negative effects of targeting are even greater when the areas to be targeted are based so heavily on copying what is already in production in the West. Even in the defense sector, the success of the approach is only relative to the failures of the civilian economy. Technological development for the defense industries has consumed massive quantities of resources and has produced generally evolutionary, rather than revolutionary, results.

Appendix

MNTK Goals and Results (Reported in the Soviet Press)

	Goals	Achievements
Anticorrosion	To develop new types of technology and processes for corrosion protection that provide increased strength of materials and reliability of machines.	None noted.
Biogen	To develop methods for genetic and cellular engineering and the latest generation of compounds for medicine and agriculture, including: insulin, interpheron, human growth hormone, immunostimulators, anticancer compounds, and hormones for cattle growth.	As of December 1987, had developed "more than 120 different items, including unique preparations, chemical reagents, and scientific instruments." One such item is Interferon Alpha 2, intended for treating hepatitis. Biogen head stated that he had not received the resources necessary for testing and production; therefore no production was envisioned until 1995-2000. In order to meet its goals for the 12th Five-Year Plan, Biogen needed greater administrative authority, economic independence, and better financing.
Geos	To develop a unified system and methods for the study of Earth's mineral resources. Collection of information is to be at four levels: space, air, ground, and well shaft.	None noted.
Catalysis	During the 12th Five-Year Plan, to create 80 percent of all new catalysts for the Ministry of Chemical and Petroleum Machine Building and Ministry of Mineral Fertilizer Production, a total of 71 assignments.	Credited in 1987 with the replacement of the catalyst used within the sulfuric acid industry. Though the MNTK had "models on the shelf" to develop when first created, it still has been slow to develop new products. Unless left alone and not disturbed by ministries, the complex is likely not to meet its objectives.
Mechanical Processing	For the 12th Five-Year Plan, to produce several new generations of machinery for the processing of mineral resources. By 1990, to obtain an economic impact of 100 million rubles; by 2000 it is to obtain an economic impact of 2 billion rubles.	Had developed by March 1987 new types of special equipment, but numerous ministries were indifferent and prevented series production.
Membrane	To produce 32,000 square meters of membranes in 1987. To increase production tenfold by 1990. In 1986, announced that it was to obtain an economic impact of 1 billion rubles by 1990. In 1987, announced that it was to obtain economic impact of 800 million rubles by 1990.	As of May 1987 the complex was "living on the scientific reserves" that existed before the formation of the MNTK and had not gone beyond prototype development. In 1987, developed a process to separate runoff paint, with an economic benefit of 1,430 rubles per square meter of membrane. The director admitted that such results were few and far between. This MNTK could not count on any significant change in its negative state of affairs, and there was little hope of being able to quickly bring membrane technology up to acceptable levels.

MNTK Goals and Results (continued)
(Reported in the Soviet Press)

	Goals	Achievements
Eye Microsurgery	Not known.	Cure rate was 96 to 98 percent. Reduced time spent by patients in hospital. Reduced costs for treatment. Had higher labor productivity than that in similar medical institutes.
Machine Reliability	To develop diagnostic hardware to make possible a twofold to fivefold increase in reliability and service life of machinery. To develop new structural materials and hardening processes to increase machine durability.	The lead institute, not the MNTK, claims to have developed a prototype of a fundamentally new robot based on "resonance effect" that cuts power consumption by one-fifth to one-seventh, incorporates composites, and increases reliability. Developed a test bench for Red Proletarly to evaluate accuracy of robot movement. The director of one of the complex's facilities complained that the quality requirements were unrealistic and could not be achieved; they were based on specifications distorted by Western marketing specialists.
Oil Extraction	To develop hydrodynamic, thermal, and physical chemical methods for increasing petroleum recovery operations 6 to 12 percent.	This MNTK was on paper only for at least its first full year. Its lead institute was so ineffective that the MNTK was resubordinated and placed under the leadership of a different institute.
Scientific Instruments	To double the production of scientific instruments by 1990. To cut the R&D time of five to seven years by one-half to two-thirds. To produce by 1990 one-third of all scientific instruments in the country. By 1990, production of scientific instruments for the entire country was to amount to 300 million rubles (100 million for the MNTK).	In 1986 the entire Academy (the MNTK's parent unit) produced 40 million rubles' worth of instruments.
Paton Welding	To develop new materials through electrometallurgy and new methods of welding. For the 12th Five-Year Plan, to save the country "millions of tons" of ferrous metals and to replace "tens of thousands" of workers.	During 1986 the lead institute developed a protective coating and a process for its application. Paton earned 1 million rubles in convertible currency from licensing during 1987.

MNTK Goals and Results (continued)
(Reported in the Soviet Press)

	Goals	Achievements
Personal Computers	For the entire country (not just the MNTK), to produce 1.1 million computers by the end of 1990.	The MNTK displayed a YeS 1840 "general purpose computer" at a March 1986 exhibit.
	To develop within the 12th Five-Year Plan period a "whole range of world-level microcomputers."	The MNTK director has admitted to falling short of plan goals because of bureaucratic obstacles.
	Production in 1988 to increase by 140 percent over that of 1987.	Had to rewrite its plan in 1987 because its proposed R&D activities were not at world levels.
Powder Metallurgy	Expects to save from the transfer of each 10,000 tons of machine-building items to powder metallurgy: 180 metal-cutting machines, 190 workers, and 1.3-1.8 million rubles.	As of February 1987, the complex had not achieved planned production objectives. The press and furnace equipment needed for powder metallurgy production did not meet requirements. As a result, the quality of metal powders was unstable.
Robot	Responsible to head the nation's effort to create robotized complexes and flexible automation systems that will lead to two-and-a-half to fivefold increase in productivity.	As of 1987 the MNTK was "unable to meet its most important assignments."
	For the entire country, 86,000 robots are to be introduced during the 12th Five-Year Plan (in 1986 there were 20,000 robots in the whole country).	One of its principal units was criticized for having only entered three robot models in series production after seven years of work.
	By 1990 to develop 20 new robot models that will serve as the "forefathers" of the entire system of industrial robots.	In 1985, 5,000 robots produced; for 1986, 13,000 produced, 8,000 installed; for 1987, 11,000 installed.
	To develop, by 1986, reliable control units capable of operating without failure for 2,500 hours.	In 1986 it had to rewrite its production plan because many of its proposed areas for research were not at world levels.
Rotor	To conduct a 1-billion-ruble program during the 12th Five-Year Plan for the development of rotary technology.	During 1986, 150 lines introduced.
	To produce 8,450 rotary lines by 1990. (This goal was later readjusted downward to 6,300 lines.)	During 1987, 300 lines introduced.
	Production for 1988 to increase by 110 percent over 1987.	As of February 1986 the MNTK was not performing to its full potential.

MNTK Goals and Results (continued)
(Reported in the Soviet Press)

	Goals	Achievements
Industrial Lasers	For 1989, to produce 200 units and 300 for 1990; by 1990, to produce "hundreds" of laser units with power of 1 kilowatt or more. The complex seeks within the "near future" to produce 1,000 units yearly. To increase service life from 1,000 to 3,000 hours between breakdown. To combine activities of MNTKs Personal Computers, Robots, and Machine Reliability for the development of new production processes. To develop lasers for medical use, measuring equipment, machining centers, and robots.	Produced 28 lasers and laser units in 1987. As of July 1987, the MNTK had received 990 requests for new industrial lasers but had only satisfied four of them because of conflicting and competing demands. Developed in 1987 a laser called Lantan 3 (Lanthanaum 3), but the factory could not produce it because of a lack of technical documentation. As of 1987, the complex's activities were "more and more taking on the character of bureaucratic warfare." Only a few of the many types of lasers it had to develop have been brought up to production stage, and these were—according to the Soviet press—inferior to foreign models.
Thermosynthesis	To develop the process of self-propogating high-temperature synthesis for the manufacture of materials with increased heat and wear resistance.	Its results had not found widespread application within the machine-building sector; there was little interest in the technology.
Fiber Optics	To conduct basic R&D for series production of fiber-optic light guides, cables, transmitters, and devices for collecting and processing information. Prototypes are to have increased reliability and resistance to cold. To shorten the time from R&D to introduction two and a half years.	Was in embryonic form and could not commit to a date to start series production.