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The Role of the USSR Academy of Sciences in Gorbachev's Modernization Campaign (

A Research Paper

SOV 87-10040
July 1987
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The Role of the USSR Academy of Sciences in Gorbachev's Modernization Campaign

A Research Paper

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The Role of the USSR Academy of Sciences in Gorbachev's Modernization Campaign

Summary

Information available as of 1 July 1987 was used in this report.

General Secretary Mikhail Gorbachev is calling upon Soviet science to help modernize the nation's industrial base and meet the technological challenge of the West. Gorbachev has frequently declared that science is the key to sustained technical progress, and he is looking particularly to the Academy of Sciences—the USSR's preeminent authority in science—as the ultimate source of technological advance

Founded in 1724 by Czar Peter the Great, the USSR Academy of Sciences is the most prestigious scientific establishment in the Soviet Union. Its 250 institutes, 800-plus members, and more than 50,000 scientific workers embrace the creme de la creme of Soviet science. The Academy oversees a research complex (including the republic academies) that employs about 9 percent of all scientific workers, 26 percent of all doctors of science, and 14 percent of all candidates of science in the USSR. Two Academy institutes—Radio Engineering and Electronics and the P. N. Lebedev Physics Institute—alone employ almost as many advanced degree holders as all the branches of the electronics and communications equipment industries. This network presently conducts half of all Soviet basic research, and in some areas it is at the cutting edge of world science and technology (S&T).

A major thrust of the Academy's deepening involvement in applied research in recent years has been toward military applications. In recognition of this, Aleksandr Prokhorov, who oversees the Academy's General Physics and Astronomy Department, once said the Academy would pay only for that which "shoots, burns, or explodes." Our identification and analysis of research projects and sponsors indicates that between one-third and two-fifths of Academy institutes do some work for the defense sector. We estimate that military research and development (R&D) undertaken by the Academy in 1985 cost between 500 million and 1 billion rubles, or 2 to 4 percent of estimated Soviet expenditures for military research, development, testing, and evaluation.

Much like Stalin, who enlisted the Academy of Sciences in his industrialization drive a half century ago, Gorbachev is counting on the Academy to spearhead his economic modernization campaign. He is turning to the Academy to make up for lagging science *and* lagging technology in the industrial branch ministries. The Academy is being called upon to do more research in support of fundamentally new technologies, step up its applied R&D work, and take greater responsibility for seeing that its ideas are adopted.

The Academy is mobilizing to support Gorbachev's targeted technologies: electronics and computers, machine automation, nuclear power, biotechnology, and advanced materials and processing. In a few critical areas, such as industrial lasers, its authority extends beyond research through pilot production and into series production. In general, Academy workers are under increased party pressure to shed their ivory tower attitudes and be more responsive to production needs.

Despite its prestige, traditions of excellence, and past performance in pioneering new technologies, several factors constrain the Academy's ability to measure up to Gorbachev's expectations. Some lie in the nature of the Soviet innovation process and the place of the Academy in the overall R&D structure:

- Longstanding organizational and administrative barriers as well as a lack of common incentives impede close relations between the Academy and industry.

- The Academy's role in technological development and diffusion is inherently limited. It can help speed scientific development and nudge the economy toward new technology, but basic decisions about the use of S&T results lie with industrial authorities.

- The scale of the Academy's applied R&D effort—now roughly 4 percent of the national total, up from 2 percent a decade ago—remains dwarfed by industry's own activities. The branch ministries perform more than 90 percent of all applied R&D, garner about 85 percent of total R&D expenditures, and employ more than half of all Soviet scientific workers.

Other limiting factors are rooted in internal Academy problems. Guriy Marchuk, 61, who last October replaced the 83-year old Anatoliy Aleksandrov as Academy president, has charged that conservatism has so penetrated this 260-year-old institution that "now we are becoming slaves of the structures and traditions that have built up over the decades." Over the past 10 years, the Academy's membership and staff have aged considerably. Today there is only one academician under 50 years old, while more than one-third are over 75. The proportion of all scientific workers in the Academy under 40 has fallen from 60 to 45 percent. Meanwhile, many Academy buildings—including leading institutes—are dilapidated and in

disrepair. Living conditions—particularly for young scientists—have reportedly worsened, lowering motivation and morale. Moreover, the Academy's weak experimental base is a major bottleneck in translating research results into production.

The Soviets recognize these constraints and are taking steps to overcome them. Within the Academy, these measures emphasize:

- *Rejuvenating the leadership.* Younger, more energetic scientists are being placed in top leadership positions. They include new President Marchuk, Gorbachev's economic adviser Abel Aganbegyan, robotics expert Konstantin Frolov, and pulsed power specialist Gennadiy Mesyats. They are avid supporters of the modernization of science and industry and reflect the hard-driving and innovative management style called for by Gorbachev. In addition, the Academy at its March 1987 meeting introduced mandatory retirement ages for scientific leadership positions.

- *Reorganizing the structure.* The Academy's internal structure is being reorganized to better focus its efforts on critical new technologies and industrial applications. New departments have been formed for machine building and computer sciences. In addition, two regionally based scientific centers have been upgraded to the status of departments in order to assist the acceleration of regional economic modernization.

- *Refocusing research.* Several new institutes dedicated to applied R&D have been established, and research activities at existing facilities are being expanded, curtailed, or redirected to accommodate new S&T thrusts. [redacted] Gorbachev regime is adopting new wage incentives and funding methods to weed out unproductive research, promote new priority areas, and improve performance.

- *Changing the Academy's composition.* More applied scientists and engineers—including experts from the defense industries—are being elected, with specialities in targeted S&T areas in which the Academy is assuming an increasingly pivotal role.

- *Stepping up resource commitments.* The Academy's budget is slated to increase by nearly 9 percent in 1987. Capital investments will grow by 70 percent during the 1986-90 economic plan in order to improve the

Academy's weak experimental base. To overcome the shortage of scientific instruments, more than 200,000 square meters of production floorspace will be added, and capital investments in this area will grow by 150 percent during 1986-90.

At the same time, the Soviets are taking measures to break down the barriers separating the Academy from industry. In January Gorbachev emphasized that the party has high expectations that new interbranch scientific-technical complexes will hasten the development of critical industrial technologies and their introduction into the economy. These complexes include research, development, and manufacturing facilities from the Academy of Sciences and industrial ministries, with nearly half led by Academy institutes. In addition, 40 temporary laboratories are being set up at Academy institutes during the 1986-90 period to focus on developing specific applications for industry. The Academy is also assuming scientific supervision of selected branch institutes in priority S&T areas.

We believe that Gorbachev's measures for the Academy and industry will lead to some modernization of Soviet science and a revitalized experimental-production base. The renewal of the Academy's leadership should result in the infusion of new blood and ideas. Morale among younger Academy workers will pick up if living and working conditions improve and new wage incentives are implemented. To the extent the Academy is able to expand its equipment holdings and testing facilities, its capabilities to develop new technology for industry and to advance the cause of Soviet basic science will grow.

Renovation of the Academy, however, will be difficult and protracted. Any attempts at radical or rapid change will encounter resistance and institutional inertia, and the regime will probably move cautiously so as not to alienate the very institution on which it is pinning such high hopes. The new organizational linkages that aim at speeding up the research-to-innovation cycle are no panacea for the longstanding problems impeding Soviet S&T development, and they have not yet proved their effectiveness. The new Academy leadership will probably spend the rest of this decade just trying to get its house in order, and it will take at least a decade to build up its lagging technological infrastructure.

Success in applying and disseminating S&T advances of the Academy will depend upon policy decisions and reforms in the industrial R&D and production sectors, and to date such measures have not produced any significant change. For Gorbachev's modernization drive to succeed, he will have to create effective incentives in the production sector for adopting new technology. Moreover, the new technologies the Academy is spearheading are generally interbranch in nature, and the obstacles to their diffusion into the economy are the most formidable. Progress is likely to be particularly slow, and the rapid pace of Western advance means the Soviets will need to exert tremendous effort just to keep from falling further behind.

On balance, we believe the Academy's contribution to modernization of the economy will be modest and will not be felt until the late 1990s. The Academy can hasten scientific development and assist industry in finding applications for new materials and processes, but it cannot dictate the implementation of S&T results. Nonetheless, to the extent the Academy can revitalize itself, strengthen its ties with industry, and advance S&T priorities critical for sustained industrial modernization, Academy accomplishments will have a positive impact on Soviet economic development in the next century.

Many of the USSR's targeted technologies are essential for the next generation of weapon systems. We believe the defense sector is especially well positioned to capitalize on Academy advances. Special mechanisms help ensure that Academy research results are more effectively scrutinized and utilized by the military than by civilian industry. There is more "demand pull" for scientific advance in defense, generated in part by military competition with the West. Moreover, the strong organizational and management tools available to the defense establishment will help to push technology development in directions that benefit the military. In particular, the military has two organizational levers which still have no real civilian counterparts:

- The Section for Applied Problems, which is subordinate to the Presidium of the Academy and staffed by the Ministry of Defense and serves as the focal point for coordinating all military research undertaken by the Academy.

- The Military-Industrial Commission (VPK) of the USSR Council of Ministers, which oversees and monitors implementation of Soviet weapon development programs.

These mechanisms will continue to ensure that the military establishment benefits quickly from scientific advances that the Academy may achieve.

The competition between civilian and defense sectors for resources in the USSR is likely to be sharp over the next decade and will help shape the course of Academy S&T development. Defense and industrial modernization programs compete for many of the same resources—particularly high-quality inputs and high-technology products that will remain in short supply. Competition for Academy R&D resources could grow as a result of either a more threatening international environment and a high-tech, SDI-oriented arms race or because Gorbachev's civilian modernization program falls short of expectations. We expect the Academy to be squeezed from both the military and civilian sides in advancing the new S&T areas underpinning industrial modernization and the sophisticated weapon systems of the 1990s and beyond.

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The Role of the USSR Academy of Sciences in Gorbachev's Modernization Campaign

Soviet Science Under Gorbachev

General Secretary Gorbachev has made industrial modernization the heart and soul of his strategy of economic revitalization. At issue is nothing less than the reindustrialization of the USSR, a task that ranks in scope and significance with Stalin's industrialization drive of the 1930s.[1] Gorbachev has repeatedly emphasized—most recently at the January 1987 Central Committee plenum—that there is simply no alternative to accelerated modernization: "Any other path means a relinquishment of position, an orientation toward lag." A prominent Soviet journalist suggested the previous December that, if the economic decline is not arrested, the Soviet Union would become another "developing country" and "could even end up as a tail to China."

Gorbachev has given new impetus to measures aimed at advancing science and technology (S&T) and making it the engine that drives industrial modernization and economic growth. In an April 1986 speech he stressed, "to continue making mistakes in technology policy means driving the economy further into an impasse." Accordingly, he has built on initiatives begun under Brezhnev, added new ones, and generally developed a long-term "strategy" for S&T progress.[2] His measures emphasize:

- *Reliance on new technologies.* Microelectronics, computers, biotechnology, industrial lasers, and advanced materials are recognized as the pacemakers of S&T progress. Their accelerated development and utilization are bringing to the forefront problems of interministerial coordination and the need for more effective mechanisms for securing joint action between science and industry.
- *Revolutionary advance.* Soviet specialists stress that the potential for real breakthroughs lies with the pursuit of fundamentally new technologies and processes, which depends on basic science.
- *Major innovations.* Because they disrupt the production process, the Soviet system discriminates against major discoveries and inventions. In 1984, 24,500 inventions were first used in Soviet industry, reportedly resulting in 2.2 billion rubles in economic savings, but only 600 of these accounted for 40 percent of the total savings.
- *Wide-scale diffusion.* According to a recent Soviet publication, 97 percent of introduced inventions are used at only one plant and less than one-half of 1 percent are used at three to five enterprises. In March 1985 the Soviets established an Interagency Commission on Questions of Accelerating the Introduction of Especially Important Inventions Into the Economy. It is to identify promising technologies and ensure their application in many industrial branches. For example, savings from the use of radiation technology alone during the 12th Five-Year Plan (1986-90) are estimated to reach 1 billion rubles.
- *Greater independence.* In numerous speeches, Gorbachev has argued that the long-established practice of borrowing and copying foreign technology has created what he calls the "syndrome of imitation and inferiority" that pervades Soviet S&T. He has stressed the importance of strengthening domestic science and technology and shedding the mentality of being copycats and "eternally second best."

Prominently reflected in Gorbachev's strategy is his frequently expressed belief in science as the key to sustained technical progress

Academy Functions and Resources

The USSR Academy of Sciences, established in 1724 by Czar Peter the Great as the Russian Academy of Sciences, is the leading scientific organization and principal conductor of basic research in the Soviet Union. The Academy plans the development of Soviet science, performs considerable research and development (R&D), and increasingly is expected to oversee the implementation of R&D results. It also trains scientific personnel, maintains ties to foreign scientific associations, and coordinates all research—regardless of institute affiliation—on the most important problems of the natural and social sciences (see figure 1). Its coordinating responsibility extends to the activities of the 14 republic academies of sciences and to specialized academies subordinate to the Agriculture, Health, Education, and Culture ministries. On the recommendation of the Politburo, the Academy in October 1986 elected Guriy Marchuk as its new president (see inset).

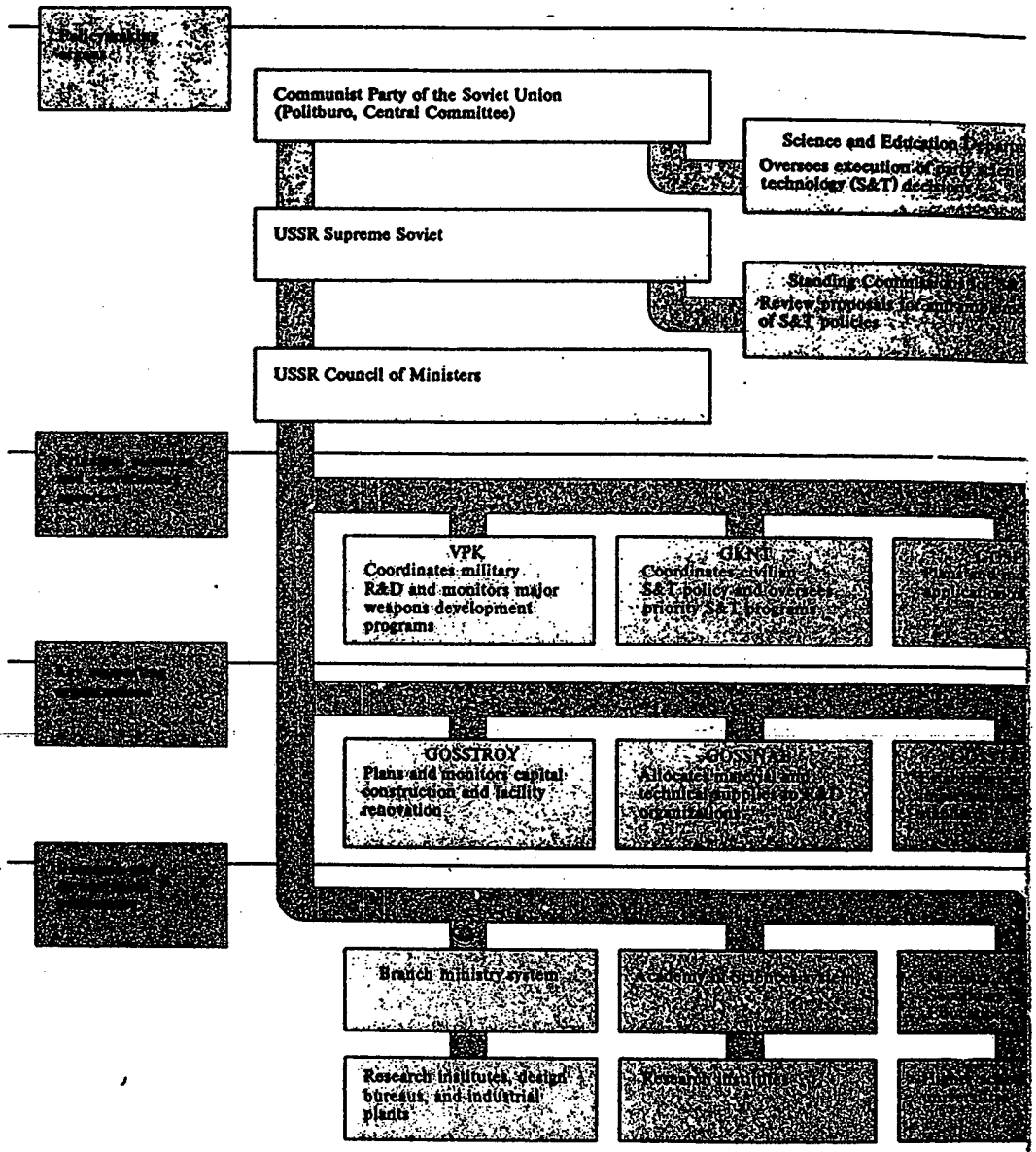
Election to membership in the Academy—by secret ballot of the members—is the highest honor a Soviet scientist can achieve. As a rule, to be elected as an "academician" (full member), one's work must be of paramount scientific significance. Communist Party membership is not a formal prerequisite, and until 1951 Academy presidents had not been members. Since then, however, the percentage of party members among academicians has steadily grown—from about one-half in the early 1960s to more than two-thirds in the mid-1980s.[1] After its last elections in December 1984, the Academy was composed of 290 full members and 555 corresponding members. With the growth of party membership among Academy members, the party is now in a better position to dominate the Academy's internal structure and influence the organization's operation—including the election process—than it has ever been before.

Planning R&D

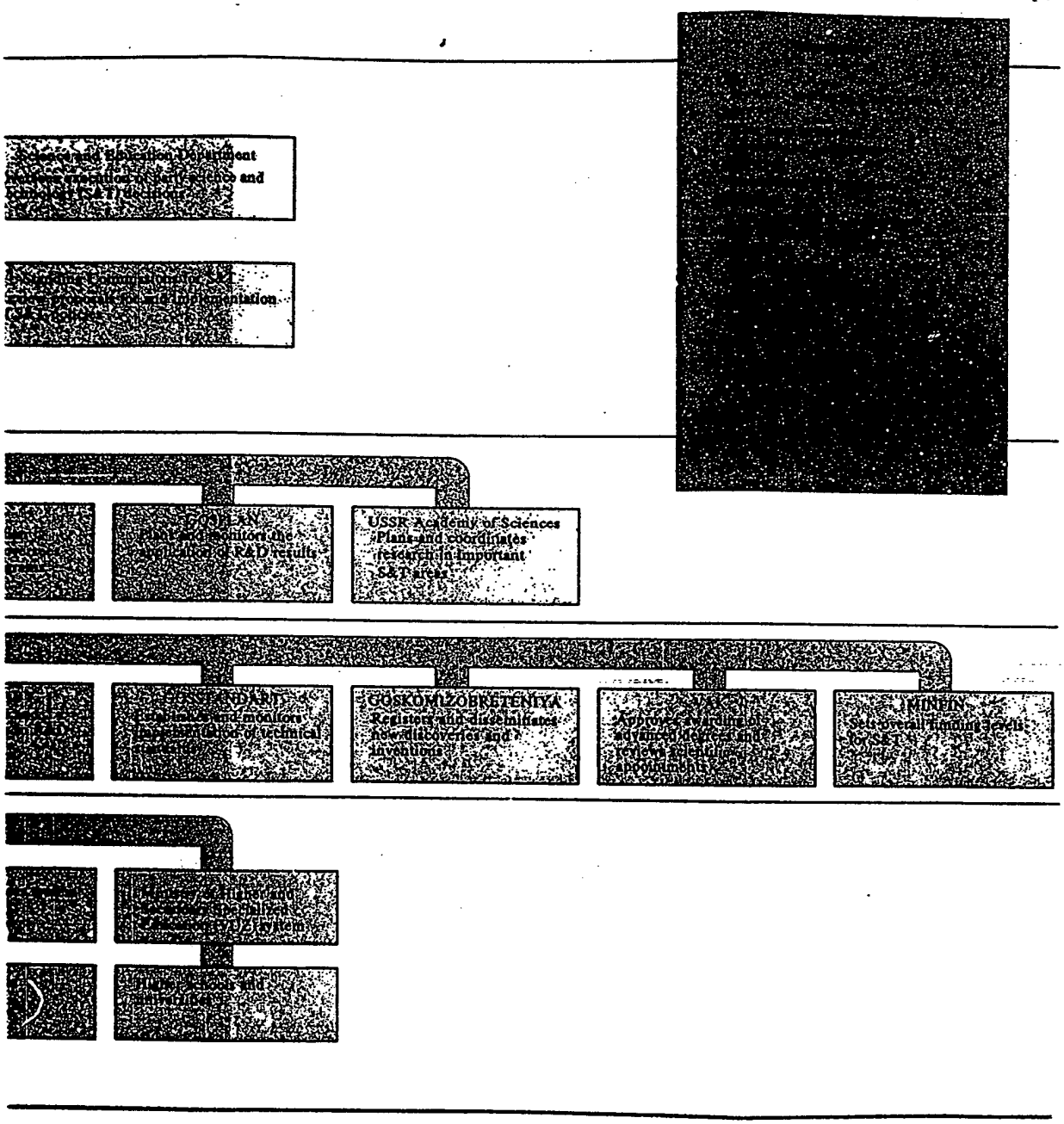
The Academy dominates the formulation of Soviet S&T policy. In the 20-Year Program for S&T Progress, the Academy, the State Committee for Science and Technology (GKNT), and the State Planning Committee (Gosplan) specify the course of Soviet science and technology. The program, which is based on long-range scientific forecasts and technology assessments, devises lists of social, economic, and S&T problems and formulates "goal-oriented programs" to address them. In turn, the program is being used increasingly to drive the system of economic plans, to

[1] See DI Biographic Research Paper CR 82-10698, May 1982, *The USSR Academy of Sciences: Independence and Political Control*

Figure 1
The Role of the Academy of Sciences in Soviet Research and Development (R&D)



it (R&D)


GOSPLAN
Plans and monitors the application of R&D results
USSR Academy of Sciences
Plans and coordinates research in important S&T areas
GOSKOMIZOBRETENIYA
Registers and disseminates new discoveries and inventions
GOSSTROY
Sets overall funding levels for S&T

attempt to more effectively integrate S&T and economic policies, and to define national priorities. The current program, for 1986-2005, was used in drafting the Basic Guidelines for the 1986-90 economic plan and for the period extending to the year 2000. The Academy has already begun work on the next version of the 20-Year Program—updated to 2010 and due to be completed in 1988. To strengthen Academy capabilities in long-range planning, a new Institute of Economics and Forecasting of S&T Progress was created in 1985. In recent speeches President Marchuk has also emphasized the critical need to bolster the Academy in this area.

The Academy's network of scientific councils for "comprehensive" problems coordinates R&D in all establishments that tackle priority problems and recommends directions for future research. Councils are composed of leading scientists and technologists from the Academy, universities, and industrial ministries; and they report directly to the Academy presidium. After receiving strong criticism of the councils, the Academy presidium was instructed in March and again in October 1986 to improve their effectiveness. The Scientific Council on Fundamental Problems of Future Technologies, established under the presidium in December 1985 and headed by President Marchuk, is likely to be particularly important to Gorbachev's program, inasmuch as it is charged with organizing Academy basic and applied research on principally new technologies.

Performing R&D

The Academy of Sciences, the industrial branch ministries, and higher educational establishments (VUZy) conduct R&D. The terms academy science, branch science, and VUZ science are commonly used in referring to this tripartite division of the research sector. Indeed, Soviet science is divided predominantly along institutional and administrative lines rather than according to different kinds of activity, such as basic research, applied research, or innovation.

At the end of 1985, the USSR Academy had approximately 250 research institutes and employed nearly 200,000 persons, including 55,583 scientific workers (4 percent of all scientific workers). Included were 31,614 workers with advanced degrees (13 percent of all doctors of science and 6 percent of all candidates of science). The concentration of scientific expertise in a few institutes is formidable. For example, the Institute of Radio Engineering and Electronics and the P. N. Lebedev Physics Institute employ almost as many advanced degree holders as all the branches of the electronics and communications equipment industries. The entire academy system—USSR, republic, and specialized branch academies—employs about 9 percent of all scientific workers, 26 percent of all doctors of science, and 14 percent of all candidates of science in the USSR.

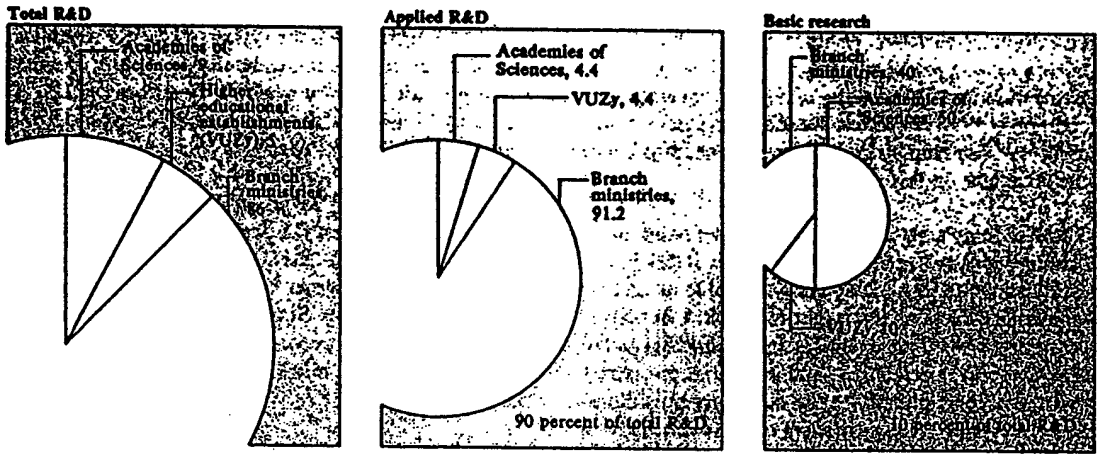
According to recent Soviet published sources and accounting measures, the academy system accounts for 9 percent of total R&D expenditures, while the branch ministries garner the vast bulk—about 85 percent (see figure 2). Similarly, Academy institutes have fewer than 10 percent of all scientific workers, while the industrial ministries employ more than 50 percent.

Although declining in strength, the Academy still dominates Soviet basic research. Several Soviet authors have reported that the Academy share of expenditures for basic research has declined from an estimated 70 percent in the early 1970s to 50 percent in the 1980s. The other half is conducted by the branch ministries (about 40 percent) and the VUZy (10 percent). Soviet published studies have estimated that expenditures for basic research now equal about 10 percent of total official science spending. This ratio suggests a nearly 4-percent decrease in the share of basic research since the early 1970s. In a November 1986 lecture at Leningrad University, Leonid Blyakhman, a noted authority on Soviet science, said that over the last 20 years there has been a drop in basic research from 14 to 7 percent of overall S&T activity.

At the same time, Academy institutes have been doing more and more applied R&D. As a result of this shift in emphasis, the share of applied research in the Academy's total funding has essentially doubled, from

Figure 2
Shares of Soviet Research and Development (R&D) by Performer, Mid-1980s[a]

Percent



[a] Based on published Soviet statements and official statistics on expenditures for science and R&D.

about 20 percent in the 1970s to 40 to 50 percent in the 1980s. According to rough estimates recently published by the Soviets:

- An average of 50 percent of all State Budget financing for the Academy now goes for work on national S&T programs—roughly half of which concerns applied R&D. Among the 170 programs in the 1981-85 economic plan, the USSR Academy participated in 112, or two-thirds, of the programs (including 32 of 41 target programs). In all, about 200 Academy institutes—out of a total of 250—were involved in this activity.

- The share of contract research conducted by the USSR Academy for industrial ministries has grown. In 1970, this share amounted to only 5 percent of all work; in 1975, already 10 percent; in 1980, 14 percent; and in 1982, 17 percent. In republic academies this share is much greater; and in some academies—notably the Ukrainian and Belorussian—it exceeds 50 percent.

Overall, the Academy now accounts for about 4 percent of total Soviet applied research, up from 2 percent a decade ago. According to a RAND Corporation analysis of Academy institute research fields, a total of more than 330 research institutes of the USSR and republic academies are important contributors to technology development. Most are located in the industrial areas of the Russian and Ukrainian Republics, and about one-half specialize in various fields of physics and chemistry.[4]

[4] See Simon Kassel and Cathleen Campbell, *The Soviet Academy of Sciences and Technological Development*, RAND Corporation, R-2533-ARPA, December 1980

This shift in emphasis toward more applied research also reflects the Academy's increased involvement over the past two decades in research with military applications. [redacted] Aleksandr Prokhorov, academician secretary of the General Physics and Astronomy Department, once said that the Academy would pay only for that which "shoots, burns, or explodes." Our identification and analysis of research projects and sponsors indicate that between one-third and two-fifths of the 250 Academy institutes do some work for the defense sector. We estimate that military R&D undertaken by Academy institutes in 1985 cost between 500 million and 1 billion rubles, or 2 to 4 percent of estimated total Soviet military RDT&E expenditures.[3]

Implementing Results

The Academy also participates actively in moving ideas from the laboratory into production and use. A Soviet scientific publication recently noted that, during 1981-85, USSR Academy institutes and the enterprises and organizations of approximately 60 ministries jointly implemented more than 3,800 R&D results. About 1,200 developments from Academy institutes were reportedly put into use by Soviet industry

Academy Support. The abilities of Academy institutes to support implementation depend on their research profiles. Some institutes encompass the entire research-innovation cycle, including pilot and small production. The Ukrainian Academy of Sciences in particular has developed a strong experimental design and pilot production base. In 1965 there were 16 pilot production subdivisions in the Ukrainian Academy with a total production volume of about 12 million rubles a year; in 1983 this number had increased to 72, and the total amount of work exceeded 200 million rubles.

In general, however, the inadequacy of pilot plant and large-scale testing facilities within the academy system is a major bottleneck to translating research results into production and use. Many Academy institutes have no pilot base at all. Although 50 percent of the employees at the Ukrainian Academy of Sciences and 30 percent at the Belorussian, Moldavian, and Latvian Academies are engaged in pilot production, at the Georgian Academy only 3 percent are, at the Kirghiz Academy only 2 percent are, and none are at the Kazakh Academy. The absence or inadequacy of pilot production is also a major deficiency in many USSR Academy institutes. At present, the total number of workers involved in experimental design and pilot production at the republic academies is nearly fivefold greater than at the USSR Academy of Sciences, according to Soviet published sources.[4]

Academy leaders, moreover, complain about the lack of experimental equipment and the overall quality of scientific instruments. This shortage of instrumentation support—including computing power—not only slows the research effort, but in some fields leaves Soviet experimentalists unable to effectively participate in forefront research.[4] Former Academy President Anatoliy Aleksandrov in March 1985 noted that "a difficult situation" had developed in this whole area, and he emphasized, "It must not be allowed that scientific instruments would be the step over which we will stumble." In November 1986, newly elected President Marchuk also stressed, "It seems to me that the time has come . . . for the establishment of a [national] program for these superimportant and supernew directions in the development of scientific instrument making, new materials, and components produced in limited quantities, ensuring more rapid S&T progress."

Industrial Acceptance. The Academy generally can only recommend and advise industry about what ideas to accept. The decision to adopt S&T advances rests with the ministries, the GKNT, and Gosplan. The Academy's scientific authority and bureaucratic leverage are generally insufficient to move the ministries to accept its results. According to Soviet calculations, only 30 percent of all research completed by the USSR Academy in the past few years has been accepted by the ministries. Overall, work done by the Academy and VUZy make up less than 6 percent of the workload of sectoral R&D organizations

[4] See White House white paper, *A Study of Soviet Science*, December 1985

Industry is particularly slow to adopt Academy recommendations on complex new technologies, materials, and processes. During the 1981-85 plan period, for example, the Academy sent to the GKNT, Gosplan, and the ministries more than 250 proposals on introducing its most important research of an interbranch nature. By March 1986, however, only 50 of these proposals had been adopted. Many innovations have not received widespread use for more than five years. Similarly, in 1985 the Academy proposed that more than 600 research results be put into production and included in the 12th Five-Year Plan. By March 1986, however, 28 ministries had not even replied to the Academy's recommendations. From 200 completed research projects proposed by the Siberian Department of the Academy for inclusion in the 1986-90 Plan, Gosplan accepted 114, including 39 for inclusion in national S&T programs.

Because the Soviet industrial sector has almost a complete veto over Academy proposals, the effectiveness of the Academy's contribution to technical progress depends substantially on its successful cooperation with industry. Because of longstanding organizational and administrative barriers as well as a lack of common incentives, such cooperation has generally not been close. For all practical purposes, the Academy stands outside the ministerial system and lacks an effective "outlet" into the economy and a mechanism for implementing its scientific results.

Although the Academy is not a central actor in the Soviet weapons acquisition process, special mechanisms help ensure that Academy research results are more effectively scrutinized and utilized by the defense sector than by civilian industry. There is more "demand pull" for scientific advance in defense, generated in part by the military competition with the West. In addition, there is greater "technology push" by a powerful customer that has strong organizational, planning, and management tools as well as incentives to support the S&T needs of weapons development and defense industrial modernization. For example, there is no civilian counterpart to the Section for Applied Problems, which is subordinate to the presidium of the Academy, staffed by the Ministry of Defense, and serves as the focal point for coordinating all military-related research in the Academy (see inset). Nor is there yet a real counterpart on the

The Section for Applied Problems: The Academy's Military Link

The Section for Applied Problems (SPP) serves as the interface between the Academy of Sciences and the Soviet military establishment. It coordinates and monitors all research projects that Academy organizations undertake for the Ministry of Defense. A major task of the SPP—reportedly quite a small organization—is to review Academy research to identify and promote technology that could support military interests or be applied to weapon systems. The section in the mid-1970s reportedly played a key role in managing the work of a commission tasked to forecast new weapon systems to 1995.

The SPP is formally subordinate to the Academy's presidium but also reports to the Ministry of Defense. (It probably developed from the Academy's wartime Department of Special Projects, which coordinated defense work between the Academy and military organizations.[ ] [ ] the president of the Academy of Sciences has the authority to reject proposals from the SPP. The section reportedly maintains corresponding branches at the Academy's Siberian Department and at each of the republic academies.

[ ] the SPP is staffed by military personnel. Since at least 1975, the section has been headed by a two-star general, Yuriy Chuyev, a doctor of technical sciences and a specialist in military forecasting. In 1984 Chuyev was nominated for, but not elected to, corresponding membership in the Academy's Department of Mechanics and Control Processes. Chuyev's predecessor at SPP was Germogen Pospelov, a retired general, who is an artificial intelligence specialist at the Academy's Moscow Computer Center and a full member of the Academy's new computer technology department

civilian side to the Military-Industrial Commission (VPK) of the USSR Council of Ministers, which oversees and monitors the implementation of Soviet weapon development programs. In fact, largely because of these special mechanisms and systemic conditions, Moscow has long been more successful at harnessing S&T progress for military power than for economic growth.

Fostering Academy Development of New Technology

Soviet leaders generally regard the Academy of Sciences—the USSR's preeminent authority in science—as the ultimate source of technical progress. They are turning increasingly to the Academy to make up for serious deficiencies—lagging science *and* lagging technology—in the branch ministries. Although the Academy is being called upon to do more basic research in support of fundamentally new technologies, it is stepping up its applied R&D work even more and is acquiring greater responsibility for seeing that its inventions and innovations are adopted.

These initiatives are rekindling a longstanding debate over the proper role of the Academy. Although basic research always has been the Academy's primary mission and strength, the Academy has had an important but widely varying responsibility for applied R&D. As part of his efforts to enlist the Academy in the USSR's industrial modernization drive, Stalin added a Technical Sciences Department in 1931. The applied physical scientists soon came to outnumber and dominate basic researchers and scientists. In the early 1960s Khrushchev reorganized the Academy, abolishing the Technical Sciences Department and transferring one-third to one-half of the Academy's applied institutes to industry.

Under Gorbachev the regime's attitude has come almost full circle. The abolition of the Technical Sciences Department is now publicly criticized by Academy leaders as a mistake. At its March 1987 general meeting the Academy began discussing the question of adding a Technical Sciences Section (that would embrace several departments) to its structure. Similarly, Gorbachev's demand that the Academy

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Academy Opposition to the Applied Research Thrust

Some scientists fear that the party's drive to involve the Academy more in applications-oriented research will detract from the Academy's traditional concentration on basic research. They stress that it is difficult to underestimate the role of theoretical science for applied purposes and insist that "the primacy of science over industry must be observed." Academician secretary M. A. Markov, for example, recently observed, "The study of basic problems, which at a given moment do not promise direct, practical results, is one of the principal tasks of the Academy of Sciences." Similarly, Academician A. S. Spirin argues, "One must not forget that basic research is the main 'bread' and the most important business of the Academy of Sciences." I. S. Shatilov, a vice president of the Academy of Agricultural Sciences, opines that "without basic science there can be no applied science."

Some scientists emphasize that the Academy's involvement in applied work already has gone too far, its resources are stretched to the limit, and it should not take on extra responsibilities and roles that more fittingly belong to the economic ministries. Academician Vitaliy Ginzburg has been particularly explicit on this score:

> *"It is inadmissible to carry out the strengthening of the contacts of science with production at the expense of other directions of the activity of the Academy. Suffice it to say that the USSR Academy of Sciences plays the leading role in the country in the development of the directions of so-called basic science, which it is impossible to do without, even under the conditions when its 'outlet' into technology is still not entirely evident."*
>
> *"It is in no way possible to reduce the assurance of S&T progress to the introduction of new equipment, technology, and so on. It is difficult to overestimate the role of basic science. . . . It is clear that the Academy cannot deal in earnest with all sciences . . . to be responsible for everything under existing conditions means not to be responsible for anything."*

Table 1
Soviet Leaders Responsible for Overseeing Targeted Key Technologies

S&T Area	General Oversight Authority	Scientific Leader
Electronics and computers ("electronization")	Yuriy Maslyukov, Deputy Premier and Chairman, VPK	Yevgeniy Velikhov, USSR Academy Vice President
Machine automation	Ivan Silayev, Deputy Premier and Chairman, Machine-Building Bureau	Konstantin Frolov, USSR Academy Vice President
Nuclear power	Ivan Silayev	Anatoliy Aleksandrov and Valeriy Legasov, Director and Deputy Director of the Kurchatov Atomic Energy Institute
Biotechnology	Vsevolod Murakhovskiy, First Deputy Premier and Chairman, Agro-Industrial Committee	Yuriy Ovchinnikov, USSR Academy Vice President
New materials and processing technologies	Vladimir Gusev, Deputy Premier	Boris Paton, Ukrainian Academy President and Director of Paton Electro-Welding Institute

support his modernization program recalls Stalin's concerns. Such pressure has kindled resistance among many Academy scientists (see inset on page 9).

Gorbachev has given no indication that he is going to ease up on this pressure. The new Academy president has long championed greater Academy-industry interaction. Former President Aleksandrov, who openly and strongly defended the priority of basic research, may have resisted Gorbachev's drive to build closer ties between scientific research organizations and industry. Marchuk's speeches indicate that he is sensitive to internal Academy concerns and will seek to balance the party's demands for more applied research and support for the modernization program while preserving the Academy's traditional and still primary mission as the nation's leading performer of basic research. In a March 1987 *Izvestiya* interview he said:

> *I would like to stress once again that much scientific research is organized according to the Russian fairy tale principle: 'Go somewhere, don't ask me where, and bring back something, don't ask me what.' There is very much that we cannot foresee, and historical experience proves that some discoveries are unpredictable.*

Targeting Key Technologies and Industrial Application

Soviet S&T policy for the 12th Five-Year Plan targets five key areas for development: electronics and computers, machine automation, nuclear power, biotechnology, and advanced materials and processing technologies. These broad areas have been made the priority directions throughout the Soviet Bloc and are embodied in the Comprehensive Program for S&T Progress Through the Year 2000, adopted in December 1985 by the countries of the Council for Mutual Economic Assistance (CEMA).

Soviet academies of sciences have prominent roles in each of the targeted areas. According to a recent Soviet journal, various deputy premiers of the USSR Council of Ministers have been assigned to oversee these priority directions, while prominent members of the presidium of the USSR Academy have also been appointed as "scientific leaders" for each (see table 1). These appointments indicate the importance attached to the Academy and to some of its key leaders in implementing Moscow's S&T strategy and industrial modernization program

The Soviets are implementing these policies by formulating priority programs, including so-called target programs, for the 1986-90 period. Although we know little about the focus of the new programs, we believe they echo the thrust of programs in the 1981-85 plan. During that period, almost 60 percent of the 129 programs for solving long-term S&T problems and almost 70 percent of the 41 shorter term target programs for bringing new technologies on stream and into series production concerned the same five key areas that Gorbachev has identified as critical to industrial modernization. Many of the target programs are said to have fallen behind schedule and are most likely being carried over into the present plan. The total number of S&T programs has been cut from 170 to 160 in the current plan.

In general, our analysis of Soviet science and technology indicates that the Academy has the wherewithal to provide valuable support in each of these areas. Academy laboratories report experimental production of microelectronic devices and sensors that are close to Western achievements, and much advanced over what is available in Soviet industry. Academy institutes have done outstanding work in laser isotope separation, fast breeder reactors, and other technologies critical to the nuclear power program. The Academy has a long and successful history of work in biotechnology. In materials and materials-processing technologies, achievements in areas like powder metallurgy and industrial laser applications approximate Western development. The challenge is centered on moving available Academy achievements into widespread application.[1]

The Academy itself is undergoing reorganization to better focus efforts on critical applied technologies and to "push" industrial assimilation (see figure 3). Several new institutes dedicated to applied research have been established, and research activities at existing facilities have been expanded, curtailed, or redirected to accommodate priority S&T thrusts. This reorientation is also seen in the increasing numbers of applied researchers, industry-based engineers, and science administrators, particularly from the defense sector, in the Academy's membership. The Academy's last elections in December 1984 reflected this trend, which is likely to become even more pronounced as the emphasis within the Academy continues to shift toward more applied science and deeper involvement in Gorbachev's modernization program. Organizational and personnel changes are particularly evident in the areas of computer technology, mechanical engineering, and applied economics and technology assessment.

The Information Science, Computer Technology, and Automation Department. The USSR Academy of Sciences played a prominent role in the early development of Soviet computer technology; in fact, it pioneered the BESM-6 computer. With the reorganization of the Academy in the early 1960s, however, some key institutes working in this area (including the Precision Mechanics and Computation Techniques Institute and the Institute of Electronic Control Machines) were transferred to industry, and the Academy's research program was cut back. The creation of the Information Science, Computer Technology, and Automation Department in 1983—the first new department in the Academy since 1968—was part of an effort by the political leadership to bring the Academy back into the computer technology field in a big way and to rebuild its lost capabilities.[2] A key task of this department is to help overcome the USSR's lag behind the West in a critical technology that is seen by the Soviets to be impeding not only modernization of the economy but development of Soviet science as well. Vice President Yevgeniy Velikhov, who heads the department, has defined its main R&D objectives as follows:

- To develop large supercomputers.
- To accelerate the development and production of small (micro-, mini-, and personal) computers for mass use.
- To develop advanced microelectronics materials, devices, and fabrication methods.

At its formation in March 1983, the computer department was given four research institutions formerly subordinate to other departments of the Academy—the large Moscow and Leningrad computer centers

[1] Soviet applied science has been the subject of study by the Foreign Applied Science Assessment Center (FASAC), Science Applications International Corporation, McLean, Virginia. For further discussion, see FASAC, *Integration Report: Selected Aspects of Soviet Applied Science*, April 1985

[2] For a more detailed analysis of this new department, see Simon Kassel, *A New Force in the Soviet Computer Industry: The Reorganization of the USSR Academy of Sciences in the Computer Field*, RAND Corporation, N-2486-ARPA, August 1986.

and two institutes that specialize in theoretical aspects of applied mathematics and programming. Since then, it has added nine more institutes and acquired an R&D technology base consisting of pilot plants and related facilities. The new institutes (and year established) are:

Cybernetics Problems Institute, Moscow (1983)
Microelectronics Institute, Yaroslavl' (1983)
Problems of Microelectronics and Ultrafine Materials Technology Institute, Chernogolovka (1983)
Computer Center, Pushchino (1984)
Informatics Problems Institute, Moscow (1984)
Automated Design Institute (location unknown) (1986)
Informatics Problems Institute (affiliate), Orel (1986)
Programing Systems Institute, Pereslavl'-Zaleskiy (1986)
Problems of Computer Technology Institute (location and date unknown)

Some of the new institutes are spinoffs from scientific organizations subordinate to industrial ministries. At least three are headed by prize-winning engineers who have been closely tied to the defense-related ministries of the electronics and radio industries.

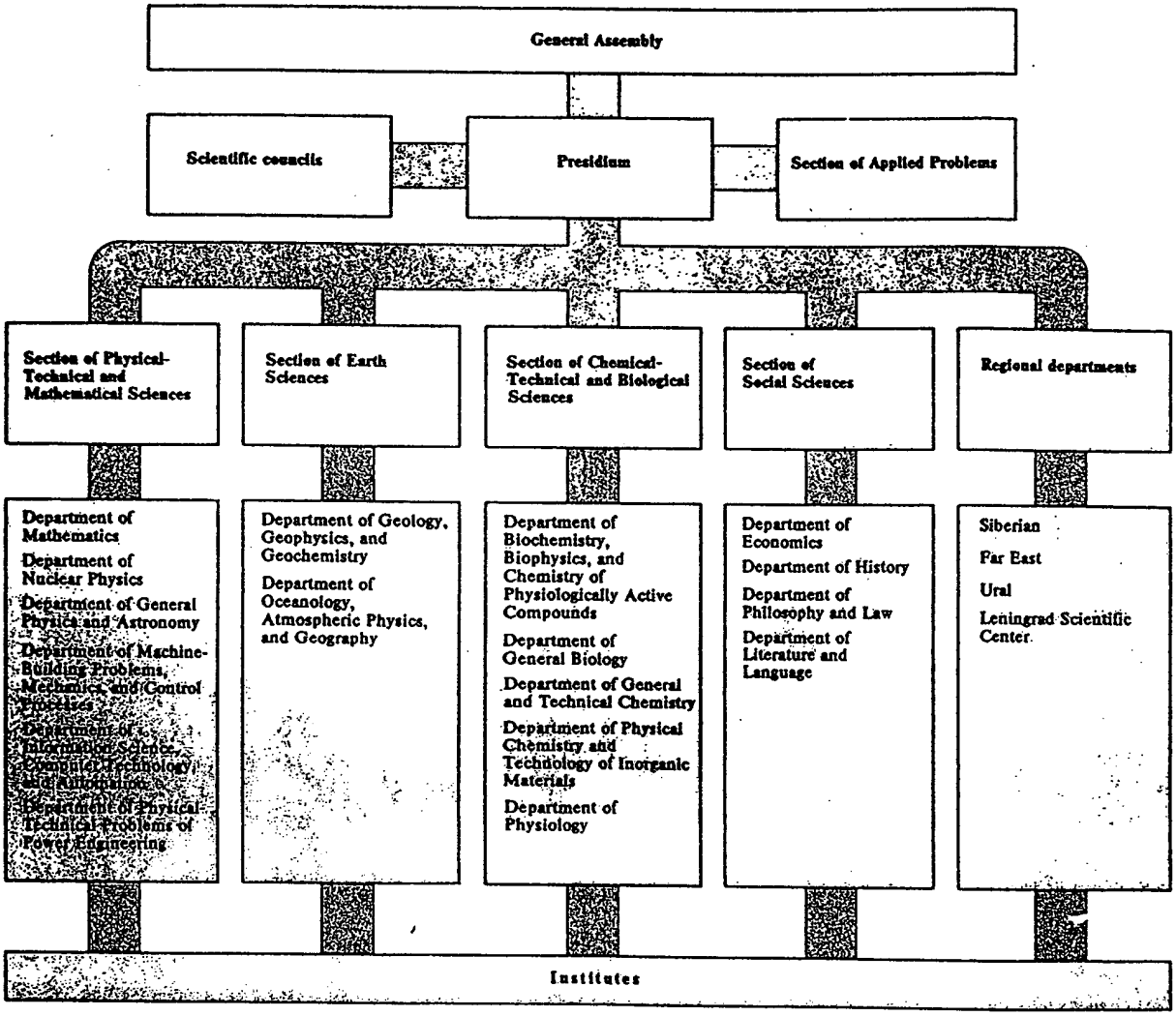
The December 1984 Academy elections further indicated the enhanced priority assigned by the Soviet leadership to computer technology as well as the regime's commitment to bring into the Academy the outside talent and experience needed for it to tackle the computer problem. As a result of the elections, Velikhov's department gained 14 full members and 26 corresponding members. This is nearly twice the number of allotted vacancies announced in *Izvestiya* on 14 September 1984. Although two-thirds of the full members work in Academy institutes, fewer than one-third of the corresponding members do. In fact, almost half of the corresponding members were drawn from facilities subordinate to industrial ministries

Moreover, the elections reflected the deep involvement of the military R&D sector in the new computer department. At least half of the newly elected members are known to have conducted research specifically for the military. Among their predominant specialties are several that relate clearly to weapon systems and technologies: artificial intelligence, guidance systems, remote sensing, and radar systems. Many of the new members head major R&D facilities subordinate to the defense industries. Lev Koshkin, chief of a design bureau for rotary technology and automated ammunition production processes, and Anatoliy Savin, chief of a design bureau and designer of a missile guidance system, were elected academicians. New corresponding members with strong defense ties include Pavel Agadzhanov, a major general who in the 1970s directed the Air Defense Systems Engineering Institute, and Dmitriy Kozlov, chief of a design bureau for space and missile components

The Mechanics and Control Processes Department. The Academy is also being pressed hard to provide support to the machine-building sector. It is this sector that embodies S&T advances "in metal" and holds the key to retooling the Soviet economy. At the June 1985 Central Committee conference on science and technology, Gorbachev called for an Academy department on machine-building problems. In March 1986 the Mechanics and Control Processes Department of the Academy of Sciences was reorganized and renamed the Machine-Building Problems, Mechanics, and Control Processes Department. Academy Vice President Konstantin Frolov heads this department and is also director of the Academy's A. A. Blaganravov Machine Sciences Institute, a leader in Soviet research on machinery, automated manufacturing technology, robotics, composite materials, and computer-assisted design and manufacturing systems.

This department is expected to play an instrumental role in meeting Gorbachev's industrial modernization goals. It brings considerable assets to the task, being one of the largest and most oriented to applied R&D of the Academy's substantive subdivisions. After the 1984 elections, in which nine full and eight corresponding members were selected, the Mechanics and Control Processes Department was comprised of 39 full and 54 corresponding members. More than half of the new members

Figure 3
Organization of the USSR Academy of Sciences, 1987



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were drawn from industrial R&D facilities, while the rest were evenly divided between Academy institutes and higher educational establishments.

The department also traditionally has had the closest ties to military R&D. All of the members elected in 1984 had worked on military or space-related research projects. Their individual scientific specialties—aircraft design, sensors, radar, and space control and guidance systems—reflect this focus. Many of the new members hold key positions at defense-related research institutes or design bureaus. New academicians include the prominent aircraft designers Aleksey Tupolev and Genrikh Novozhilov, who head the Tupolev and Il'yushin design bureaus, and the designer of ballistic missiles Vladimir Utkin, who heads the Yangel Design Bureau. New corresponding members include Petr Belyanin, director of the Aviation Technology and Organization of Production Institute; Nikolay Semikhatov, director of a research institute for sea-launched ICBMs; and Valeriy Vasil'yev, a specialist on composite materials at the Moscow Aviation Technological Institute.

As part of the reorientation and expansion of this important department, affiliates of the Blaganravov Machine Sciences Institute are being created during the current five-year economic plan in large machine-building regions of the USSR—Gor'kiy, Sverdlovsk, Leningrad, and Saratov. Each will specialize in a particular problem area: Gor'kiy—new hardening technologies; Sverdlovsk—new technological processes in metallurgical machine building; Leningrad—automation in machine building; and Saratov—automated design systems for machine building and their software. Plans are also being laid for additional affiliates in Kuybyshev and Volgograd in the early 1990s. A new Academy Institute of Superhigh Plasticity Problems is being created in Ufa. The Academy recently drew up a long-term program on basic research in machine building for the Machine-Building Bureau of the USSR Council of Ministers.

The Economics Department. Abel Aganbegyan, a close adviser to Gorbachev, was recently installed as academician secretary and is moving vigorously to restructure this department and its work. Last year, the heads of its two largest institutes—the Institute of Economics and the Central Economics and Mathematics Institute—were replaced. Both institutes have been roundly criticized by the CPSU Central Committee for lagging rather than leading the country in research and analysis on the economic and social problems of technological change. In 1985 a new Institute of Economics and Forecasting of S&T Progress was created to assist the Academy in its long-term planning and technology assessment efforts. The rector of the Academy for the National Economy, Yevgeniy Sergeyev, was also replaced in mid-1986. The new leaders, most of whom are in their late forties or early fifties, represent the biggest injection of new blood into the management of economic sciences in many years.

One of the key missions of the Economics Department and its new institute leaders is apparently to produce the kind of innovative thought and solutions needed to implement reform and accelerate modernization of the Soviet economy. *Pravda* recently called upon economists to be "the navigators" of restructuring efforts. In his March 1986 report on the work of the Economics Department, Aganbegyan emphasized in particular the need for a better methodology for determining the economic effectiveness of new technology. He has been a strong critic of costly high technology, such as robotics, that frequently does not bring a commensurate economic return. Equally blunt on this score is Leonid Abalkin, the new director of the Institute of Economics. He told the Academy's October 1986 meeting:

> *If we do not fundamentally change our approach to determining many scientific and technical solutions and their introduction into practice, if we introduce robots for the sake of robots and FMS [flexible manufacturing systems] for the sake of FMS, then instead of reconstruction of the national economy we will ruin it within the next five to 10 years. This kind of progress can turn out to be ruinous, disastrous, and ineffective.*

As Gorbachev's modernization campaign moves into high gear, the economic and social costs and benefits of S&T progress are likely to become an increasingly important and contentious issue in economic policy and Kremlin politics. Interaction and conflict between

the economists and engineers, both inside and outside the Academy, will grow. Economists will press the engineers to be more cost conscious, while the latter will urge the former to be more technology oriented. Aganbegyan and other Academy economists may find themselves more and more the voice of caution and restraint against overzealous salesmen of high technology. Moreover, a lack of adequate Soviet measures for calibrating S&T progress and the economic effectiveness of new technology will exacerbate the debate and complicate decisionmaking over policy choices.

Stepping Up Resource Commitments

The Soviet leadership is aware of the strained conditions under which the Academy of Sciences operates and has taken steps to improve the Academy's capabilities to accelerate S&T progress. In the 1986-90 plan, Moscow has increased substantially the allocation of resources to the science sector in general and to the Academy in particular:

- Expenditures on science (excluding capital investment) are to rise to 33 billion rubles in 1990 from 24.8 billion in 1985. This would bring the average annual growth during 1986-90 to 5.9 percent compared with 4.3 percent during 1981-85. These expenditures would allow R&D organizations to purchase more and better materials and small-scale equipment, improve training, and increase wages or bonuses.

- More important, the Soviets plan to increase capital investments in science by 70 percent during 1986-90—an average annual rate of 11.2 percent compared with 7.5 percent during the 1970s. These increases are slated directly for capital improvements at research organizations—new and better equipment and facilities to do scientific research, development, testing, and evaluation (RDT&E)—and to build up the RDT&E base to develop this new equipment.

- Capital investments allocated to national S&T programs in the 1986-90 plan are almost three times the amount allocated in the last five-year plan.

Industry is also being told that it should allocate an increased share of its budget to science. The USSR Supreme Soviet's Commission for Machine Building recently rejected proposals by some of the machine-building ministries to spend about 7 percent of their capital investment on science and instead recommended that up to 12 percent be allocated "for every branch of machine building in the USSR in 1987."

As part of the increased funding for science, substantially more resources are flowing to the USSR Academy of Sciences during the current five-year plan period:

- The general budgetary allocation for the Academy in the Soviet State Budget in 1987 is 8.8 percent more than in 1986. In October 1986, Politburo member Yegor Ligachev indicated that, on the instructions of the Central Committee, proposals are being drawn up to accelerate the development of research by the Academy in the priority areas of chemistry, chemical technology, high-energy physics, and mathematics. The Politburo, in fact, approved a special decree on developing mathematics in January 1987.

- Capital investments for the Academy are being increased by 70 percent—the same rate as for total science—to about 1.5 billion rubles by 1990.

- Capital investments aimed at strengthening the Academy's experimental-production base and its instrument-making "shop" will grow by 150 percent. The volume of production of precision instruments and means of automation for scientific research will more than double by 1990 (to more than 100 million rubles a year) and will more than quadruple by 1995, according to Ligachev. To help accomplish this task, a number of new design bureaus and plants with more than 200,000 square meters of floorspace will be added to the Academy during the current plan period. The share of total capital investments in science devoted to instrumentation now equals 15 percent, up from 10.4 percent in the 1981-85 plan and 4.1 percent in the 1976-80 plan

Managing Support to Industry

Science and industry in the USSR have been largely separate worlds, coexisting rather than cooperating in moving ideas from the laboratory into practice. Last November *Pravda* characterized the relations between science and industry as similar to "communication between earth dwellers and inhabitants of other planets." In general, science has been unresponsive to the needs of production, while production has been unenthusiastic about the results of researchers. The scientific activity of the Academy in particular has been isolated from manufacturing activity. This has contributed to the endemic ivory-tower attitude of many Academy members and to its traditional public image of aloofness from daily economic problems.

A major thrust of recent organizational efforts has been to strengthen the Academy's traditionally weak technology base, both to enhance Academy capabilities to conduct applied R&D and to raise industry's interest and confidence in Academy research results. At an international scientific conference in July 1986, for example, Academician Gennadiy Mesyats, new head of the Academy's Ural Scientific Center (now Ural Department), remarked that his ability to "interface with industry" will be limited unless a large pilot plant is built to support the center's work. Besides expanding their own experimental and testing base, Academy leaders are also working to increase their access to, and joint use of, facilities and services across sectors on the basis of negotiated settlements and shared interests. Academy scientists, for example, are making greater use of the experimental design and pilot production bases of ministries—including the defense industries—while the latter are tapping the basic and applied research capabilities of the Academy.

Scientific and political leaders have high expectations that new organizational forms integrating science, technology, and production will speed the development and utilization of research results. Some Academy members, however, are taking a more skeptical view of current organizational approaches. They emphasize that these new mechanisms are no panacea for overcoming longstanding problems in coupling science with production and, for that matter, are no substitute for faulty research and development. Aleksandr Bayev, who directs the Academy's Biochemistry, Biophysics, and Chemistry of Physiologically Active Compounds Department, reminded the December 1985 general meeting of the Academy that "organizational work by itself does not create any conceptual or practical value but only ensures conditions for creative work. Thus, we should not flatter ourselves with the hope that organization can compensate for shortcomings in research."

Organizational Measures

To break down the barriers separating the Academy from production, a number of linkages are being established or strengthened.

Subordination of Branch Institutes to Academy Scientific Leadership. To enhance the Academy's ability to coordinate and control key directions of basic research outside the Academy, selected branch institutes have been made subordinate to both their parent ministry and the Academy of Sciences. In 1981, the Academy's charter was amended to enable its departments to exercise tighter scientific supervision over such institutes. Under this arrangement the departments are supposed to evaluate the state of basic research at the institutes every three years. In addition, the presidium of the Academy must approve the appointment and dismissal of the directors of these institutes. By early 1986, 29 branch institutes had been brought under the "scientific methods supervision" of the Academy.

So far, however, this mechanism has not been effectively employed. During 1981-85, Academy departments heard reports on the work of only seven of 29 branch institutes. Both the departments and the presidium have been criticized for "passive interference" in the affairs of these institutes. The work of one such collective, the Scientific Research Institute for Biological Testing of Chemical Compounds, was roundly criticized at the February 1986 Congress of the Communist Party of the Soviet Union (CPSU). Citing this institute as an example of what such an irresponsible attitude toward scientific methods supervision leads to, the chief scientific secretary of the Academy in March 1986 emphasized, "It is time to put an end to such a situation, and as quickly as possible.

Konstantin Frolov, an Academy vice president and academician secretary of the Mechanics and Control Processes Department since March 1985, has actively promoted this form of Academy-industry linkage in the machine-building area. Although the Academy's largest department in terms of individual members, it has among the fewest Academy institutes under its jurisdiction. Thus, this mechanism would seem to offer this department a particular opportunity to extend Academy influence over key institutional R&D actors outside the Academy—including the defense industries—in the development of new industrial technologies.

According to the Soviet press, the following Leningrad organizations have been put under Academy scientific and methodological leadership:

- The All-Union Scientific Research Institute of Electrical Machine Building—a major S&T center of large electrical machine building and the scientific headquarters of the giant Elektrosila Production Association.

- The Central Scientific Research and Experimental Design Institute of Robotics and Technical Cybernetics of the Leningrad Polytechnical Institute *imeni* M. I. Kalinin—the leading organization in the USSR in the development of industrial robots and responsible for the standardization and technical evaluation of robot equipment.

- The All-Union Scientific Research Institute of Metrology *imeni* D. I. Mendeleyev, with the status of a scientific production association (NPO).

- The All-Union Scientific Research and Planning Institute for the Mechanical Processing of Minerals—the head organization of the newly established Mekhanobr interbranch scientific and technical complex.

The process is continuing. Academician Igor Glebov, chairman of the Leningrad Scientific Center, recently proposed that the Central Boiler and Turbine Institute *imeni* I. I. Polzunov—also an NPO and the leading organization in the country for problems in power machine building—be brought under Academy scientific supervision. In late 1985, the NPO for Machine-Building Technology of the Ministry of Power Machine Building was added to the list of branch institutes under Academy scientific guidance. In the January 1986 issue of the Academy's organizational journal, Frolov proposed that the Institute of Corrosion attached to the GKNT come under the scientific methods supervision of the Academy. In addition, he suggested that this status also be extended to several major higher educational establishments—including the Scientific Research Institute of Mechanics attached to Moscow State University and a number of institutes attached to the Moscow Higher Technical School *imeni* N. E. Bauman.

Creation of Temporary S&T Laboratories. Special laboratories are being set up at Academy institutes to focus on developing specific applications for industry on the basis of research performed at these institutes. These so-called temporary S&T laboratories are created for a period not to exceed three years and are to function essentially as special project teams for solving particular problems. Funded entirely by various ministries, the laboratories permit Academy scientific workers to use the equipment, instruments, and facilities of the contracting ministries as well as to collaborate directly with industrial R&D and production personnel who, as one academician puts it, "know the problems and reality."

The idea of this organizational form evidently arose with Vice President Velikhov. The Academy's Section of Physical-Technical and Mathematical Sciences—which he oversees—first proposed the establishment of such collectives. In 1981, temporary S&T laboratories were formed on an experimental basis at eight Academy institutes in Moscow, Leningrad, Sverdlovsk, Gor'kiy, and Vladivostok. Seven of the institutes have been publicly cited for significant accomplishments (see table 2).

On the basis of these initial results, various Academy leaders and Soviet press commentary argue that this organizational form has proved its effectiveness and "has earned the right to life." The GKNT positively evaluated the experience of these laboratories in late 1985 and recommended that they be organized more broadly. Consequently, 12 temporary S&T laboratories are being created at institutes under the Department of General Physics and Astronomy for the 1986-90 period. According to the department's academician

Table 2
Temporary S&T Laboratories at Academy Institutes

Institute	Focus of Development
Institute of Radio Engineering and Electronics	Computer components and assemblies . . . awarded the S&T Prize of the USSR Council of Ministers for 1984 . . . devices now being put into series production.
Institute of High Temperatures	Laser technology for reconditioning and surface hardening of rollers of the 2000 rolling mill for the Cherepovets Metallurgical Combine.
Institute of Metal Physics (Sverdlovsk)	Special flaw detectors for testing welds in arc-welded pipes . . . introduced at six metallurgical and pipe plants in the Urals . . . discontinued importing similar foreign equipment.
Institute of General and Inorganic Chemistry *imeni* N. S. Kurnakov	New technology for producing electronic instruments for the Elektron Production Association.
Institute of Solid-State Physics	A new technological process and equipment for producing amorphous fine-crystalline alloys . . . aimed at problems of communications equipment technology.
Institute of Applied Physics (Gor'kiy)	A new technological process for the rapid growing of large single crystals . . . introduced at the Monokristall Reaktiv NPO of the Ministry of the Chemical Industry . . . shortened the time to produce such crystals from one and a half years to only a few weeks.
Physical-Technical Institute (Leningrad)	Special kinds of semiconductors for fiber-optic communications lines.

secretary, they will focus in particular on developing applications of lasers in medicine and industry and of fiber optics of different types. By October 1986, 31 laboratories were already operational throughout the Academy, and nine more were in the planning stage.

Organization of National-Level Interbranch S&T Complexes (MNTKs). As part of Gorbachev's modernization program, the Soviets are establishing large scientific and technical complexes to speed the development of critical industrial technologies and their introduction into the economy. The complexes include research, development, and manufacturing facilities from both the Academy of Sciences and industrial ministries and are designed to bridge the gap between theory and production. They focus on areas in which breakthroughs would benefit the entire industrial front, and they report directly to the USSR Council of Ministers. These so-called interbranch scientific and technical complexes, or MNTKs, are the most important organizational innovation in Soviet S&T policy since the creation of NPOs in the late 1960s.

Basically, MNTKs aim at providing an outlet to the economy for major S&T innovations that fall outside traditional branch lines of industry and run into the greatest organizational obstacles. As Marchuk explains, MNTKs have been created to overcome these impediments and "to open a wide road for the most advanced technologies that by their nature are interbranch and, if we are to be entirely precise, multibranch." Scientific results in these key areas generally have an "ownerless quality" and the "character of Cinderella," according to various Soviet writers. Such promising innovations typically fall into a "no man's land." Vladimir Revnivtsev, corresponding member of the Academy and general manager of the Mekhanobr MNTK, observes, "Interbranch S&T complexes will be vitally interested in the use of the extensive possibilities of the no man's land."

To a large extent, MNTKs are an outlet for the practical application of research results produced by Academy institutes, which have frequently been in the

forefront in developing innovative and complex technologies. Indeed, Academy institutes are the lead organizations in at least half of the new complexes—including the areas of fiber optics, industrial lasers, and chemical catalysis (see inset). This also indicates that the Academy of Sciences is assuming increased responsibility for the implementation of research results.

The spectrum of technologies placed under the purview of the complexes offers insight into Soviet priorities. All are oriented toward practical applications, and many target the development of advanced equipment and materials for industrial modernization—especially machine tools, robots, flexible manufacturing systems, microelectronics, computers, and composite materials. Many of the technologies are dual use—important for cost-effective production of more sophisticated weapon systems as well as for high-quality civilian goods. Some of the new complexes include defense-related R&D and production facilities, indicating that defense industries will be actively involved as both developers and users of the new technologies.[10] A special responsibility of MNTKs is to oversee the implementation of national S&T programs—including target programs—in their area of specialization.

So far, however, these complexes in general have had a hard time getting off the ground. In October 1986, Politburo member Ligachev complained that organizing them was being "dragged out unjustifiably" and declared that the party leadership had recently discussed the situation and had "warned" leaders of ministries and the Academy of their "personal responsibility for effective use of this basically new form of interbranch integration of science with production."[11] At the January Central Committee plenum, Gorbachev stressed that the party is pinning high hopes on MNTKs and that the closest attention must be paid to their formation and development. Party secretary Lev Zaykov, who oversees the defense industries, carried the same message when he visited the Rotor MNTK in February and the Membrany MNTK in May.

According to the Soviet press, MNTKs led by Academy institutes—with a few notable exceptions, like the Paton Electrowelding Institute complex—are particularly weak and are having growth pains. A *Sotsialisticheskaya Industriya* two-part article reported in February 1987 that most MNTKs are unable to implement their programs and establish reliable relations with production units. Several MNTKs are having difficulty getting capital investment, credit, qualified staff, equipment, and, above all, experimental and pilot production facilities. Their internal organization and management are bogged down in bureaucratic red tape. Some scientist-leaders apparently are finding it difficult to be technological entrepreneurs, who must market products and nurture customer/user relations. Evidently because of these problems, some Academy-led MNTKs (focusing on fiber optics, personal computers, and machine reliability) have recently been resubordinated to industrial ministries, leaving the Academy responsible only for

[10] The Rotor MNTK is led by the Design Bureau for Automated Lines, which is subordinate to the Ministry of the Defense Industry and has pioneered the development and application of rotary technology, including its use in ammunition production automation. Lev Koshkin, who heads the design bureau and is Rotor general director, was elected a full member of the USSR Academy of Sciences in December 1984. According to the Soviet press, some 29 organizations from 22 ministries are involved in the work of this complex.

[11] Published accounts of last October's special Academy of Sciences session indicate that former President Aleksandrov's possible resistance to closer ties between the Academy and industry may have brought him into conflict with Marchuk, the driving force behind the creation of MNTKs. Aleksandrov's initial misgivings about MNTKs came through in his speech. He related that "at first we supposed" that this would require the transfer of many industrial enterprises to the Academy, something that would provoke "serious contradictions between the Academy and industry and that therefore nothing would result." He emphasized that the success of this organizational innovation will require considerable help from not only the political leadership but also the industrial ministries, since "we still have not found common language and real forms of joint work with all of them."

Interbranch Scientific and Technical Complexes (MNTKs)

According to Politburo member Lev Zaykov, as of March 1987, 21 MNTKs had been created or were in the final stages of approval. Since the creation of MNTKs in December 1985, Soviet press articles have referred to proposals to found the following 24 complexes:

Name of Complex	*Area of Focus*
Personal'nyye EVM [a]	*Personal computers*
Svetovod [a]	*Fiber optics*
Tekhnologicheskiye Lazery [a]	*Industrial lasers*
Nadezhnost' Mashin [a]	*Diagnostic means to improve machine reliability*
Biogen [a]	*Biotechnology*
Katalizator [a]	*Chemical catalysts and new catalytic processes*
Nauchnyye Pribory [a]	*Scientific instruments*
Radiatsiya [a]	*Industrial applications of radiation technologies*
Mikrofotoelektronika [a] *(proposed, not yet confirmed)*	*Miniaturized optoelectronic detectors*
Impul'snyye Mashiny [a] *(proposed, not yet confirmed)*	*Pulsed-power machines and storage devices*
Avtomatika [a] *(proposed, not yet confirmed)*	*Computer-aided design and manufacturing systems*
Institut Elektrosvarki Ye. O. Paton	*Welding and electrometallurgy*
Rotor	*Rotors and rotary-conveyor lines*
Robot	*Robotics and flexible manufacturing systems*
Membrany	*Polymers and membrane filtration systems*
Nefteotdacha	*Oil and gas enhanced-recovery technology*
Mikrokhirurgiya Glaza	*Eye microsurgery*
Metallurgmash	*Metallurgical equipment*
Poroshkovaya Metallurgiya	*Powder metallurgy*
Mekhanobr	*Crushing and pulverizing equipment*
Termosintez [a]	*Thermal synthesis of new inorganic compounds and materials*
Antikor	*Anticorrosion techniques and protective coverings*
Geos	*Geological prospecting and exploration of mineral resources*
(Unknown)	*Computer technology*

[a] *A USSR Academy of Sciences institute serves as the lead organization.*

The Laser Technology MNTK

The Laser Technology MNTK is subordinate to both the USSR Academy of Sciences and the Ministry of the Electrical Equipment Industry (Minelektrotekhprom). The lead organization is the Academy's Scientific Research Center for Industrial Lasers (NITsTLAN), located in Shatura, near Moscow. NITsTLAN's director, Galym Abil'siitov, also serves as the director of the complex.

Besides NITsTLAN, the MNTK includes the Academy's General Physics Institute, P. N. Lebedev Physics Institute, and Problems of Mechanics Institute. The complex also encompasses at least seven Minelektrotekhprom organizations or subunits. According to a May 1986 newspaper article by Abil'siitov, however, some of the facilities existed only on paper. Before the complex can become fully operational, the ministry must organize and build a new institute for laser technological equipment as well as a special design bureau.

The complex, as envisioned, will differ from many of the other Academy MNTKs in that its activities will extend beyond the pilot production stage into series production. By 1990, the complex is to produce hundreds of laser units with a power of 1 kilowatt or higher to be used for the treatment and processing of materials for machine building. Current production is mainly focused on carbon dioxide (CO_2) lasers and ion lasers. Planned work also includes the development of lasers for medicine and communications.

Like other MNTKs, the complex has encountered difficulties and bureaucratic obstacles in getting started. According to Abil'siitov, major problems include a lack of support in obtaining supplies, facilities, and worker housing. He called for the State Committee for Science and Technology, responsible for procedural support of the complexes, not only to make recommendations on how to organize the MNTKs, but also to assist the MNTKs by responding quickly to queries and interceding and resolving bureaucratic disputes. Abil'siitov warned that, without total support, there was indeed a danger that the complex would never get beyond the paper-planning stage. In effect, no one is in charge. "Dual" subordination fragments responsibility, leaving the ministry and the Academy indifferent and with insufficient authority to integrate and manage the complex as a whole.

"scientific leadership." Three other complexes (concerned with thermal synthesis, chemical catalysis, and biotechnology) headed by Academy institutes have also been realigned more closely with particular ministries. They may now enjoy "dual subordination" status, whereby the Academy shares overall management responsibility with a separate ministry—as it does in the case of the Laser Technology MNTK (see inset)

Strengthening the Role of Regional Scientific Centers. The Soviet leadership is also pressing the Academy to have its regional scientific centers play a more active role in supporting economic modernization. Ligachev called for "bolder steps" in this direction during his October 1986 speech before the Academy. Noting that more than half the scientific workers in the Academy system are employed at the regional centers and republic academies, Ligachev emphasized, "This is a large potential, and it must be used more effectively."

While this effort to strengthen the role of the regional centers began under General Secretary Andropov, Gorbachev has given it new impetus. Marchuk, who formerly headed the Siberian Department, already has signaled that this will be a key direction in "restructuring" the Academy in the months ahead. In general, the regional scientific centers are being directed to strengthen their technical orientation and industrial ties, to concentrate resources on priority regional economic problems, and to coordinate the research of industrial and educational establishments

with that of Academy institutes. Party leaders are trying, nationally and locally, to use the Academy to break down or circumvent ministerial barriers to technological change.

Leningrad. In March 1983, a new scientific center of the Academy was created in Leningrad—a major stronghold of defense industry and high-technology development. A primary task of the center is to spearhead S&T advance in the northwestern and northern economic regions. Construction of an "academic town"—along the lines of the Novosibirsk model—has begun on the northern outskirts of the city in Shuvalovo Ozerki. Most of the center's existing 53 scientific organizations and more than 20,000 scientific workers will gradually be moved there. The entire complex of buildings is planned to be completed by 1995.

The Leningrad Scientific Center has had the strong backing of and has cooperated closely with regional party leaders. The center exercises scientific supervision over the so-called Intensification-90 Program, Leningrad's blueprint for modernization. More than half the center's scientific institutes are taking part in this program, which Gorbachev praised early on and may have used as a model for his industrial modernization drive for the USSR as a whole. Gorbachev also brought former Leningrad party boss Lev Zaykov into the CPSU Secretariat to oversee the Soviet defense industry and the economy.

In late 1986, [redacted] reported that Gorbachev has launched a new scheme of regionalizing research institutions under the aegis of the Academy of Sciences and that the Leningrad area has been selected for a two-year pilot program. This program began last summer and aims at eliminating the duplication, lack of coordination, and enormous disparities in equipment, personnel, and funding among industrial R&D units, the Academy, and educational establishments. The impetus for this initiative reportedly is economic: the USSR can no longer support three distinct, independent, and overlapping research communities, given its chronic agricultural problems and the massive costs of its military posture.

The Far East. In November 1986 the Academy decided to upgrade the Far Eastern Scientific Center—set up in 1960—to the status of a department and to restructure it along the lines of the Siberian Department. Up to now the latter had been the Academy's only regional department (besides its 17 substantive departments). During his July 1986 trip to the Far East, Gorbachev emphasized the strategic importance of this region for the country's economy. At the same time, he criticized the Academy's Far Eastern Center for its isolation from practice and poor use of scientific potential in solving problems connected with development of the natural resources and productive forces of the region. Only two of its 20 institutes have an applied engineering orientation, and fewer than 15 percent of its scientific workers are in the area of industry. During a recent session of the presidium of the Academy of Sciences in Vladivostok, the first secretary of the Maritime Regional Party Committee summed up the situation:

> *Either we change the state of affairs in science in the near future and secure from it the necessary, full influence on all aspects of the region's social and economic development, or we will continue to become ever weaker and fall further behind, while having practically unlimited potential for a mighty leap forward.*

According to Marchuk, the new Far Eastern Department will be given great autonomy in planning research and determining future directions. Funding for the department will come from the budget of the Russian Republic and not—as is the case with the USSR Academy itself—from the all-union budget. Even if resources are forthcoming, however, building up the existing meager material and technical base of this department will be a lengthy and difficult process.

The Urals. The Academy has also reorganized its Ural Scientific Center into a department. Together, then, "these three departments—the Siberian, Far Eastern, and Ural—will be serving the most dynamic oblasts and regions of the Russian Federation in the East of our country," according to Marchuk.

Leadership efforts to promote S&T in the Urals, one of the USSR's oldest industrial and most technologically backward areas, predate Gorbachev's rise to power. In October 1983, the CPSU Central Committee issued a special decree on the Academy's Ural

Scientific Center aimed at improving its work. The decree called upon the Council of Ministers to increase the resources devoted to the center.

In the spring of 1986, Gennadiy Mesyats was made head of the Ural Scientific Center in Sverdlovsk and a member of the USSR Academy presidium. Formerly director of the Institute of High Current Electronics in Tomsk, he is a prominent expert on pulsed power and reportedly is deeply engaged in SDI-type research. He has told other scientists that he was brought to the Ural Center to work on commercial applications of his pulsed power devices—specifically, ion implantation, metal surface treatment, and metal hardening.

Mesyats described his new responsibilities as "the industrialization of high technology." told that Mesyats is "a very important person, charged with bringing high technology to heavy industry in the Urals area."

Mesyats has permission to build a new science center near Sverdlovsk that will be similar to Akademgorodok in Novosibirsk. He also has said that one of his main responsibilities will be to expand scientific-industrial cooperation. At the same time, Mesyats expects that the Ural Center will have a tough time implementing this policy—particularly if support for construction of a pilot plant for the center is not forthcoming

Although it supports the orientation of the Academy toward applied research, the trend toward regionalization also represents further encroachment by the party and industry on the Academy's institutional autonomy. According to the Soviet press, party officials are prominently involved in several regional scientific centers, especially in the Ukraine and parts of the Russian Federation. Indeed, Ligachev himself was actively engaged in science issues when he was a regional party official in both Novosibirsk and Tomsk. In practice, these scientific centers appear to function as coordinating arms of their respective party committees as much as of their republic academies or the USSR Academy. Local party authorities are using them to propel S&T development and industrial modernization in their areas.

Strengthening Motivation for Innovation

The Soviets also are adopting measures aimed at creating a more favorable climate within the Academy for applied research and technology development. They include greater rewards for innovation and sanctions to weed out unproductive research. The issue of improving living and working conditions for Academy workers—particularly young scientists—is also being aired in the Soviet media (see inset). However, a better incentives policy is the least developed part of Gorbachev's modernization program. While ongoing measures may lead to improved performance to some extent, they are also causing anxiety and confusion among Academy workers

Increased Salaries and Bonuses. The salaries of Academy personnel are being raised in accord with a 22 May 1985 party-government decree on measures to raise the pay of Soviet scientists, designers, and engineers—on average by 35 to 45 percent. In early 1983 staff scientists at Academy institutes in Moscow were openly complaining to foreign scientists about their low salaries.[12] They contrasted their incomes with those of foodstore clerks or truckdrivers who, because they can make extra money through black-marketeering and other illicit activities, allegedly "earn more than all but the upper ranks of scientists."

scientists and engineers were becoming increasingly frustrated because they were rarely rewarded for their effort and had few incentives to do innovative work. Vice President Vladimir Kotel'nikov in October 1986 noted that this issue had been raised several times at recent general meetings of the Academy of Sciences

The new system establishes a more differentiated pay scale for each position, allowing management greater flexibility in promoting and rewarding productive

[12] The former pay scale for scientists with advanced degrees—nearly half of all Academy scientific workers—had not been changed in nearly 30 years and no longer stimulated productivity and innovation. All salaries were established in a fixed amount, pay increments were not regularly granted, and the level of pay was not dependent on quality and end results

Living and Working Conditions at the Academy of Sciences

Along with the prestige of working at Academy facilities, scientific workers have generally been afforded a wide range of benefits and better living conditions than other R&D personnel. Benefits and privileges vary widely, of course, with one's position; academicians enjoy high salaries, chauffeured cars, luxury apartments, a summer dacha, and access to special retail shops and goods. However, over the past decade the living and working conditions within the Academy—especially for junior scientists—have deteriorated. This deterioration reflects, in part, the erosion of the prestige of science as a profession, acknowledged by the Soviet leadership as an issue of major concern.

Housing conditions for workers at the USSR Academy of Sciences have reportedly worsened in recent years. At the scientific centers in Pushchino, Troitsk, Chernogolovka, and Fryazino, housing construction has lagged badly. At the beginning of 1986, the queue to obtain living space in Pushchino alone came to 1,340 families; in Troitsk, 1,526 families; in Chernogolovka, 1,107 families; and in Fryazino, 953 families. Many scientific associates of these centers have been waiting to receive better housing for 10 or more years. The housing needs of Academy workers in Moscow and Leningrad also have not been met.

Moscow has 185 scientific institutions of the Academy of Sciences, but they have only 33 dining halls and 15 snack bars at their disposal. Many Academy buildings, including prestigious institutes, are dilapidated and in disrepair. The construction of many medical facilities and health resorts for Academy workers is far behind schedule. A polyclinic in Moscow, which began construction in 1979 and was planned to be put into operation in 1984, is only half finished. The building of the Uzkoye Sanatorium has stretched over two five-year plans but still is only 60-percent completed. On 1 January 1986 the value of unfinished construction projects at the USSR Academy of Sciences approached 400 million rubles.

According to the March 1986 report of the Academy's chief scientific secretary, the publishing-printing base of the Academy has fallen behind the needs of the times. The equipment at the printing plants of the Science Publishing House is sorely outdated and in poor working order. The Main Editorial Board of Physical Mathematical Literature even lacks a simple copying machine. According to Academician Ginzburg, scientific institutes "even in comparatively poor India" receive several times more money to buy foreign scientific literature than the Academy's large Lebedev Physics Institute

employees. Instead of two scientific position categories (senior and junior scientific worker), there now are five: chief scientific worker, leading scientific worker, senior scientific worker, scientific worker, and junior scientific worker. The three lower levels are now independent of an advanced degree. It is now possible for a scientist who has not defended a dissertation but has achieved high practical results to receive a higher wage than a candidate or doctor of sciences whose research results seem more modest.

According to the decree, directors of Academy institutes have been granted the authority to allow pay increments of up to 50 percent of base salary for the fulfillment of very complex and crucial work and pay increments of up to 30 percent for skilled engineering and technical workers for meeting deadlines. New legislation in October 1986 authorized even larger bonuses but did not specify their exact size. Directors are able to reduce or cancel the increments if deadlines are not met, if work quality is unsatisfactory, or if work discipline is violated. Scientific workers will be reclassified every five years based on their performance. Directors can increase a worker's salary between classification periods if his work is of high quality and timely.

Under the decree, heads of temporary S&T laboratories, which are created at Academy institutes but work on industrial assignments, are permitted to pay their workers 30 percent above their normal salary as well as offer a substantial bonus for meeting new technology goals. Meanwhile, additional material incentive funds are being created at Academy institutes—including a fund for social-cultural measures and a fund for housing construction—along the lines of industrial R&D organizations. Institute directors have also been given authority to fire unproductive workers and to use their wages to reward top performers. The magnitude of these incentives depends directly on the courage of directors.

According to the Soviet press, more than 80 percent of Academy institutions had shifted to the new system of remuneration by 1 October 1986. In the process, official salaries were reduced for about 3 percent of Academy workers and were increased for 31 percent. As in other R&D-related initiatives, however, these measures have not lived up to expectations. Head of the Economics Department Aganbegyan recently observed in the Academy's journal that the new system of incentives for scientists has "the risk of becoming yet another good idea which will wither away" because of failure of implementation. Basically, Academy institute directors have approached this issue like their industrial R&D counterparts. Fearing conflicts and complaints, they have been reluctant to get rid of deadwood.[11] Moreover, institute directors, not wishing to offend anyone, have generally distributed any wages saved equally to all rather than reward only the most productive workers.

Gorbachev made a similar assessment of the incentives problem in his September 1986 speech in Krasnodar. Referring to the practice of releasing weak scientists, designers, and engineers in order to reward the strong, which was first tried in Leningrad, he noted:

> *We were of the opinion that this was a fine course and a correct course. We decided to recommend it to others. But now this decision is evidently not being implemented as it should . . . .People have approached the matter in a purely formal way and have limited things to just a wage leveling and an increase of a few rubles to all and sundry regardless of their contribution. Naturally, nothing has come of it. Nothing has changed. This was not the aim, not the aim at all. Without it there can be no technical progress.*

Encouragement of Scientist-Entrepreneurs. Under Gorbachev the Soviets have expressed new interest in understanding the practice of technological entrepreneurship in Western market economies and in adapting this concept to Soviet conditions:

- Last year Soviet economic officials raised this subject [ ] at a Moscow symposium.

- [ ] scientists at a leading Academy institute were being encouraged to market their own inventions with managers of Soviet industry to supplement research funding

[ ] systemic constraints on private initiative run deep and continue to dampen the desire of scientists to assume the burdens of entrepreneurship:

- [ ] Academician Nikolay Yenikolopov [ ] stopped his efforts to market a polymer machine in the West. He was initially very excited about his invention because he saw it as a way of

[11] This generally lenient approach was also manifested in the initial stages of the reclassification of Academy scientific workers after the February 1986 CPSU Congress. By October, only 0.6 percent had reportedly been dismissed or demoted in the process. In recent months, however, Academy officials have taken a much harder line on this issue. In a March 1987 *Izvestiya* interview, Marchuk reported that reclassification—now completed—resulted in 2.5 percent being dismissed and 5 percent demoted.

becoming financially secure. He hoped to take advantage of a limited Soviet economic incentive under which holders of patents would be allowed 3 percent of the sales of their inventions, but he ultimately lost interest.
other Soviet scientist entrepreneurs have also become discouraged after finding it very difficult to actually obtain the profits they had been promised.

- The continuing frustrations and delays encountered in introducing inventions prompted the chief of the patents department at a major Soviet industrial enterprise in February 1986 to tell his superiors, "We've got people 'screaming' here too for compensation for their inventions . . . .There should be some order established for the developers themselves as well as for those of us who have to administer the program."

- [redacted] most scientists were far more interested in publishing their research, which brought renown in the scientific community, than in seeking patents, which were "a lot of trouble and provided only limited benefits to a scientist." However, scientists who made discoveries were required to fill out a form answering the question as to how their discovery could be implemented. If they answered it positively, they would be required to apply for a patent and would not be permitted to publish their research, according to this source.

New and pending Soviet legislation suggests that the restrictions on private entrepreneurship by scientists and engineers are not likely to be appreciably lifted soon. The November 1986 law expanding the rights of individuals and families to engage in small-scale private business activity does open up some opportunity. Taking advantage of the new regulations, a private citizen has established the USSR's first computer referral agency to provide technical consulting services to industry, according to *Izvestiya*. Staffed by eight moonlighting employees and using a rented government computer, the agency located specialists to solve problems an enterprise was having in installing expensive foreign equipment. On balance, however, the new law falls short of allowing the kind of expanded private enterprise practiced in some East European countries and urged for the USSR by prominent Soviet reform advocates.

Nor does a new patent law being formulated by the USSR State Committee for Inventions and Discoveries hold much promise for individual scientist-entrepreneurs. According to the Soviet press, the new law is not a patent law in the Western sense because it will not give exclusive ownership of an invention or innovation to the originator. This will remain with the state. In fact, judging by comments of the chairman of the State Committee, the new law will give a greater share of rewards for an invention to the enterprise that develops and utilizes it, since the enterprise is supposedly the one taking the risk. Risk—or rather risk avoidance—is a central concern in present discussions of the law, and its drafters appear to agonize much more over the plight of the enterprises and ministries attempting to exploit an invention than over the inventor

Promotion of Young Scientists. Under party pressure, Academy leaders are beginning to address the problems of motivating and promoting young scientists in the Academy. With the least status, they are the most disadvantaged and perhaps frustrated group of scientific workers. Energetic and innovative young researchers who are working in the frontier areas of S&T feel particularly stifled by the lack of headroom and incentives in an increasingly geriatric society dominated by the science of the past. In this connection, Politburo member Ligachev last October strongly reproached Academy scientists for failure to develop their own replacements, noting that "this is not to the benefit of our science or our Academy." He then emphasized, "As of today, work with scientific youth is one of the most important, most critical tasks facing the Academy. This is an absolutely mandatory condition for the successful development of science, and a guarantee against the emergence in science of such diseases as stagnation and conservatism."

Vice President Velikhov, who chairs the Academy's Commission on Work With Young People, has been in the forefront in pressing initiatives in this area,

especially in the Section of Physical-Technical and Mathematical Sciences, which he oversees. Specific measures aimed at recruiting and promoting talented youth include the following:

- Because they can offer higher wages and bonuses, temporary laboratories are being used—most extensively in Velikhov's section—as one means of attracting skilled junior scientific associates into priority areas and applications-oriented work. Academician Zhores Alferov of the Ioffe Institute observed in a January 1986 *Izvestiya* article, "The main thing is that it is possible to promote young people." This causes problems, however. As Alferov explains:

  An associate of the permanent laboratory comes to you and complains: I have a family, children; I perform no less important work, but receive less than a recent undergraduate. The situation caused some complications in the moral climate of the department. But it cannot be helped. We agreed to the deliberate stimulation of work in a scientific and technical direction which was very necessary for the country at the given moment.

- The Academy's newly established applied R&D institutes also provide a mechanism for pursuing new advanced S&T areas and recruiting young scientific workers to staff them. Such institutes are often spared the heavy hand of scientific tradition, domineering personalities, and nepotism characteristic of older institutes. The average age of associates of the new Programing Systems Institute—created in 1986 under the Computer Technology Department—is only 29 years old. Academician Frolov has also noted that the new affiliates of the Machine Science Institute being set up in Leningrad, Gor'kiy, Sverdlovsk, and Saratov will be heavily staffed with young scientific workers.

In January, the Academy's presidium decided to organize youth collectives in scientific establishments of the Academy in order to better utilize the scientific potential of young people. They will be formed as a rule from young people up to 33 years old. Institutes that create such collectives will receive priority in the development of scientific directions and allocation of resources. Alternatively, establishments that lag in work with young people will be deprived of a part of their resources for the benefit of youth collectives in other institutes. In addition, the Academy has decided to hold a competition for young scientists in the sphere of basic and applied research and also in the development of new methodologies, materials, and technologies in the years 1986-89.

Stronger Administrative Pressure. Besides offering greater material incentives, Academy leaders are increasing administrative pressure to improve productivity and move the Academy toward applied science and technology. The Gorbachev regime appears to be adopting a fundamentally new approach to financing basic research in the Academy and higher educational establishments—based on projects rather than institutions (see inset). Individual scientists and entire institutes are being ordered to refocus their work:

- In late 1985, [ ] told [ ] that theory is being deemphasized and money is going into experimental work. A real attempt is being made to reduce the number of theorists, and there is active discrimination against them. According to one Soviet scientist, theoreticians are being urged to associate themselves with experimental groups to make their activities more practical. He attributed this shift to a general Soviet feeling that present problems lie more in the manufacturing process than in scientific understanding.

- [ ] the Kurchatov Atomic Energy Institute is phasing out its nuclear physics activities and will be devoting greater resources to solid-state physics and superconducting technology. According [ ] classical nuclear science efforts were being steadily downgraded at the institute. Similarly, a Soviet scientist at a major Academy institute in early 1986 said that a new facility is being built for the Semiconductor Physics Group on the site where the Ioffe Physical Technical Institute's old cyclotron machine is located. The

The Soviet Approach to Financing Research: Moving From "Block" to "Project" Funding?

The method of financing basic research in the USSR differs significantly from that used in the United States. The Soviets primarily award block grants to fund entire institutes, rather than allocating funds for specific research projects. The Soviet approach also does not subject research to the rigorous scrutiny and justification generated by the competitive bidding and peer review typical of the American approach.

This system of block funding furnishes stability to research facilities and personnel—but at the cost of reduced responsiveness and flexibility for Soviet science as a whole. The inertia of existing institutions and ongoing projects is hard to break. The system allows some institutes and programs to go for years without producing any significant results. At the same time it is difficult to get new ideas and projects accepted. In 1985 a Soviet academician observed that it was as difficult to find a new development in such institutes as to find the treasure crypt in pyramids.

At the institute level, this approach gives near dictatorial control to the director and laboratory chiefs over the choice of projects to be supported. Referring to the stifling effect of the "cult of the director," Soviet scientists have complained of the great damage that directors have inflicted on the development of science. Creating institutes to reflect their own personal interests, directors have squashed projects that—no matter how promising—might have diverted resources from their pet areas or favorite researchers.

[ ] *Gorbachev regime is moving toward project-oriented funding at home and in the Bloc. The new measures are part of its efforts to weed out unproductive research, promote new areas, improve quality, and orient performers toward end results:*

- [ ] *in mid-August 1985 a Soviet director of meteor research said that Gorbachev was instituting a zero-based budgeting policy that will force Soviet scientists each year to develop a sound scientific program against which their achievements can be measured.*

- [ ] *during a November 1986 international conference, a Soviet scientist commented that magnetohydrodynamics research was being subjected to greater scrutiny by the USSR Academy of Sciences. Researchers now are expected to show measurable progress, and "no scientific programs are above scrutiny and evaluation."*

- *Moscow State University administrative officials in October 1986 reportedly told* [ ] *that the Soviet Government is promoting a movement to make university research more applicable and available to the factory. Large block grants of research funds were no longer being made. Instead, individual projects had to be justified on a case-by-case basis in order to qualify for support.*

- [ ] *Dr. Istvan Lang, Secretary General of the Hungarian Academy of Sciences, indicated that a newly established National Fund for Scientific Research will be administered by his academy, using a peer review/individual grant system. Such a system will be new to the Hungarian scientific community, which (like in most East European countries) traditionally has operated on the Soviet model of block-funding to research institutions.*

abandoned machine is being renovated and used in the implantation of ions to make self-absorbent diodes, which act as cue-switched lasers.

- [redacted] in the Academy's Moscow Computer Center in September 1986 reported that several Soviet institutes and organizations involved with systems studies—especially those dealing with economic modeling and reform—were being fundamentally reorganized and told to concentrate on more practical applications. The Institute of Control Problems, for example, is being directed to focus on designing computer systems that will facilitate and enhance automation, especially in the aircraft and railroad industries.

- [redacted] the Academy's Institute of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation had begun to shift its main focus to SDI-type research.

The leaders of the Academy—Marchuk, Velikhov, Frolov, and Mesyats—reflect this hard-driving and innovative management style called for by Gorbachev. All are energetic individuals with strong applied science backgrounds, and they are all avid supporters of accelerated modernization of science and industry. Frolov, for example, told [redacted] shortly after his election as a vice president and head of the Mechanics and Control Processes Department in March 1985 that he was given "a mandate to break with tradition" and demonstrate "a new work ethic" in the Academy. According to Frolov, he has been tasked to work very hard, to lead, and to be innovative. Though he expects some discontent from associates, he has been told "to push them along whether they like it or not."

Implications and Prospects

The Academy

We expect that the Academy of Sciences will undergo significant changes in structure, management, and makeup over the next few years. President Marchuk has laid out the broad outlines of a bold program for "restructuring" the Academy's work, and Gorbachev has publicly pledged to support him. Marchuk has charged that conservatism has so penetrated this 260-year-old institution that "now we are becoming slaves of the structures and traditions that have built up over the decades." Such a revitalization is essential—indeed, is a precondition—if the Academy is to meet the party's high expectations and act as the spark plug in Gorbachev's modernization program. To effectively accomplish its tasks, the Academy must be substantially renewed, "fired up," and transformed from a geriatric society dominated by science of the past into an energetic and innovative force oriented to science and technology of the 21st century.

Renovation of this unique Soviet institution, however, will be a most difficult and protracted process. The Academy elects its members for life by secret vote. There are no viable mechanisms for easily purging or rapidly renewing the membership. Efforts to change the structure, operating procedures, and scientific activity of the Academy will encounter heavy resistance from its powerful and entrenched interest groups (see inset). In addition, Soviet science is heavily personality dominant. While the regime may be anxious to curb the power of aging scientists and research directors who have lost the spirit of innovation, the role of powerful scientific leaders has been an important one in the advancement of science and technology. Restricting the power and position of individual scientists could well impede the initiative and creativity that Gorbachev is calling for.

Reorganization measures are already having a mixed impact on Academy morale. Some scientists welcome the changes, seeing them as opportunities to advance their professional and personal interests. In late 1985, a computer scientist at the Academy's Systems Research Institute told [redacted] that most Soviet scientists and engineers are optimistic that Gorbachev's new incentive programs and S&T reforms will improve the climate and overall level of productivity at research institutes. Junior staffers hope the changes will eliminate abuses that allowed their superiors to

Marchuk's Challenge: Overcoming Academy Interest Groups

A major challenge that Marchuk must confront when restructuring the Academy will be resistance from entrenched, powerful groups within the organization. The Academy's relative autonomy has fostered an environment in which numerous strong leaders could appear. Holding key positions as institute directors, academician secretaries of the Academy departments, and presidium vice presidents, these individuals have surrounded themselves with groups of supporters who are either Academy members or are working within the Academy system.

[ ] *the relations between the various groups tend to be competitive and bitter and have had a debilitating effect on the Academy's research efforts. Key academicians will obstruct the research projects, acquisition of instrumentation, and facility construction of their competitors. Rivals refuse to share pertinent information with each other.* [ ] *the status of research programs is so dependent on the personal status of their leaders that even promising projects are discontinued when their leader falls from favor, dies, or is reassigned.*

Similarly, in many instances, personal connections, not one's technical expertise, account for one's appointment to key positions and election to Academy membership. Voting together in blocs, the groups frequently block each other's candidates from gaining election to the Academy [

[ ]

receive most of the credit—and material rewards—that the junior workers deserved, as well as to base personnel decisions on political considerations and personal ties rather than merit. Indeed, [ ] indicates that scientists working in several key applied science and technological areas are excited about the dramatic turnaround in their situations. Many of their laboratories and institutes are now reportedly thriving with new equipment, ample funding, and expansion plans

Other Academy workers, however, are apprehensive about the reforms, viewing them as threats to their job security, professional standing, and relatively easy lives. Scientists who are being forced to abandon research areas (and sometimes years of work) for new scientific priorities are demoralized. At the Kurchatov Institute, for example, morale among nuclear physicists is reportedly at "rock bottom." [ ] their outlook has never been "so gloomy"; many believe they have no future at the institute. Space scientists at the Institute of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation in early March 1986 [ ] that Soviet scientists are concerned [ ] number of issues, primarily the lowering of the mandatory retirement age, lack of money for nonmilitary research, and continued restrictions on travel to the West. According to these researchers, Soviet scientists are becoming increasingly aware that Soviet SDI work will drain funds from theoretical research.

In general, recent trends within the Academy and, more broadly, Gorbachev's evolving domestic policies have created uncertainty and confusion among Soviet scientists. Gorbachev's modernization program with its emphasis on "acceleration" and "restructuring" seems to have generated in the scientific community much the same kind of uneasiness as it has in the Soviet population:

- [ ] in March 1986 a senior scientist at the Institute of the Physics of the Earth said the general situation among the scientific establishment was one of

"extreme confusion" and that important decisions affecting the Academy were being postponed because of more pressing political issues. Party cadres tried to explain policy decisions but could only provide generalities. "This left scientists not only concerned but confused."

- During an October 1986 lecture in Leningrad, a Soviet scientist noted that the directors of several research institutes had recently exhorted the staff about "acceleration, acceleration." The response was "Yes, but what do you want us to do?" According to this lecturer, scientists cannot be expected simply to work faster. They must have objectives, plans, and an understanding of how their work will mesh with that of production units.

The initiatives Marchuk has announced since assuming the Academy's top post are intended to address key problems that have accumulated but gone unresolved within the Academy, including the mood and low morale of its associates. However, both his plans and rhetoric about restructuring and rejuvenating the Academy are bound to enhance confusion and anxiety within its ranks.

We believe the Academy is likely to get a new or amended charter this year that will facilitate and embody the changes the regime would like to introduce. In general, the restructuring of the Academy is likely to focus on three main directions: rejuvenation, decentralization, and industrialization.

Rejuvenation. With one-third of the Academy's members (full and corresponding) over 75 years of age and fewer than 5 percent under 50 years old, this task has become urgent (see inset). Any changes in membership policy and procedure will require amendments to the Academy's statutes. Specific measures (based on East European experience) that have recently been proposed to deal with the issue include the following:

- Once a member reaches 75, automatically creating a slot for election of an additional member (used in Hungary).
- Imposing an age limit of 65 on new members (from the German Democratic Republic).
- Restoring the requirement (removed from the statutes in the 1960s) that scientists over 55 cannot be elected corresponding members.

The Graying of the Academy

Over the past decade there has been a substantial aging of the membership and staff of the USSR Academy of Sciences. This "graying" of the Academy has become a matter of serious concern to the political leadership, prompting party "Second Secretary" Ligachev in October 1986 to declare:

> *"The task of replenishing the Academy with young scientific forces is an urgent one today. Let us say bluntly that mistakes have been committed here and obvious disproportions have arisen."*

The situation is indeed alarming. In 1976, nearly 6 percent of the academicians were less than 50 years old, but by late 1986 there was only one full member under 50. The percentage of corresponding members in this age bracket fell from 18 to 7 percent during this interval. At the same time, the share of full members over 75 has more than doubled and now exceeds one-third. The proportion of corresponding members over 75 has increased from 8 to 14 percent.

Meanwhile, the percentage of doctors of sciences in the Academy under 40 has fallen by two-thirds (from 10.7 to 3 percent), while the percentage of candidates of sciences under 40 in the Academy has dropped by a third (from 52.4 to 35.2 percent). Whereas in 1973 more than 60 percent of all scientific workers in the USSR Academy were under 40, by 1983 only 45 percent fell in this age bracket

Marchuk recently announced that the presidium has decided to adopt other measures aimed at accelerating the renewal process at various levels of the Academy hierarchy. These include:

- Enforcing the mandatory retirement of scientific leaders at 65, aimed particularly at institute directors, deputy directors, department heads, and laboratory chiefs. This rule does not apply to academicians and corresponding members of the Academy.
- Having academicians and corresponding members resign their leadership positions between the ages of 65 and 70. Such members may become "advisers" to the Academy's presidium and to institute directors.
- Setting quotas for hiring young scientists for every scientific establishment. The presidium is reportedly proposing that every institute must fill 5 percent of its vacancies with new, young specialists every year.
- Other proposals advanced by individual academicians that may be adopted in the next few years include the forced reduction in institute staff by 5 to 10 percent a year and the introduction at Academy institutes of both permanent and temporary staff positions.

Decentralization and "Democratization." Marchuk is likely to continue to press for a decentralization of power within the Academy, with a devolution of decisionmaking from the presidium to the Academy's substantive and regional departments. The latter will evidently gain greater clout to define work and control resources, cadres, and international scientific contacts. The structure of the departments is accordingly being strengthened, and a new post of "deputy academician secretary for organizational work" is being created in each department to direct the staff. We will also probably see an extension of Gorbachev's openness or *glasnost* campaign to the Academy, with greater emphasis on criticism and rank-and-file participation in Academy affairs. "Democratization" measures will also aim at improving creativity and innovation within institutes and the overall climate and morale among Academy workers.

"Industrialization" of the Academy. We expect to see more applied scientists and engineers elected to the Academy, particularly in targeted areas of S&T where the Academy's capabilities have been more limited but also where the Academy is assuming an increasingly pivotal role in speeding S&T development. We expect the next elections of the Academy to reflect this changing composition of the Academy and the commitment of the political and Academy leadership to the modernization program. (According to the Academy's statutes, these elections should have been held in December 1986. Therefore, we anticipate that they will take place this fall.)

Any attempts at radical or rapid change will encounter formidable resistance and institutional inertia, and the regime will most likely move cautiously so as not to alienate the very institution on which it is pinning such high hopes. More broadly, the Academy will face the difficult task of finding the right balance between its various responsibilities and roles—trying to meet the party's demands for more applied research and support for the modernization program while preserving its traditional and still primary mission as the nation's foremost performer of basic research.

Science and Technology

The deepening involvement of the Academy in Gorbachev's drive for industrial modernization should lead to some modernization of Soviet science. This, rather than modernization of the economy, appears to be the primary aim of many Academy scientists. They are likely to use and manipulate the campaign to benefit science as much as possible, while paying lipservice to industrial modernization goals. Even the most applied Academy scientists and strongest supporters of economic modernization, such as academician Boris Paton, probably share this view. That is, they regard the buildup and modernization of their own technology

base as important as, if not more important than, the goal of rejuvenating industry's technology base. As Paton recently put it,

> *Academic institutes are in need of modernization and reequipping, and their need is no smaller and possibly greater than that of the production base. Only through reequipping will we be able to develop science along the intensive path and to do battle not by force of numbers but by force of skill.*

To the extent that the Academy is able to expand its experimental and test base, its capabilities not only to develop new technology for industry, but also to advance the cause of Soviet basic science, will grow. Thus, we expect that, if the Soviets are able to sustain the flow of resources and capital investment to science over the long haul, the prospects for important scientific advances and technological applications will grow. But the new organizational mechanisms that aim at speeding up the research-to-innovation process are no panacea for overcoming longstanding problems and have not yet proved their effectiveness. Current plans to raise the pay of S&T workers may improve performance to some extent, but they are not likely to produce large gains in productivity, efficiency, and innovation. Numerous Soviets stress that scientists are not moved by monetary incentives alone. Gorbachev will need to take additional measures to create within science economic conditions and a psychological climate more conducive to innovation and initiative. At the same time, the leadership risks straining the Academy's resources and pushing it into areas, such as production engineering and testing, which are further from its expertise. If they press the campaign to reorient the Academy toward applied research and production too far and too fast, Soviet basic science—and ultimately the economy—could lose

Soviet technology development is likely to present a mixed picture. Some of the targeted technologies and programs under way concern leading-edge high technologies where the Soviets are lagging the West, and they will need to exert tremendous effort just to keep from falling further behind. In other areas, some of the technology at issue is more low-tech, and some has been around for a long time. Here the issue of technological risk appears to be low. Success in developing and assimilating these technologies will depend on factors in industry outside the control of the Academy.

The Economy

We believe that the Academy's contribution to modernization of the economy will be, on balance, relatively modest. The Academy's role in technological development and diffusion is inherently limited. The Academy is essentially in the position of "leading a horse to water," but it "cannot make it drink." It can speed the development of science and technology and assist industry in finding applications of new materials, products, and processes, but it cannot dictate the implementation and use of S&T results.

The degree to which new technologies are absorbed depends on the willingness and ability of industrial managers to implement them. It is not sufficient for Gorbachev to make science responsive to production. He must also turn production to science, and make industry more receptive to the technological advances. For Gorbachev's modernization drive to succeed, he will have to take additional and bolder steps to create effective structures and incentives in the production sector to permit both the technology push and demand pull for new technology to work effectively. Thus, success in applying and disseminating S&T advances of the Academy will depend on policy decisions and reforms in the production sector, and to date such measures have not produced any significant change.[14] Moreover, the new technologies that the Academy is spearheading are generally interbranch in nature, and the obstacles to their diffusion into the economy are the most formidable. Progress is likely to be slow.

In many respects, the Academy's ability to directly influence industrial modernization is limited also by the scale of its own efforts in applied science—roughly 4 percent of the national total in ruble

[14] See joint Defense Intelligence Agency and Central Intelligence Agency report, (Unclassified) March 1987, *Gorbachev's Modernization Program: A Status Report*

terms—which is dwarfed by industry's own R&D activities. The Academy cannot substitute for the industrial R&D sector. Much of its success will depend on the extent to which it can develop cooperation with industry in advancing new technology. The new organizational/managerial schemes under way appear to help forge closer ties, but many problems remain, especially in setting the new structures—above all the MNTKs—in motion. At the same time, open press articles and intelligence reporting indicate that some Academy institutes are coming to be viewed as competitors with industry, a phenomenon that may lead to increased conflicts between science and production

In any event, given the long leadtimes in developing and assimilating new technology in the Soviet Union, modernization of the economy to the year 2000 will involve primarily pre-1987 technology. Although many of the USSR's priorities for S&T development are critical for sustained industrial modernization—and are the principal focus of the Academy's efforts in particular—industrial applications based on major breakthroughs by the Academy in fundamental science are not likely to appear at the enterprise and workbench level over the next decade. Academy accomplishments under Gorbachev's program will figure more prominently in Soviet economic development in the next century

Defense

To the extent that Gorbachev's modernization program succeeds in enhancing Soviet civilian industrial capabilities, the defense sector will obviously benefit in a similar time frame. However, the military establishment is also likely to benefit from S&T advances that the Academy may make but fail to find extensive application for in the civilian economy, inasmuch as the defense sector will be better positioned to capitalize on them. This will be particularly true if Gorbachev fails to build an effective organization and management structure to push technology in the civilian ministries as well as an incentive structure that creates demands for new technology by the end user.

Since many of the USSR's targeted technologies are essential for the next generation of weapon systems, the defense sector will be keenly interested in following Academy developments. It also is better positioned than civilian industry to push certain directions in S&T if the opportunity or perceived need arises. A change in the international environment and military competition might well shape the evolving course of Gorbachev's modernization program and Academy S&T development. Indeed, we expect that, given existing constraints on R&D and investment resources, the conflict between the needs of defense and civilian modernization will grow either as a result of a more threatening international environment and high-tech SDI-oriented arms race or because the civilian modernization program falls short of expectations, generating increased pressure for more resources or bolder steps.[15] The Academy in particular is likely to be squeezed from both the military and civilian sides in advancing these new S&T areas. Its assets—specialists and facilities—will be caught squarely in the middle.

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