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Militarization of the Soviet Academy of Sciences*

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> *"The Leninist approach to the Academy of Sciences determined its subsequent development. After 50 years of Soviet rule, the Academy was converted from an association of scientists, which it was before the revolution, into the largest centre of Soviet science. . . . It . . . leads the world on many problems, having most important significance . . . for increasing the defence might of our Motherland."*
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> **M. V. Keldysh**, Former President of the USSR Academy of Sciences, in *Lenin i Sovremennaya Nauka*, (Lenin and Contemporary Science), Moscow 1970, p. 18.

THE USSR Academy of Sciences, the largest research and development (R&D) network in the world, is more deeply involved in military-related work—and has been for a longer time—than is commonly believed in the West. What is equally important, the Academy's scientific–technical capabilities are likely to be even more involved in such work in the future, as a result of the perception of Soviet political and military leaders (a perception shared by the Academy's own leaders) of the strategic challenges and geopolitical requirements confronting the USSR, in particular those posed by the US.

The Soviet Regime's Transformation of the Russian Academy

The current militarization of the Academy (detailed below) stems from, and is reinforced by, its traditional role in the Soviet S&T system, and any future increase in its role in military R&D will be the logical extension of such tradition. Indeed, the Academy's deep involvement in military-related work at present cannot be understood without reference to its historical evolution. Only by such reference can one appreciate the full extent of the Academy's transformation and militarization under Soviet rule, and the likelihood of still further change in that direction in the future.

Shortly after seizing power in 1917, Soviet leaders began to expect and count on the Academy to help in the development of the USSR's industry, which also subsumed the development of Soviet military capabilities. These expectations were fully in tune with the original role intended for the Academy by its founder Peter the Great. He created the

* The views expressed in this article do not necessarily reflect those of the US State Department.

[illegible] Academy of Sciences (later known as the Russian Academy) in [illegible] the explicit objective of its helping to modernize Russia both [illegible] and militarily.[1]

[illegible] Academy's contribution was intended to advance Peter's larger [illegible] of a modernized Russia able to play a major role in European [illegible] much as the Soviet leaders have striven to develop an industrially [illegible] advanced USSR able to affect the global scene as a *Velikaya* [illegible] (a tsarist term meaning Great Power, subsequently used by [illegible] to describe the USSR).

[illegible] Peter's ambitions for it to have a larger involvement in [illegible] the Imperial Academy under his tsarist successors [illegible] into a highly academic and elitist institution on the model of the West European academies, viz. it did basic research in many non-physical [illegible] areas (e.g. philosophy and archaeology) with little or no [illegible] industrial or military application. The Academy's wide deviation from Peter's original intent can be illustrated by its role during the final days of the tsarist empire: the Academy contributed next to nothing to Russia's war effort in the First World War. For example, after the war broke out, its major activities featured the establishment of a Permanent Commission for the Study of Russia's Natural Resources and [illegible] of a workshop which helped to produce clinical [illegible]

On [illegible] power in 1917, the Bolshevik leaders renewed Peter the [illegible] to involve the Academy in industrializing backward Russia [illegible] the country's military capabilities to support a larger [illegible] world. In the process, the Academy under Soviet rule [illegible] academic character radically transformed.

[illegible] process by pushing the Academy to contribute to [illegible] and military development with some balance [illegible] orientation it acquired during the tsarist days [illegible] for its involvement in applied research and [illegible] military. The latter was urgently needed to [illegible], shattered by the First World War and the Civil [illegible] Soviet state the military weapons it needed to [illegible] capitalist world " as the first and, at the time, the [illegible] But he protected the Academy from zealots who [illegible] totally to " practical and useful " industrial and [illegible]

[illegible] that the Academy be treated " scrupulously [illegible] gradually, without injuring its organs, introduce it

[illegible] Western Europe, learning about Western science and [illegible] For example, in the Netherlands he learned how to build [illegible] therefore rightly be called the father of the Russian Navy as

[illegible] with this [illegible] effort, the USSR Academy played a major [illegible] War, ranging from the development of tanks and aircraft to radar and atomic

[illegible] new building of Communism."[3] To this end, he ordered the People's Commissariat of Education to desist from a planned drastic reorganization of the Academy.[4] Instead, he directed that the Academy be instructed to form commissions of specialists to prepare a plan for the reorganization of industry and economic development.[5]

However, pursuing accelerated industrial development, Stalin brushed aside Lenin's balanced approach between basic and applied research in favour of the forced " industrialization " of the Academy. This laid the basis for the Academy's subsequent heavy involvement in military work: by forcing engineering and technical capabilities on the Academy for civilian production, the regime was also able to draw on these capabilities for meeting military needs. Stalin justified his approach by citing the urgent need to modernize the Soviet Union and develop its defence capabilities quickly in order to avoid a repetition of Russia's past military defeats.[6]

To involve the Academy in the USSR's industrialization and rearming, Stalin introduced fundamental changes designed to politicize, " industrialize " and militarize the Academy. Thus, in 1931 the professional composition of the Academy was radically altered by adding a technical-engineering section and relevant personnel who, together with the applied physical scientists, soon came to outnumber and dominate the traditional basic researchers and scientists in other disciplines. Included in the new technical section of the Academy were such areas as energetics, metallurgy, mechanics and mechanical engineering and transport. And among the new Academy members were those who subsequently played a major role in military-related development and Academy leadership. For example, Academician S. I. Vavilov, who was an elected member in 1932, later headed the Soviet military optics programme, served within the Academy as the representative of the all-powerful State Defence Committee (the highest policy body during the Second World War, headed by Stalin), and was elected Academy President in 1945, serving until his death in 1951.[7] In the words of a Soviet spokesman these developments (the decree of 21 August 1931 adding the Technical Section, and the relevant Academy elections in 1932 and thereafter) were the most important in the reconstruction of the Academy to include not only theoretical science but technical disciplines. They helped, in his words, to convert the Academy from an association into " the genuine headquarters of Soviet science."[8]

At the same time, Stalin increased political control by adding Party

[3] As cited in *Soviet Science 1917–70*, p. 17.
[4] Ibid.
[5] V. I. Lenin, *KPSU o Razvitii Nauki* (The CPSU on the Development of Science) (Politizdat, Moscow, 1981), p. 100.
[6] See his report on the results of the First Five-Year Plan in January 1933. (Joseph Stalin, *Sochineniya* [Collected Works], Politizdat, Moscow, 1951, Vol. 13, p. 173.)
[7] *Sergei Ivanovich Vavilov* (Nauka, Moscow, 1979), pp. 3–10.
[8] V. D. Esakov, *Sovetskaya Nauka v Gody Pervoi Pyatiletki* (Soviet Science in the Years of the First Five-Year Plan) (Nauka, Moscow, 1971), pp. 203–4. It should be noted that the Russian term for headquarters (*shtab*) has traditionally a military connotation.

members to the Academy's rolls (there were none before 1929[9]); this enabled the Party to control many Academy members not only through the Academy's formal hierarchical, organizational lines but also through local Party cells. Stalin also expanded the governmental administrative hold over the Academy. In 1933, the Academy was placed directly under the jurisdiction of the Council of People's Commissars (the forerunner of the present Council of Ministers); the Academy had earlier been under the Commissariat of Enlightenment (later renamed the Ministry of Education). And in 1934 Stalin further tightened the regime's administrative control by moving the Academy's headquarters from Leningrad to Moscow, i.e. physically closer to the power centre from which the Academy could be supervised. Later, Stalin altered the professional composition of the Academy still further by forcing special elections on the Academy in 1942 in " strictly specified specialities. "[10] This increased the number of members with physical and engineering sciences and with technology disciplines that were in the main military-related.[11]

The changes that Stalin wrought in the Academy's composition and character were fundamental: it became heavily oriented towards applied research and technology, with deep involvement in military work. The number of research institutes grew spectacularly from eight in 1928 (on the eve of the First Five-Year Plan) to 25 by 1934.[12] The increase was chiefly in the applied S&T areas; the involvement of the Academy in military work was reflected by the fact that even in peacetime—up until the Nazi attack in 1941—its research institutes were working on 200 military programmes.[13] After war broke out, the Academy was involved in 150 programmes;[14] since 1962, the beginning of the current Soviet military build-up, it has been involved in many comparable military programmes.[15]

Obviously, Stalin's transformation of the Academy was demonstrated above all by its activities in the Second World War, during which it developed technology, ranging from conventional arms (aviation, artillery, rocket launchers, tanks) to more exotic systems (radar and nuclear

[9] Loren Graham, *The Soviet Academy of Sciences and the Communist Party, 1927–32* (Princeton University Press, Princeton, NJ, 1967), p. 31.
[10] Komkov et al. pp. 384–85.
[11] Among those elected were aircraft designers Ilyushin and Yakovlev, and Kurchatov, the leader of the group that developed the Soviet A-bomb.
[12] *The Great Soviet Encyclopaedia*, third edition.
[13] Komkov et al. p. 341.
[14] Ibid. p. 353. This decrease in programmes from 200 to 150 was due to disruption caused by evacuation of Academy facilities and personnel in the face of the Nazi invasion, and not by change of emphasis.
[15] Many of the 200 military programmes in the 1930s and those in the recent era covered the same weapons systems areas, e.g. aircraft, tanks or radar, and optics. To be sure, the systems currently addressed are at a more advanced technological level and some did not exist in the 1930s, e.g. missiles. But even regarding the latter, Soviet scientists and technologists were already working on rocket technology as evidenced by their very successful and famed *Katyushas* in the Second World War. These could be viewed as the forerunners of the post-war and current Soviet missiles.

weapons.[16]) Indeed, the Academy was credited with solving defence problems, previously considered not solvable.[17]

BUT the militarization of the Academy continued after the Second World War. In fact, the Academy never became disengaged from large-scale military work. According to Academy leaders, it was given the task of breaking the US nuclear monopoly by developing Soviet nuclear weapons in record time and of doing so with its own resources.[18] This it did with great speed by developing the Soviet A-bomb in 1949, some 15 years ahead of Western estimates.[19] Similarly, Academy members (led by Academician Sakharov) and facilities helped to develop the Soviet H-bomb in the early 1950s, again ahead of Western expectations. (The Soviets even claim that they developed their bomb ahead of the US.[20]) Shortly thereafter (in 1957), the Academy members (led by Academician Korolev) helped to develop the ICBM and put the first satellite into space. Regarding *Sputnik*, it was indisputable that the Soviet Union clearly scored a breakthrough ahead of the US.

The rapid post-Second World War Soviet successes indicated the tremendous S&T resources that were being devoted to Soviet military programmes, including those of the Academy and its organizational style: numerous *ad hoc* defence commissions, formed during the war to link Academy and military personnel in various weapons areas,[21] were adopted as models for *standing* weapons advisory councils formed to meet the post-war US " threat." The most illustrative example was the organization of the Permanent Commission on Nuclear Research by the Academy's Presidium under the initial chairmanship of S. I. Vavilov, the Academy President from 1945 to 1951. This council planned and coordinated the development of A- and H-bombs.[22] The Academy's work on nuclear weapons, ICBMs, and the adaptation of wartime science and technology planning and coordination organizations facilitated the Academy's " natural fit " in the massive Soviet military build-up, initiated after the 1962 Cuban Missile crisis.

Indeed, Khrushchev, who was responsible for initiating this build-up (contrary to the assumption of some Western observers that it was Brezhnev), extended the Stalinist process of reshaping the Academy by imposing further drastic measures. In 1961, motivated by his dissatisfaction with the Academy's contribution to the Soviet economy,

[16] " Nauka i Nauchnye Uchrezhdenie," *The Great Soviet Encyclopaedia* (Vol. L, Moscow, 1957), pp. 430–510.
[17] Ibid.
[18] A. P. Aleksandrov, *Vestnik Akademii Nauk SSSR*, No. 6, 1982, and M. V. Keldysh in *Nauka Soyuza SSR* (Science of the USSR) (Nauka, Moscow, 1972), p. 24.
[19] As one Soviet historian put it: " Academy scientists helped liquidate the US atomic monopoly in two years after they mastered atomic energy in 1947 " (Komkov et al. pp. 394–95.)
[20] Yu. V. Sivintsev, *I. V. Kurchatov i Yadernaya Energetika* (I. V. Kurchatov and Nuclear Energy) (Atomizdat, Moscow, 1980), pp. 22 and 79. To underscore the Soviet achievement, this scientist claims that while the Soviets on 12 August 1953 exploded an H-bomb, the US six months later was only able to set off a device, and not an air-deliverable weapon.
[21] Komkov et al. p. 347.
[22] Yu. V. Sivintsev, op. cit. p. 11.

he set up the State Committee for the Coordination of Science and Technology (renamed in 1965 to the present State Committee for S&T). This step broke the Academy's virtual monopoly over the development and guidance of Soviet science and over contacts with foreign S&T communities. (Such contacts are highly prized in the USSR in terms of prestige, among other things, as was evident during the US–Soviet S&T exchanges in the " *détente* " period of the 1970s.)

At the same time, Khrushchev ordered further evisceration of the Academy by removing many of its applied research institutes and placing them under the jurisdiction of production ministries. This put the Academy under new competitive pressure for funds and personnel, the like of which it had not experienced before.[23]

UNDER Brezhnev, the Soviet regime continued to remould the Academy by further limiting its freedom of action, particularly through the purse-strings. For example, instead of receiving all of its funds from the state budget and thus being assured of an uninterrupted money-flow to carry on more of the basic research which it preferred, the Academy was cut back in the early 1970s to 85 per cent of budget financing, and thereafter was forced " to forage " for the balance of its funds from contracts.[24] It had to obtain such funds from production ministries, including defence organizations. As a result, the latter can, and do, dictate many of the S&T problems on which the Academy research institutes work; they thereby bend the Academy more to applied and less to basic research.

Then, too, direct political pressure was applied in the Brezhnev era to influence the make-up of the Academy's leadership, and therefore the direction of its S&T. For example, Party secretary and chief ideologue Mikhail Suslov, in an unprecedented appearance at the 1975 annual meeting, delivered the Party's wishes for the election of the aged and ailing physicist Aleksandrov, a weapons specialist whose military work dates back to the Second World War. Suslov's blatant pressure resulted in the selection of the then 71-year-old Aleksandrov despite the reservations of many Academy members regarding his age and state of health.

[23] Some Western observers, e.g. Loren Graham, interpreted the 1961 divestiture as leaving the Academy with only basic research that it wanted all along. This explanation cannot hold up in either bureaucratic or substantive terms: the Academy was not happy to lose almost half of its " empire " and, since it was already heavily involved in applied research, it lost essential resources and not just those it wanted to be rid of. Then, too, the dividing line between basic and applied is very thin. The Lebedev Institute's work in lasers well illustrates how an Academy Institute's work can cover the entire R&D spectrum from basic to experimental and applied, and from civilian to military use. Its scientists, beginning with its Nobel prize-winners, Academicians Basov and Prokhorov, have been engaged in work within such a wide spectrum, serving as project directors or consultants on military as well as civilian tasks. Therefore, when the Academy lost the Kurchatov Institute (which has a similar mix of basic and applied, civilian and military work) it lost a real asset and not an unwanted capability. In any case the Academy later regained many of the institutes it " lost " in the early 1960s.

[24] One US estimate noted that by the mid-1970s, contract research " accounted for 12% of the overall expenditures of the USSR Academy excluding capital construction. " Thane Gustafson, *Selling the Russians the Rope? Soviet Technology Policy and US Export Controls* (Rand Corp. R-2649-ARPA, April 1982), p. 55.

Some members were reluctant to perpetuate the election of Academy leaders with both military-related disciplines and direct weapons research background. At the very least, before the election there was some sentiment for selecting younger men such as Academicians Ovchinnikov, Khokhlov, or Millionshchikov. But all this was overcome by the Party's intervention in support of Aleksandrov.

Simultaneous with the foregoing intervention, the Party, to make the Academy still more pliable in meeting industrial and military policy goals, has tightened the screws by requiring that henceforth all research institute directors must be Party members. (Until recently, many prominent academicians, who were also institute directors, were not Party members.) This requirement will now make scientific leaders subject to Party discipline (through local cells) in addition to the usual administrative subordination of the Academy.

IN sum, the " industrialization " of the Academy under Soviet rule has transformed it into a science establishment involved overwhelmingly in applied research, and very much in military R&D. This development has overcome its traditionally academic orientation and has transformed the character it had under the tsars. The transformation has weakened its preference for classic basic research and for non-political and non-military involvement, though such sentiment survives even today among some Soviet scientists, particularly those old enough to have been trained and/or to have had research experience in the West. A prominent example was the late Academician Peter Kapitsa who worked in England in the 1920s and whom Stalin placed under house arrest when he refused to work on the A-bomb.[25]

Selected Topics of the Academy's Current Military Involvement

The militarization of the Academy[26] can be currently illustrated by reference to some key aspects of its involvement, such as military and military-related programmes, funding, organizational, leadership and personnel links with the Soviet military, and the involvement of republic Academies. The extent of the Academy's current involvement in military-related work is emphasized by the accelerated pace and trends in all these categories, following the Soviet military build-up after the 1962 Cuban Missile crisis. The relevant categories can be summarized as follows:

Military and Military-related Programmes. Even before Soviet involvement in the Second World War, the Academy was working on military programmes ranging from conventional arms (tanks, aircraft, artillery) to exotic—for that time—weapons such as space and *Katyusha* rockets, the

[25] A. Kramish, *Atomic Energy in the Soviet Union* (Stanford University Press, 1959), pp. 109–10.

[26] As defined herein: direct or indirect involvement of Academy research institutes and personnel in military or military-related work.

forerunner of today's missile technology.[27] During the Second World War, it was also involved in such programmes;[28] given its well-known direct role in nuclear, missile and space programmes in the immediate post-war period, the Academy has probably been involved at the same or a greater level since then.[29] This is illustrated by its role in the space programme which has been under military jurisdiction from the very outset of the Soviet programme, unlike the US space effort which is directed by NASA, a civilian agency.[30]

In addition to major weapons development, many of the Academy's 250 institutes and 300,000 scientists have also been heavily involved in nominally civilian programmes, many of which, however, have dual use and purpose, i.e. both civilian and military applications. This is reflected in the Academy's sizeable role in the USSR's current 170 national-level inter-branch programmes. These were jointly formulated in the late 1970s for the coming decade by GKNT, Gosplan, the Academy, and the Ministry of Higher and Secondary Education. By 1981, the Academy was involved in implementation work on 110 of the 170 programmes, including 32 " target-complex " (broad-scope) programmes and 78 S&T (specific) programmes.[31]

Many of the latter S&T programmes are probably related to the Soviet military programmes, particularly those of the 78 that have dual-use application such as space, powder metallurgy and fibre optics. The Academy's involvement in these dual purpose programmes can be inferred since many of its 250 research institutes are involved and perform the most advanced work in the USSR in each of these S&T areas, e.g. the Academy's Space Institute in Soviet space R&D, the Baikov Institute in powder metallurgy, and the Lebedev Physics Institute in fibre optics and lasers.[32]

Indeed, the Soviets explicitly admit that many of their research institutes (NIIs) have been and are involved simultaneously in both applied and basic research, and in both military and civilian work, as illustrated by one of the Academy's oldest R&D facilities—the Ioffe Physics Institute. This institute, the major Soviet physics centre before the Second World War, was and is heavily involved in theoretic nuclear physics and, on the applied side, in helping to develop the USSR's nuclear weapons.[33] In fact, the Ioffe Institute had and has on its staff many of the

[27] Komkov et al. op. cit. p. 341.

[28] The number in 1941, the first year of the war, was at least 150, (Komkov et al. p. 353); the number undoubtedly went up as the war continued and military requirements grew.

[29] The Academy's increasing role in defence and space technological innovation is noted in David Buchan's *Western Security and Economic Strategy Towards the East* (IISS Adelphi Paper, No. 192, London, Autumn 1984), p. 8.

[30] For cosmetic purposes, the Soviets set up Intercosmos; it has no operating and launching capabilities, but is used by the Soviet regime to deal with foreigners.

[31] G. Skryabin, *Vestnik Akademii Nauk* (Herald of the Academy of Sciences, referred to herafter as *Vestnik AN*), No. 6, 1982, p. 18. Skryabin is the Academy's Scientific Secretary and chief day-to-day official, and *Vestnik* is its central organ.

[32] Ibid. p. 19 and Holloway, op. cit. pp. 144–45.

[33] See Yu. Sivintsev, *I. P. Kurchatov i Yadernaya Energetika* (I. P. Kurchatov and Nuclear Energy) (Atomizdat, Moscow, 1980), pp. 19, 23 and 55.

Soviet physicists who were responsible for developing the first Soviet nuclear weapons. The most prominent of these was the late Academician Kurchatov who headed the scientific team that included Ioffe Institute scientists and which produced the Soviet A-bomb.[34]

Organizational Links. On the organizational side, new links and changes since the 1960s have tied the Academy institutionally even closer than before to military-related work. These links are centred on the Academy's Section on Applied Problems (SPP).

The SPP serves as the administrative interface between the Academy and USSR's military-industrial establishment. Its main task undoubtedly is to keep abreast of current research and identify technology that can support military interests or be applied to weapons systems; and then help obtain funding for the Academy to work on military-related projects.[35] Given the Academy's involvement in long-term R&D on advanced technologies, the SPP is probably also involved in long-range weapons forecasts and in providing inputs for defining future Soviet weapons needs.[36] The SPP's and Academy's role as a whole in this connection can be inferred from the fact that many Academy members serve on advisory commissions to defence and military production ministries.

Leadership Links. At the very top, the Academy's militarization is illustrated by the direct connection of its presidency with the military. This link extends back to almost 40 years of Soviet history and contrasts sharply with the earlier situation. Thus, before the Second World War, this post was occupied by scientists with life- or non-military-related science disciplines (e.g. botany and geology). Since then, the Academy's presidency has been and is in the hands of scientists with disciplines directly related to weapons R&D (chemistry, electronics and applied mathematics, and physics). More than that, all the Academy presidents since 1945—Vavilov, Nesmeyanov, Keldysh, Kotelnikov and Aleksandrov—have themselves been directly involved in weapons R&D.[37] The continuity of the relationship between the Academy presidents and the military is currently underlined by the fact that Aleksandrov was one of the few civilians present at the extraordinary conference of top military commanders on 27 October 1982 addressed by Party Secretary Brezhnev. At this unusual high-level gathering, Brezhnev indicated that the

[34] See *Voenny Entsiklopedicheskii Slovar'* (Military Encyclopaedic Dictionary), Voenizdat, Moscow, 1983, p. 387.

[35] The SPP has existed, at least under its present name, since 1969, if not before. It is shown in a table of organization for the Academy, appearing in the third edition of the *Great Soviet Encyclopaedia* published that year. The SPP does not appear in the tables in the two previous editions published in 1931 and 1957.

[36] See Holloway, op. cit. p. 140.

[37] In fact, the current President's (Aleksandrov) involvement dates back to the Second World War. At that time, he was involved in developing anti-mine devices for the Soviet Navy (Komkov et al. p. 348). See also, *Voenny Entsiklopedicheskii Slovar'*, op. cit. p. 27. His immediate predecessors, Academicians Keldysh and Kotelnikov, were similarly involved in the Second World War and since then, the former in developing high-speed jet aviation, and the latter in radio communications (see *Sovetskaya Voennaya Entsiklopediya*, op. cit. Vol. 4, pp. 137, 407).

political and military leaders expected Soviet scientists to maintain Soviet weapons up-to-date and not to allow the USSR to lag behind the West.[39]
This post-war domination of the Academy's leadership by a weaponeers," i.e. by those with military-related, "hard" science disciplines and with direct involvement in weapons R&D, is likely to continue in the future. Among the widely-speculated future replacements for the 80-year-old Aleksandrov (who was re-elected this year), Academician Velikhov is high on the list. His selection would be a logical step in the further militarization of the Academy. As the 50-year-old protégé of Aleksandrov and his deputy at the Kurchatov Nuclear Energy Institute, Velikhov has been the only occupant of the key Academy post of Vice-President for S&T since its creation in 1977; this post was established to provide a focal point for improved coordination of the Academy's R&D with production activities, including meeting military requirements. His coordination effort is significantly helped by the fact that Velikhov himself has worked extensively on and directed military-related energy programmes.

Individual Links. In addition to organizational and top-level ties, the Academy is also linked to the military through the activities and links of its individual members. These cover a wide range. Thus Academy members and scientists hold active-duty military rank (many at general officer level), work directly on military-related R&D projects, lead institutes and/or laboratories that work on such projects, even though these facilities are represented publicly as involved in civilian-use S&T programmes, serve on committees implementing and guiding overall military R&D and production such as the Military-Industrial Commission (VPK), the highest level link between the Party, government and military complex, serve on advisory councils in weapons-related S&T areas, e.g. cybernetics, micro-electronics, laser materials, and serve as individual consultants to military-related government and ministry bodies. Many academicians and senior Academy scientists have all or nearly all these links, [illegible] are involved in all or nearly all these military-related activi[illegible] include such leading academicians as Prokhorov and Basov [illegible] USSR's joint winners of the Nobel Prize in Physics), Zhav[illegible] Vadim Trapeznikov, Berg (retired admiral), and Major-General [illegible].[40]

The impact of Academy members and scientists on, and links with, Soviet military R&D does not end with their retirement. Indeed, the influence of many extends far beyond active duty. Thus, many retired academicians and senior scientists serve as members of the Academy's research councils which pass on research project proposals from the

Academy's institutes. In this capacity, they undoubtedly can and do veto "useless" projects, including those which they consider lacking in military utility or application.[40] This arrangement provides still another mechanism for the Academy's responsiveness to current political/ military needs. It also illustrates how many Academy members, after helping to develop Second World War and early post-Second World War weapons, have stayed on to provide the continuity of the Academy's militarization from the 1930s and the war years into the current era. More important, the service of Academy members in military-related tasks long after nominal retirement ensures that there is no break in, or lack of attention to, meeting future military requirements from current R&D effort.

Involvement of Republic Academies. The extent of militarization of the entire Soviet Academy network is further reflected in the increasing involvement in military-related work of many of the 370 research institutes and 50,000 scientists belonging to the 14 republic Academies and subordinate to the central USSR Academy.

Normally, the Soviet authorities would prefer to keep the republic Academies out of such work because, with few exceptions, their scientists are considered to have lesser capabilities and skills, their facilities are not as well equipped as the central Academy research institutes (NIIs), and the non-Slavic personnel in general is viewed as less politically reliable than that of the central NIIs, most of which are directed and staffed by Great Russians. Of course, "the centre" has formed these negative judgments by ignoring the fact that both political and S&T authorities in Moscow are responsible for the measures that create the deficiencies of the republic Academies' personnel and facilities. For example, most non-Slav minorities do not have access to the best educational institutions of the USSR; republic Academy facilities do not get first crack at the new or latest equipment; and, with few exceptions, non-Russian scientists are not allowed the same degree of contacts with, and the resulting stimulation from, the advanced foreign scientific communities. The latter limitation applied even during the politically favourable "*détente*" period of the 1970s when normal restrictions on such contacts with foreigners were eased somewhat.[41]

Despite the situation and the attitudes of the central authorities noted above, republic Academy NIIs have been increasingly drawn into military R&D. For example, in the strategic weapons area, the most

[39] [illegible] political and military leadership were subsequently confirmed [illegible] Aleksandrov's [illegible] with the new political and military leadership were subsequently confirmed [illegible] funeral several weeks later: he was one of only four (together with the new General Secretary Andropov, Defense Minister Ustinov, and a Moscow "worker") to present a eulogy in Red Square. Aleksandrov was again re-elected as President of the Academy on 14 March 1985.

[40] [illegible] staff links are noted in Holloway, pp. 111 and 140.

[40] The role of many academicians is enhanced by the fact that they simultaneously hold military ranks (The eight-volume *Sovetskaya Voennaya Entsiklopediya* [Soviet Military Encyclopaedia], Voenizdat, Moscow, 1976–79, lists many of these dual holders.)

[41] The present author, having dealt with USSR and republic Academies' personnel during most of the 1970s, can testify from personal experience about the above-noted attitudes of, and state of relations between, the central and republic personnel. For example, he participated in negotiations for joint projects involving US researchers and Ukrainian republic NIIs in Kiev; after agreements were worked out with local institutes, the projects were taken over, on the Soviet side by central NIIs, to the dismay and anger of the local, non-Russian scientists.

prominent example is the Cybernetics Institute of the Ukranian Academy of Sciences, which was headed, until his recent death, by Academician Glushkov and which has worked on strategic missile guidance systems.

By now, many republic NIIs are doing military related work routinely. Thus, many NIIs of the Georgian Republic are engaged in science areas with military application, such as physics, cybernetics and metallurgy. A sizeable part of this republic's military R&D effort is carried on by its Physics Institute in Tbilisi, the republic's largest research facility with over 1,000 employees.

The large-scale, routine involvement of republic Academies in military R&D is underscored by the fact that many of their research institutes hosted foreign visitors in the 1970s—even though these facilities were involved in military work—something that would have been unheard of in earlier years. But so widespread is the role of the republic Academy NIIs in military work that the Soviets could not avoid " opening " these facilities to foreigners when they were pressed to do so for political and prestige reasons, viz. to show off such NIIs as the Georgian Physics Institute and the Cybernetics and Paton Institutes in Kiev, among others, during the "*détente*" period as examples of S&T achievements by non-Russian minorities under Soviet rule.[42]

The USSR's Modernization Drive

The Academy's massive involvement in military-related work to date cannot be understood without reference to the larger context of the USSR's industrial modernization and foreign policy objectives.

The Soviet Union is a fully modernized state if measured in physical terms, e.g. the number of literate people, the size of its educational establishment, the number of scientists and technologists, and by industrial-military indicators such as output of steel, energy resources (oil, gas, electricity), tractors, machine tools, aircraft, tanks, nuclear weapons, missiles and space systems. For its large-scale modernization, even if it lacks comparable efficiency, the USSR is indebted to Stalin; he was determined rapidly to transform a rural Russia into an advanced industrial state because of the danger he perceived to the USSR's existence. As he put it in early 1931:

> To slow down the tempo [of industrialization] means to fall behind. But the backward get beaten. And we don't want to be beaten. . . . The history of old Russia was, among other things, one of being continually beaten because of backwardness. . . . Such is always the law of exploiters—to beat the backward and the weak. This is the capitalist law of the wolves. If you lag behind, if you are weak, then you are wrong and you can then be beaten and enslaved. If you are strong, then you are right and need to be treated with wariness. This is why we can no longer lag behind.[43]

Less noted, however, was Stalin's determination not only to drag Russia from industrial and military backwardness but to develop its production capabilities to a level that could, by extension, enable the USSR to acquire military superiority over the capitalist world. In fact, he declared that the Soviet system could not endure unless it ultimately outstripped the industrial capabilities of the Western states.[44]

The Nazi attack in 1941 prevented Stalin from achieving his goal: it placed the Soviet Union's very existence in question before the intended industrialization and rearming plans could be fully implemented. But his successors are implementing such a policy. It is driving the USSR's military modernization and is heavily taxing the Academy's capabilities, not out of sheer survival and solely defensive needs but in active pursuit of influence far beyond Soviet borders. Post-Stalin foreign policy accounts for a military modernization that has produced Soviet arms capabilities equal to or, in some areas, exceeding those of the US.

One dramatic measure of how the Soviets closed the military gap with the US, aided significantly by the Academy's effort, is represented by strategic weapons delivery systems: a US lead of 1,000 land-based ICBMs over 200 for the USSR in 1962 (at the time of the Cuban Missile crisis) was changed by the late 1970s to a Soviet lead of some 1,550 missiles over 1,054 for the US. Similarly, the Soviets reversed the situation in sea-based strategic missile systems: for example, in 1970 the US had 656 to 289 for the USSR; by 1977, the USSR had a 3:2 lead over the US inventory of 656 (which basically remained unchanged in the interim). To underscore the Soviet military achievement, it should be noted that for the first time in its history, Russia/USSR has a sizeable oceanic navy, a fact that would have gladdened Peter the Great's heart.

The strategic parity with the US achieved by the Soviet Union has given substance, just in military terms, to Stalin's slogan of the 1930s: the Soviet need " to overtake and surpass " the US, " the leader of the capitalist world ": it has provided the military muscle for the USSR's expansive foreign policy.

[42] Together with other foreigners, the author had the opportunity to visit these and other S&T facilities in that area and to have informal discussions with Soviet personnel. Thus, the visit to the Georgian NII occurred during his service and two-month stay in Tbilisi as Director of the USIA-sponsored US R&D exhibition in the USSR. During exhibit service of over six months in the USSR in 1972, and subsequently through 1978 as Soviet Programme Director at NSF involved in the implementation of the bilateral US-Soviet S&T Cooperation Agreement, the author also visited many other USSR and republic Academies' NIIs and Soviet industrial plants and facilities, and had numerous formal and informal contacts and discussions with Soviet S&T personnel. This included Academy personnel at all levels: Academy presidents and senior academicians serving in other high-level capacities, e.g. GKNT officials; Academy Presidium members and heads of AN depts.; and working scientists in numerous USSR and republic Academy Institutes and facilities around the USSR. This experience heightened his awareness of how heavily the Academy has been involved in military or military-related R&D.

[43] J. Stalin, *Sochineniya* (Collected Works) (State Political Publishing House, Moscow, 1951), Vol. 13, pp. 38–39.

[44] See his report on the results of the First Five-Year Plan to a Central Committee plenum in January 1933. Ibid. p. 173.

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The Strategic Background

The beginning of the transformation of the Soviet Union from an insular landlocked nation to a worldwide competitor of the US, can be dated to the mid-1950s. It was then that the Soviet leadership openly asserted global aspirations and Khrushchev declared the USSR to be a Great Power with worldwide interests without whose participation no problem on earth could be successfully resolved. The post-Khrushchevian leadership reaffirmed these views with even greater vigour; Gromyko put it most explicitly:

> The Soviet Union is a great power situated on two continents—Europe and Asia—but the range of our country's international interests is determined not by its geographical positions alone . . .[45]

The expansive character of Soviet foreign policy was enshrined in the 1977 Soviet Constitution. Unlike its 1936 predecessor (the so-called Stalin Constitution), the new basic charter proclaimed that Soviet foreign policy is " directed towards ensuring favourable international conditions for . . . strengthening the position of world socialism, the support of the struggle of peoples for national liberation. . . . "[46]

To underscore the significance of this change, Brezhnev, in a report to the Party's Central Committee in May 1977, focused on what he called " the key principal issues underlaying the new Constitution. " In this connection, he noted pointedly that for the first time a Soviet constitution features a special foreign policy clause. This was inserted because of " radical changes in the international position of the Soviet Union, " and thereby " in the social-political profile of the world. " He explained further:

> The capitalist encirclement of the USSR has been ended. Socialism has been converted into a world system . . . The position of world capitalism has been substantially weakened.[47]

In effect the new Soviet Constitution was used as a formal headstone to mark the USSR's activist policy abroad and the strategic changes it has wrought.

Having [illegible] a cue from their political chiefs, the Soviets' military leaders [illegible] their definition of the mission of the Soviet armed forces to cover the greater scope of Soviet interests. According to Marshal Grechko, the late Soviet Defence Minister, the USSR Armed Forces serve to defend the extensive gains of the socialist commonwealth now that " under the impact of the growth of the international authority of the USSR fundamental changes in the world have occurred . . ." and capitalism has ceased to be the indivisibly dominant force in the world. "[48]

General Epishev, the chief political officer of the Soviet Army, extended Grechko's appraisal by indicating that " the international tasks and obligations of the Soviet Armed Forces have widened and deepened and their responsibility for fulfilment [of these tasks and obligations] has increased. "[49]

In the oceanic policy context, Admiral Gorshkov, the Soviet Naval Commander, further underscored the global reach of Soviet foreign policy by noting the consequences for his command: the USSR has created a new type of armed forces—an oceanic navy which, " with its long-range capabilities, guards Soviet state interests on the world's seas and oceans. "[50]

Just as the new Constitution marks the post-Stalin changes in Soviet foreign policy, so it formally recognizes and enshrines the role of the Soviet Armed Forces. Thus, Brezhnev noted that specific reference to their mission appears for the first time in the new Soviet Constitution.[51]

Pursuing new global aspirations and missions in line with its expansive foreign policy, the USSR has leapfrogged into distant areas. Soviet material aid and military and technical personnel have been sent to many areas of the world which had never before seen a Soviet presence.

The foreign policy of Stalin's successors has not only intensified the strategic challenge to the US, it has also triggered the USSR's effort to project its influence to countries far beyond its immediate periphery.

The Academy's Role in Solving Soviet Strategic Problems

The transformation of the Academy to meet wider Soviet strategic needs has been best summarized by one of its former presidents:

> The Leninist approach to the Academy of Sciences determined its subsequent development. After 50 years of Soviet rule, the Academy was converted from an association of scientists, which it was before the revolution, into the largest centre of Soviet science. . . . It . . . leads the work on many problems, having most important significance . . . for increasing the defence might of our Motherland.[52]

More specifically, the Academy was predominant in meeting the USSR's main post-Second World War strategic challenge from the US: the

[45] A. A. Gromyko, *Leninist Foreign Policy of Peace*, Report to the USSR Supreme Soviet on 27 June 1968 (Novosti Press, Moscow, 1968), pp. 37–38.

[46] *Konstitutsiya SSSR* (Constitution of the USSR) (Izvestiya Publishing House, Moscow, 1977), p. 14.

[47] L. I. Brezhnev, *O Proekte Konstitutsii SSSR* (On the Draft of the Constitution of the USSR) (Political Literature Publishing House, Moscow, 1977), pp. 4 and 12.

[48] A. A. Grechko, *Vooruzhennye Sily Sovetskogo Gosudarstva* (Armed Forces of the Soviet State) (Military Publishing House, Moscow, 1975), p. 96.

[49] A. A. Epishev, *Partiya i Armiya* (The Party and the Army) (Political Literature Publishing House, Moscow, 1977), p. 5.

[50] *Boevoi Put' Sovetskogo Voennomorskogo Flota* (The Fighting Course of the Soviet Navy) (Military Publishing House, Moscow, 1974), pp. 5-6. Further to highlight change, this work traces the transformation of the Soviet fleet from a defensive to an offensive arm of the USSR; it notes that for the first time in its history, the Soviet fleet has long range, strategic capabilities which can fundamentally affect the outcome on oceanic and continental war fronts.

[51] Brezhnev, *O Proekte . . .*, op. cit. p. 12.

[52] M. V. Keldysh, *Lenin i Sovremennaya Nauka*, (Lenin and Contemporary Science) (Moscow 1970), p. 18.

Academy was responsible for breaking the US nuclear monopoly, an effort led by Academician Kurchatov and the Academy's research institutes. As President Keldysh put it:

> The concentration of scientific forces and material resources allowed Soviet science and technology to solve the atomic problem in a short time. . . . The development of atomic weapons in the Soviet Union liquidated the US monopoly which had tremendous political significance, allowed the international situation thereafter to be significantly improved. . . .[53]

After "solving" the "US nuclear monopoly" problem, the Academy was given the task of dealing with another important requirement of Soviet foreign policy and strategy: to help eliminate the US territorial invulnerability to Soviet military action or retaliation by developing nuclear weapons delivery capabilities for reaching US soil. At the Academy's annual meeting in 1982 the current President reminded the members of their achievement:

> Another group of scientists, headed by [Academician] S. P. Korolev, worked on missile weapons for our country. . . . The creation in the Soviet Union of intercontinental rockets demonstrated that the USSR cannot be attacked with impunity. It was very important then. Our rockets became, so to speak, the technical basis for the fruitful outcome of negotiations to soften the international situation, being proposed continuously by our government and Party. The international situation was indeed softened, and this led to our people being able to live in peace since the end of the Second World War.[54]

But the Academy has been warned that it cannot rest on its laurels and that the leadership expects the Soviet S&T community, led by the Academy, to pitch in even more to meet a perceived growing US strategic threat. Thus, shortly before his death, Brezhnev provided the context for yet another surge in military R&D work expected of the Academy:

> Competition in military technology has sharply intensified, often acquiring a fundamentally new character. A lag in this competition is inadmissible. We expect that our scientists, designers, engineers and technicians will do everything possible to resolve successfully all tasks connected with this.[55]

In reply to the political leaders' expectations, Academy leaders have given their appraisal of the external threat to the USSR and the Academy's President declared:

> Today, for the third time the same history [of threat to the USSR] is being repeated. The situation is very tense, and for that reason it is necessary for all our scientific development, which our country requires, to proceed without delay. The development of new materials, the creation of new machines, instruments and technologies are in our hands.[56]

[53] M. V. Keldysh, *Nauka Soyuza SSR* (Science of the USSR) (Nauka, Moscow, 1972), p. 24.
[54] A. P. Aleksandrov, *Vestnik Akademii Nauk*, No. 6, 1982, p. 9.
[55] L. I. Brezhnev, in a speech to a convocation of senior Soviet military personnel on 27 October 1982.

Military R&D Policy, Organizational Factors and the Academy's R&D Performance Style as Determinants of its Future Military Work

Despite its militarization to date, the Academy acquired and retains its own unique style in performance of R&D, distinct from that obtaining in the Soviet production ministries. The demands of the Academy's increased involvement in military-related work is likely to be stimulated by the perception of the Soviet leaders that only the Academy, with its experience and capabilities for work on advanced technologies, can meet the new challenges. However, any further large-scale and effective involvement by the Academy in military R&D will depend on several key factors: possible changes in Soviet military R&D policy and the ability of the S&T community to accept, or for the Academy to readjust, its R&D approach, unique to the Soviet system. Yet, any possible changes in military R&D policy must consider and will be affected by the interplay between the past, traditional simplicity and the technological sophistication that has now been forced on the Soviets by the US, and will be even more so in the future. This interplay must be considered in the context of Soviet weapons options, related organizational problems, and the performance style of the Academy.

Possible Changes in Soviet Military R&D Policy

Soviet military R&D policy to date has emphasized simplicity of design, conservatism in the application of well-tested methods, the incorporation of reliable technologies in weapons systems, and an incremental approach to innovation.[57] The essential principle underlying this policy is that simplicity should not compromise adequacy in meeting the basic mission requirements. But simplicity and adequacy are relative terms when applied over time, classes of systems and within or between countries. Thus, evidence of increased sophistication in new systems does not necessarily imply a change in R&D policy, but rather may represent an evolutionary process responding to new military requirements or technological opportunities that become available.

A rigorous definition of the Soviets departing from the simple-but-adequate military R&D policy must be supported by evidence that they are adopting technological solutions whose degree of sophistication is significantly higher than that required by the given basic mission or more complex mission requirements. Evidence of some highly sophisticated new Soviet systems, incorporating relatively untested exotic technologies, is available, as for example in the Typhoon submarine system. However, this system appears to be an example of R&D forced in a

[56] A. P. Aleksandrov, *Vestnik AN*, No. 6, 1982, pp. 9–10.
[57] For a detailed discussion of recent military R&D policy, see Arthur Alexander, *Decision-making in Soviet Weapons Procurement*, IISS Adelphi Papers, Nos. 147–48, London, Winter 1978–79.

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narrow specialized area to meet the basic requirements of a specified mission. It does not necessarily indicate a fundamental change in policy according to the above definition. On the other hand, the emergence of many such systems in the Soviet arsenal across a broad front of advanced technologies and mission requirements, or evidence of a trend in such a direction, would signify a qualitative change in the innovation practice of the Soviet defence industry. The prerequisite of such a change, however, would have to be a more developed technological base which would effectively convert advanced research results into industrial production.[58]

The possibility and the problem of Soviet development of such a base to include the Academy should be considered with regard to three possible modes of further weapons development:

1. increasing complexity of conventional or existing systems stimulated by new mission demands;
2. application of advanced or exotic technologies to current weapons systems stimulated by scientific development;
3. introduction of new-in-principle weapons.

The first mode represents the gradual evolutionary process accomplished within the current Soviet defence industry system and without major departures from traditional R&D policy. The second and third modes imply the greater participation of R&D resources outside the traditional defence industrial system, mainly those belonging to the Soviet Academy of Sciences.

On this point, it is relevant to recall that the Academy has the statutory responsibility for basic and applied research and for nationwide coordination of basic research. It is the acknowledged preeminent authority in applied research that leads directly to the development of advanced technologies. In these areas, including automation, electronics, acoustics, solid-state, high temperatures and pressures, nuclear science, hydrodynamics, and other disciplines, the Academy claims outstanding achievements, leading scientific personnel, and the best research facilities in the USSR. If we consider only the area relevant to the development of advanced technologies, the number of Academy institutes exceeds by one-quarter those in the ministry system.[59] The Academy must, therefore, be recognized as the dominant S&T organization in the Soviet development of advanced technologies; consequently, it has the capability to play a still greater role in the military sector. Indeed, the participation of the Academy in military R&D, while heavy before the early 1960s, has increased substantially since then, especially in the area of "big science." (The latter refers to coordinated research involving many participants, extensive resources, and costly facilities for investigating questions on the frontiers-of-knowledge.[60])

But any contemplated expansion of the Soviet applied research base to support broad dissemination of advanced technologies to military weapons systems involves three important considerations: (1) the overall, larger organizational problems affecting the performance of the Soviet S&T community, including military R&D; (2) the style of R&D performance characteristic of the Academy of Sciences, and (3) the special problem of coordinating the Academy's work with the military-industrial establishment. All of the foregoing considerations have an impact on Soviet military R&D policy and must be taken into account in assessing future changes in that policy and the role of the Academy in implementing such a policy.

Organizational Problems Affecting Soviet S&T Performance

In general terms, the performance of Soviet science and technology, including military R&D, is heavily affected by the current organizational structure of, and policies affecting, the Soviet science and technology community. These have produced S&T shortcomings likely to continue into the foreseeable future because their correction or elimination would require unlikely broader and drastic political reform, viz. the removal of the Party's control over Soviet S&T, and major organizational reform of the S&T community itself.

The Soviet R&D shortcomings result in large part from rivalries generated by the overlapping responsibilities for management of Soviet science and technology among the Academy, the State Committee for Science and Technology (GKNT), and the more than 50 production ministries. This situation has produced fragmentation, duplication, and a failure to capitalize on innovations.

The situation has been worsened by lack of coordination. Past organizational changes have not resolved this problem. Indeed, the GKNT was established in 1961—under a somewhat different name until 1965—to provide the necessary oversight and integration because of Khrushchev's dissatisfaction with the Academy's performance regarding R&D application. When the Academy protested the formation of the GKNT, many applied research institutes were removed from the Academy's jurisdiction and subordinated to the production ministries.[61] These moves created the current overreaching problems, involving the Academy, the GKNT, and the production ministries, and have the following three dimensions:

[58] The Academy's Scientific Secretary Skryabin has already spoken of the need for the Academy to expand such a base. (See *Vestnik AN*, No. 6, 1982, p. 19.)

[59] Simon Kassel and Kathleen Campbell, "The Soviet Academy of Sciences and Technological Development," Rand Corp. R-2533-ARPA, December 1980, p. 9. In analysing "the uniqueness" of the Academy in the Soviet S&T community, the author wishes to acknowledge the sizeable benefit he derived from long-term professional interaction on this subject with Simon Kassel.

[60] The Academy's crucial and growing role in military R&D in general and specific technologies with military application such as control systems, lasers and charged particle beams are noted in David Holloway, *The Soviet Union and Arms Control* (2nd edition, Yale University Press, New Haven, 1984), pp. 144–45.

[61] Academicians Semenov, the then President of the Academy, and Bardin the then head of the Technical Sciences Division, differed over the desirability of this divestiture.

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— There are jurisdictional disputes between the Academy of Sciences and the GKNT. These involve such matters as the Academy's loss of its monopoly over establishing and maintaining contacts with foreign scientific communities, and in providing the most authoritative guidance for Soviet science and the required coordination in implementing R&D results.

— Then there are differences between the Academy and the production ministries over the issue of basic versus applied science. Many in the Academy prefer to do basic research; the ministries, including the nine defence production ministries, however, want help on the applied end because of their need to meet new technology and production goals. Tensions arise because the Academy no longer receives its entire funding from the state budget and its research institutes must make up the shortfall through contract work from production ministries, which exert pressure on the Academy to work on applied problems. This creates another negative reaction in that many Academy scientists on assignment to ministry enterprises are unhappy because they are given the task of working on what they consider to be " nuts and bolts " production-related tasks rather than the more interesting fundamental problems.

— Finally, there are problems between the GKNT and the ministries. The GKNT is charged with identifying advanced foreign technologies and promoting their introduction into Soviet production and use. But the ministries resist the imposition of such technologies because they do not get an allowance for the time involved in installing new equipment and retraining workers. Furthermore, the resultant interruption of production can in turn lead to failure to achieve the annual production goals that affects bonuses and promotion of ministry officials and production personnel.[62]

These problems affecting the performance of Soviet S&T and industry are well known not only to political and government leaders but to such leading S&T figures as Academician Velikhov, the Academy's Vice-President for Science and Technology. The problems should have led a key official like Velikhov to propose substantive solutions and organizational alternatives. That he has not done so to date, even when he has discussed other major issues affecting Soviet S&T, is significant, especially in view of his position and past experience. He can speak with authority on the need for greater efficiency in the R&D effort, including the persistent problem of bridging the gap between research and application: he has been heavily involved in applied as well as theoretical research, including weapons development. (As a prominent physicist and Deputy Director of the Kurchatov Nuclear Energy Institute he has

[62] For a more detailed discussion of the foregoing problems, see the author's chapter in *Soviet Science and Technology, Domestic and Foreign Perspectives* (John R. Thomas and Ursula M. Kruse-Vaucienne, eds.). Published for the National Science Foundation by George Washington University, Washington DC, 1977. Cf. also *Survey*, Spring 1977–78, Vol. 23, no. 2 (102), on " Soviet Science and Technology."

directed [illegible] related energy programmes.[63]) Since assuming his present post, his views on greater efficiency have paralleled those of the political leadership.

Given this background, Velikhov has been specifically asked, in a wide-ranging interview covering the " health " of Soviet S&T,[64] about the key issue related to improved R&D integration and application, namely, the desirability of having a single science agency provide overall S&T coordination and follow-through with industry in order to overcome difficulties in adapting and diffusing innovations. Regarding the USSR Academy of Sciences, Velikhov was explicit about its inability to fulfil such a function because of personnel and budgetary constraints. He noted that the Academy has only a small fraction of the over four million persons engaged in Soviet science and receives only a small percentage of the 20-billion-ruble science budget.

At the same time, Velikhov has strongly implied that the GKNT should not play an expanded coordinating and implementation role. Parenthetically, the GKNT has been headed by scientists who previously held high posts in the Academy, e.g. Academician V. A. Kirillin from 1965 until 1980, and Academician G. I. Marchuk since then. This Academy-GKNT interfacing has not, however, solved nor ameliorated the need for institutionalizing centralized R&D coordination. Even though Velikhov was explicitly asked about such an alternative, his failure to respond suggests he rejects centralized coordination as a solution to the problem of obtaining greater effectiveness from the Soviet R&D-production cycle.

If anything, Velikhov has refused to acknowledge the existence of an R&D coordination problem. For example, his satisfied tone in describing how the research-to-production process currently works, seems to reflect such a belief, despite the fact that *vnedrenie* (adoption and utilization of innovations) has always been, and is increasingly now, recognized as a major deficiency in Soviet science and industry.

Velikhov's views are relevant, however, not only for the present but for future Soviet S&T development and R&D policy. He has implied (in the same significant overview assessment of Soviet S&T cited earlier[65]) that no fundamental policy and structural changes are in the works to overcome the USSR's most pressing S&T problem: its inability to translate research and development achievements into actual production despite the massive and uninterrupted S&T investment in recent decades. Velikhov's assessment also suggested that there are no firm plans for S&T reform (much less reform of the Party's ubiquitous and jealously guarded control over S&T) despite increasing recent concern among the political leaders over the need to enhance the role of S&T in improving the flagging Soviet economy.

[63] It should be recalled that Kurchatov and the Institute which bears his name were involved in the original and early development of the USSR's nuclear weapons.

[64] In *Literaturnaya Gazeta*, 9 June 1981.

[65] Ibid.

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A revived economy would, of course, reduce current pressure on Soviet leaders to choose between "guns and butter." But without reform, this economy is likely to perform poorly in the future and affect Soviet R&D, including military-related work, accordingly.

Whether the Soviet leadership will initiate the necessary basic reform (as opposed to cosmetic measures) remains to be seen. In any case it is unlikely to do so at the expense of Party control over Soviet S&T. Moreover, Soviet leaders might be dissuaded from the necessary basic reform because this would require, in the case of scientific elites, non-material incentives such as greater freedom to travel abroad and interact with foreign S&T communities; these reforms could lead precisely to loosening of controls. This, however, is unacceptable to a Soviet leadership which is trying to tighten internal discipline and to guard against hostile Western influence.

The Academy's R&D Style

Despite the leadership's stand-pat attitude on reform to date and the specific problems noted above, conservatism and incrementalism are not uniform to all Soviet R&D activities. These characteristics affect mainly the final stages of the R&D cycle involving the industrial innovation process. The early stages of the cycle, comprising basic and applied research, cannot by their nature be conservative or incremental. However, Soviet industry has the particular problem of being less bold, since innovative results of scientific research are seldom introduced into industrial production.

During the past two decades, the Academy's institutes specializing in the physical and engineering sciences have become increasingly involved in project work beyond the applied research stage. Here, the Academy has been far from conservative. It has displayed a willingness to take risks by undertaking large prototype construction projects prior to the solution of all the technical problems involved. An example of this style of R&D performance is the U-25 magnetohydrodynamic power-plant installed in Moscow by the Academy's Institute of High Temperatures. This large experimental prototype facility has been built as an operational component of the Moscow power grid, although some basic problems of heat-resistant electrodes, plasma channels, and superconducting magnets remained unsolved. The philosophy underlying this approach was based on the value of being plugged into a large established system as a way of stimulating individual local solutions to be worked out under operational conditions. Another example is the large-scale laser fusion facility at the Lebedev Physics Institute. The multi-channel Del'fin glass laser system was installed and operated at a relatively early stage of R&D, without solving the key problem of parasitic energy transmission losses.

While these attempts have to date produced relatively unimpressive results, other activities of the Academy R&D system have seen imaginative and highly successful use of new, untested approaches, such as the development of high speed abrasives at the Institute of Superhard Materials and new welding techniques at the Paton Institute of Electric Welding, both of the Ukrainian Academy of Sciences.**

The above examples illustrate an R&D policy that is relatively bold and innovative, rather than conservative and incremental. The two contrasting policies, one characterizing the conservatism of industry and the other, the boldness of the Academy of Sciences, have coexisted for some time. From the viewpoint of the end results, the main difference between these two policies is that the former affected serially-manufactured industrial products, while the latter led to the construction of one-of-a-kind installations or to small-batch production without extensive participation of industry. This has led to perpetuation of the R&D production gap.

The Organizational Problems of Industrial Innovation

Vnedrenie, or the introduction of R&D results into industrial production, has been the Achilles' heel of the Soviet economy. In the civilian sectors of the industry, innovation faces well-known difficulties due to many factors of an economic, organizational and technical nature. The economic factors include the absence of suitable incentives for innovation, quantitative goals penalizing innovation, and a minimal system of effective demand. The organizational problems (analysed earlier in the context of Soviet S&T as a whole) include in more specific terms an R&D cycle fragmented among diverse research institutes and plants, and a pervasive lack of an effective umbrella organizational structure that could carry an entire project from applied research to production under a single leadership. Though intended to do so, formation of various scientific-production associations since the mid-1960s has not solved these problems. The technical factors involve scarcities of experimental equipment and instrumentation, and inadequate technical information support.

The inhibiting effect of the Soviet S&T organizational problems on innovation is particularly strong in R&D projects that straddle industry and the Academy system. The Academy institutes, as independent R&D performing organizations, are difficult to bring under a single project leadership outside the Academy. The independence and organizational remoteness of the Academy from industrial production, and the divergence, if not outright conflict, of interests between the Academy and the industry, tend to hamper the efficient introduction of the results of the Academy's research into mass production. The Soviet press features

** Western observers have had an opportunity since the 1970s to familiarize themselves with the work of the three institutes noted above: the Institute of High Temperatures, Lebedev, and Paton Institutes were among those involved in joint activities under the 1972 US–USSR Agreement for Cooperation in S&T. The author, along with others, visited many of these and other Academy institutes (as well as industrial plants) during the 1970s when he served as the Soviet Programme Director of the National Science Foundation, the Executive Agency responsible on the US side for implementing the foregoing 1972 bilateral agreement.

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complaints about industrial research institutes preferring to duplicate the work done by the Academy in order to avoid using its results.

Hence, the organizational difficulties related to industrial innovation and stemming from the jurisdictional independence of the Academy of Sciences may well become the major pacing factor in the development of advanced technologies in the Soviet Union.

The military industrial sector has been less affected to date by these problems. The military leadership's ability to concentrate resources and to cut across bureaucratic rigidities in many cases effectively alleviates the economic and technical problems. In organizational structure, the military R&D also tends to depart from the typical civilian pattern. The design bureaux, research institutes, and production plants of the aircraft industry and other military industrial areas bring under one ministerial roof the R&D and production organizations that enable them to cope most effectively with technological innovation problems under Soviet conditions.[67] However, such a structure is not feasible in situations requiring the participation of the Academy's R&D institutions.

The Academy's Role in Military R&D

Advanced, or exotic, technologies have been utilized far less in developing military systems to date than there is potential for; in this context, the Academy's contribution to the development of military technology has often been limited to advisory and troubleshooting roles. But this situation may be changing as the Soviet leaders perceive a growing technologically sophisticated US threat, and as Soviet military planners pay increasing attention to the technologies of computers, very large systems integration, composite materials, directed energy, quantum electronics, etc. On these, the Academy's research facilities are the primary source of knowledge and site of R&D activity.

In this connection, it should be noted that the Academy has in the past made contributions to the development of " new-in-principle " weapons. The most outstanding of these was its leadership of the Soviet nuclear weapons programme. This programme was organized and headed by Academician Kurchatov and involved at one time the now-dissident Academician Andrei Sakharov. More recently, Academicians A. M. Prokhorov and N. G. Basov of the Academy's Lebedev Physics Institute have played major roles in the high-energy laser programme. Significantly enough, several achievements of the Academy in the directed energy field during the past decade have been adopted by the US for its own military projects, such as the cyclotron resonance laser (called the gyrotron and originated by the Academy's Lebedev Physics Institute and the Institute of Applied Physics), the high-brightness ion source, and the gyrotron high-efficiency converter for radio-frequency accelerators. (The last two were developed by the Institute of Nuclear Physics of the

[67] For detailed discussion of the advantages of military R&D and production over civilian, see *Problems of Communism*, May–June 1983, pp. 70–73, and David Buchan, op. cit. pp. 9–11.

Academy's Siberian Department, headed by Academician Budker until his death in 1978 and since then by Academician Skrinsky, the Academy's youngest member.[68])

But, any large-scale introduction of the Academy of Sciences into the weapons procurement process, involving advanced technology applications and new-in-principle weapons, would constitute a major change in the Soviet military R&D practices. In such a case, the type of organizational linkage between the Academy and the defence industry will be important in determining the success of such practice.

Two organizational policies have helped bring the Academy and the military closer together. The first is the encouragement of contract research in Academy institutes, combined with state budgets that have provided for little or no growth. This policy has encouraged academic institutes to seek contractual relations with sources outside the Academy's system, including the military. The second policy is the use of project planning, especially as represented by the VPK decree, in which a lead organization is given the responsibility and legal authority to plan and manage complex projects that span diverse organizational boundaries. Both policies have encouraged and permitted the growing role of the Academy in military-related R&D. However, it is unlikely that the Academy research institutes will voluntarily surrender their operational independence to defence ministry organizations. For this reason, unless a more satisfactory formula is devised permitting a smooth and efficient flow of high technology projects through the entire R&D cycle, the broad dissemination of such technologies within the Soviet defence industry will remain uncertain.

Even if the flow of technology to industry can be increased, the technology must still be produced by a Soviet industry, whose motivations are unlikely to change in the near future unless there are large-scale, basic reforms. Furthermore, the technologies must be demanded by a military that understands many of the negative effects of pushing technology and requiring performance beyond reason—higher costs, greater complexity,[69] the strain of imminent S&T manpower shortage, etc. Although the Academy of Sciences and the military are working more closely together than ever, this has not yet signalled a sharp break in past patterns of weapons development. However, the potential for such a break and still larger Academy role in military R&D may come from proposals to give the Academy added capability for an increased role in solving the problem of *vnedrenie*: as noted earlier, the Academy's

[68] Together with other foreign observers, the author had numerous opportunities to visit this institute and to meet these leading figures. They were and are proud of their achievements, including their claim that their particle accelerator work leads that in the West.

[69] The present author, in accompanying Academician Vadim Trapeznikov in 1973 on a visit to big US companies involved, among other things, in defence production, heard him note that the Soviet military often demands weapons performance that is beyond the laws of physics. His view implied the military's ignorance of the scientific process and its limits. Trapeznikov can speak with great authority on the scientific–military relations. He is a senior Academician, an automated systems expert, director of one of the Academy's largest research facilities (the Institute for Problems of Management) and an advisory member of the Military-Industrial Commission.

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Scientific Secretary has proposed that it get its own technological base.[70] Such a move, added to its already sizeable research facilities, would, of course, also extend the Academy's ability to contribute to military R&D.

Impact of Key Factors

In sum, it can be supposed that any R&D that results in increased complexity of weapons systems would not, when viewed as an evolutionary process, necessarily imply major changes in the Soviet military R&D programme or an increased Academy role. But the application of new, advanced technologies to military systems and the development of new-in-principle weapons, being urged by political and military leaders, will require greater participation of the Academy of Sciences in the weapons procurement process. The Academy is one Soviet S&T institution which has done and is doing the kind of applied research that leads directly to the development of advanced technologies. Because the Academy, unlike Soviet industry, has been noted for some innovative approaches, its still greater involvement could signal a shift in the Soviet military R&D policy towards less conservative and more risky undertakings. Such a shift could be induced by an accelerated, technologically sophisticated US weapons build-up. Such a shift could also reflect a change in mission requirements which demand greater performance and a multiplicity of measures.

However, any necessary greater involvement of the Academy, which currently exists as a relatively independent performer of R&D, would confront Soviet military planners with a specific, major management problem, arising out of the larger S&T organizational difficulties noted earlier: how to integrate successfully the Academy's R&D with industrial production on a broad scale that has not been accomplished to date and which would be essential to the development of weapons embodying advanced technology.

The organizational problems that have plagued the Soviet S&T community and have caused the less than fully productive situation to date have been and are manageable as long as the regime was and is content to tolerate the current fragmentation and overlap of the Soviet S&T components—the Academy, production ministries and *VUZy*—and not to force tight integration and centralized direction of the Soviet S&T effort.

However, the Soviet need to match the increasing proliferation of high and advanced technologies and the faster pace of technological development in the West, combined with a pressing scarcity in Soviet S&T resources and the deteriorating Soviet economy, may make it imperative for the Soviet regime to reconsider the obsolete organizational forms and traditional R&D approach dominating Soviet S&T. Such reexamination, as part of drawing the Academy into military work even further, may be stimulated by changes in military R&D policy. In relative terms, military

[70] G. Skryabin, *Vestnik AN*, No. 6, 1982, p. 19.

R&D facilities operating under that policy, with its traditionally higher political priority, have been more efficient. Consequently, the Academy may benefit from the advantage that greater military sponsorship may provide in terms of ability of the military to influence reordering of S&T policy and procedures that could permit the " unleashing " of the Academy's talents and capitalizing on its uniqueness. This assumes that the military themselves will appreciate, and more fully and effectively utilize, the Academy's talents, skills and experience.

In any case, significant change in Soviet R&D policy will most likely be gradual and difficult to discern in its early stages. Important leading indicators of potential change in Soviet R&D policy and performance would include trends in the size of investment in speculative applied research, increase in number and scope of enigmatic systems, and major organizational changes, both in the overall Soviet S&T community as a whole and in the specific relationship between the Academy and the production ministries, including those of the defence industry.

Implications of Systemic and Societal Developments

In addition to the impact of possible changes in Soviet military R&D policy and organizational relationships (noted in the preceding section), the Academy's future involvement in military-related work will be affected by larger systemic and societal developments. On the political side, the moves by the Party to tighten its grip over the Academy were assessed earlier. It should get further " responsiveness " by the Academy in the short run. (Whether this will increase the effectiveness of the Academy's output is another matter.)

The Academy's role will also be affected by changes in the professional composition of its personnel. The increased number of Academy scientists with weapons- and military-related disciplines (e.g. applied physics and engineering sciences) foreshadows still greater militarization of the Academy through greater potential to meet military requirements. In this connection, the increasing influx into the Academy of personnel with narrow engineering training and a " nuts-and-bolts " approach will enable the Academy to be more responsive to the regime's call for a greater applied research effort, than was earlier the case with a personnel composed of more theoretically-inclined scientists.

Then, too, the change in its professional composition has political implications: Soviet scientific ranks to date have, in relative terms, produced more dissidents than have the engineers. This would suggest that as the number of the latter in the Academy grows, it may prove to be more responsive to the regime's wishes in general, and to its military requirements in particular, with fewer activist dissidents rising from engineer ranks.

But, to the degree that such growing military-related experience and skills cannot be transferred, or are difficult to transfer to civilian use, any trends towards further militarization of the Academy will lessen its ability

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to help solve the basic problems now plaguing the Soviet civilian economy. In turn, the longer these problems remain unsolved, the more they will affect the attitude and vigour of Soviet society, including its S&T community. For, any addition to this community's already low morale and indifferent attitude towards the Soviet system would ultimately have an impact on the Academy scientists involved in military-related work, with implications for its future role in such work.

Indeed, the Academy's and other scientists do not work and exist in a vacuum. They are intimately affected by economic and political developments in their country. Therefore, even if there were at one time two distinct worlds in the Soviet S&T community—civilian and military—as some have maintained, the greater professional interdependence and interactions and other societal developments beyond the Soviet leadership's control have long broken the artificial wall the Soviet regime has tried to maintain between the two worlds. This has had undesirable consequences for the regime's effort to utilize its scientists " according to plan, " and in a compartmentalized manner. For example, the eagerness of young Soviet scientists in the past to work for the military because of greater incentives and other financial perquisites is being offset by the increasing desire of the younger generation of Soviet scientists to travel abroad, to have their work published at home and abroad, and to participate in and be accepted as members of the international S&T community. In recent years—particularly during the "*détente*" of the 1970s—this desire was stimulated by the relatively large-scale US–Soviet S&T interaction; exchanges, joint seminars and research projects.[71]

If the Soviet regime fails at least partially to satisfy such desire, it could ultimately reduce the Academy's ability to contribute to military R&D as it lost its ability to attract " the youngest and the brightest. " Moreover, such a loss could be compounded by the Academy becoming even more militarized, and therefore subject to additional security requirements; this, when added to the already sizeable restrictions on its personnel, could further serve to repel future applicants.[72] These negative developments could be extended by a still larger societal problem affecting Soviet S&T potential. Soviet spokesmen openly acknowledge that their youth is beginning to lose its enthusiasm for mathematics and physical sciences, and that it holds these disciplines, which are the underpinnings for applied research, in lower esteem than before. For example, the head of Kharkov University has noted these trends in the Ukraine.[73] This is a revealing admission in a nation in which the honour, utility and benefits of science and technology have been so highly propagandized for 68 years of Soviet rule. Any further lowering in the USSR of the hitherto high regard for science could affect the Academy's future ability to draw the most talented into its ranks.

Finally, the future capabilities are likely to be affected still further by the generational change in Academy leadership: the older Academicians, many with direct training and/or extensive experience in and contacts with the West have passed or soon will pass from the scene; they are being replaced by those trained under the Soviet regime, with very little or no experience in the West. In the short run, such a change can portend greater responsiveness to the Soviet regime's requirements, but in the longer run such pliability may be obtained at the expense of greater creativity provided by scientific leaders such as Kapitsa.

In short, the Academy's future creativity may be significantly affected by the increased " engineerization " of its personnel, the decreasing enthusiasm for S&T among Soviet youth and the decreased ability to attract the most talented, as well as the general change in the Academy's leadership. Such a loss of S&T creativity would affect the USSR's ability to compete with the US in the fast-paced, high-technology race that increasingly underpins modern military R&D and weapons production. The impact would be greatest if the loss occurred at a time when both the US technological challenge and the perceived Soviet need to meet such a challenge might be greatest. Would it profit the Academy to become even more militarized and lose its creative soul?

Conclusions and Implications

The foregoing examination of the USSR Academy's involvement in military-related work leads one to emphasize the following points:

Sixty-eight years of Soviet rule have transformed the USSR Academy of Sciences from an elitist association of scientists engaged primarily in basic research in non-physical sciences, into the largest and the most militarized scientific-technical network of research facilities and personnel in the world. The involvement of the Academy in the development of weapons and dual-use technology is more extensive and dates back much further than is commonly believed.

The Academy's " industrialization " and " militarization " has been driven by the Soviet leadership's goals of the USSR's industrial and military modernization, by the expansive Soviet foreign policy and resultant strategic problems and opportunities. Unless these goals and foreign policy are radically altered, the Academy's already sizeable involvement in military-related work is likely to grow. In particular, it will be needed to develop advanced weapons systems, requiring appropriate scientific and technological breakthroughs, because the Academy is the leading Soviet S&T organization with the requisite capabilities and experience to achieve such breakthroughs. This has been demonstrated by its past leadership in developing Soviet nuclear weapons, ICBMs and space systems, and by its current R&D work on exotic weapons, e.g. lasers and particle beam weapons.

[71] The present author can speak from personal experience during numerous visits to the USSR and discussions with Soviet scientists, including some from military-related research institutes, about the changing aspirations of Soviet scientists, particularly of the younger generations.

[72] There are already numerous reports of many young Russians " dropping out " of the Soviet S&T community when given no choice but to work only on military-related projects.

[73] *Pravda*, 12 November 1982.

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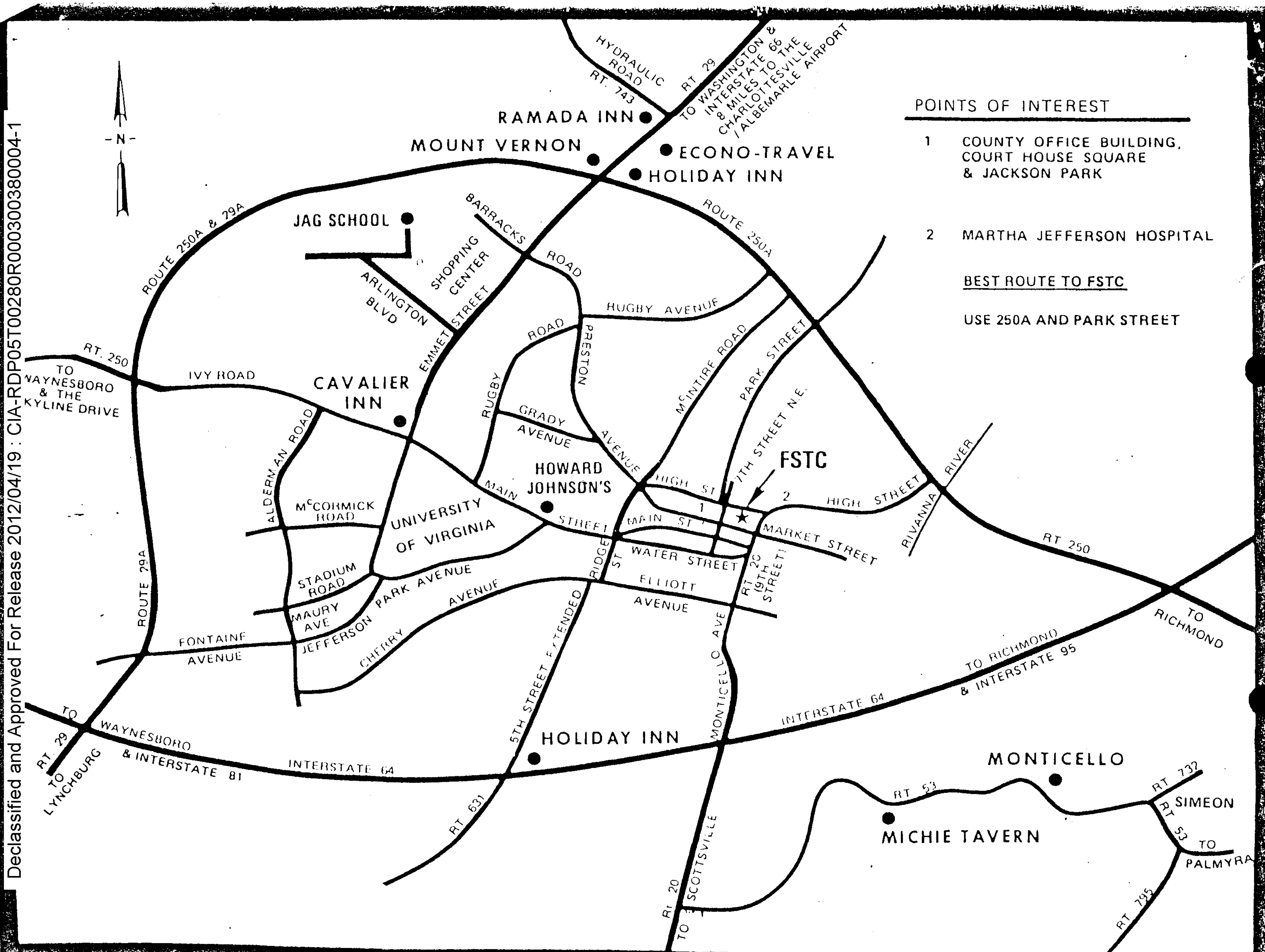
The Academy's leadership has recently hinted at the Academy's greater future involvement in developing new weapons, particularly in the burgeoning Soviet space programmes. These hints have been made against a background of pressure on the Academy by Soviet political and military leaders to help solve the USSR's strategic problems.

The extent to which the Academy can effectively increase its already sizeable involvement in military-related work will be determined in large part by changes in Soviet military R&D policy, viz. receptivity towards more innovative approaches, by the ability of the Soviet S&T community to accommodate itself to the Academy's relatively independent R&D performance style. Such an accommodation within the S&T community would, however, require fundamental organizational reforms in the relationship among the key S&T organizations in the USSR, viz. the Academy, the State Committee for Science and Technology, and the production ministries (including those of the defence production). Such reform is unlikely in the near future if recent history is any indication.

However, larger, systemic developments, such as growing political control over the Academy, the generational change currently under way within the Academy, which is reducing the ranks of older, more independent-minded scientists, and the growing " engineerization " of the Academy's personnel, are likely to affect its current posture.

In the short run, these developments are likely to reduce its relative independence and make it more receptive to political–military leadership pressure for still greater involvement in developing the more advanced weapons systems. But in the long run, this pliability, together with the decreasing enthusiasm of Soviet youth for S&T, is likely to be at the expense of the Academy's creativity. Such a diminuition of Soviet scientific–technical potential could reduce the USSR's ability to compete with the US in the larger high-technology race that increasingly underpins military R&D and weapons production. In turn, this would have an impact on the USSR's ability to develop its advanced, sophisticated weapons systems and match the US technologically-advanced military capabilities.



POINTS OF INTEREST

1 COUNTY OFFICE BUILDING, COURT HOUSE SQUARE & JACKSON PARK

2 MARTHA JEFFERSON HOSPITAL

BEST ROUTE TO FSTC

USE 250A AND PARK STREET

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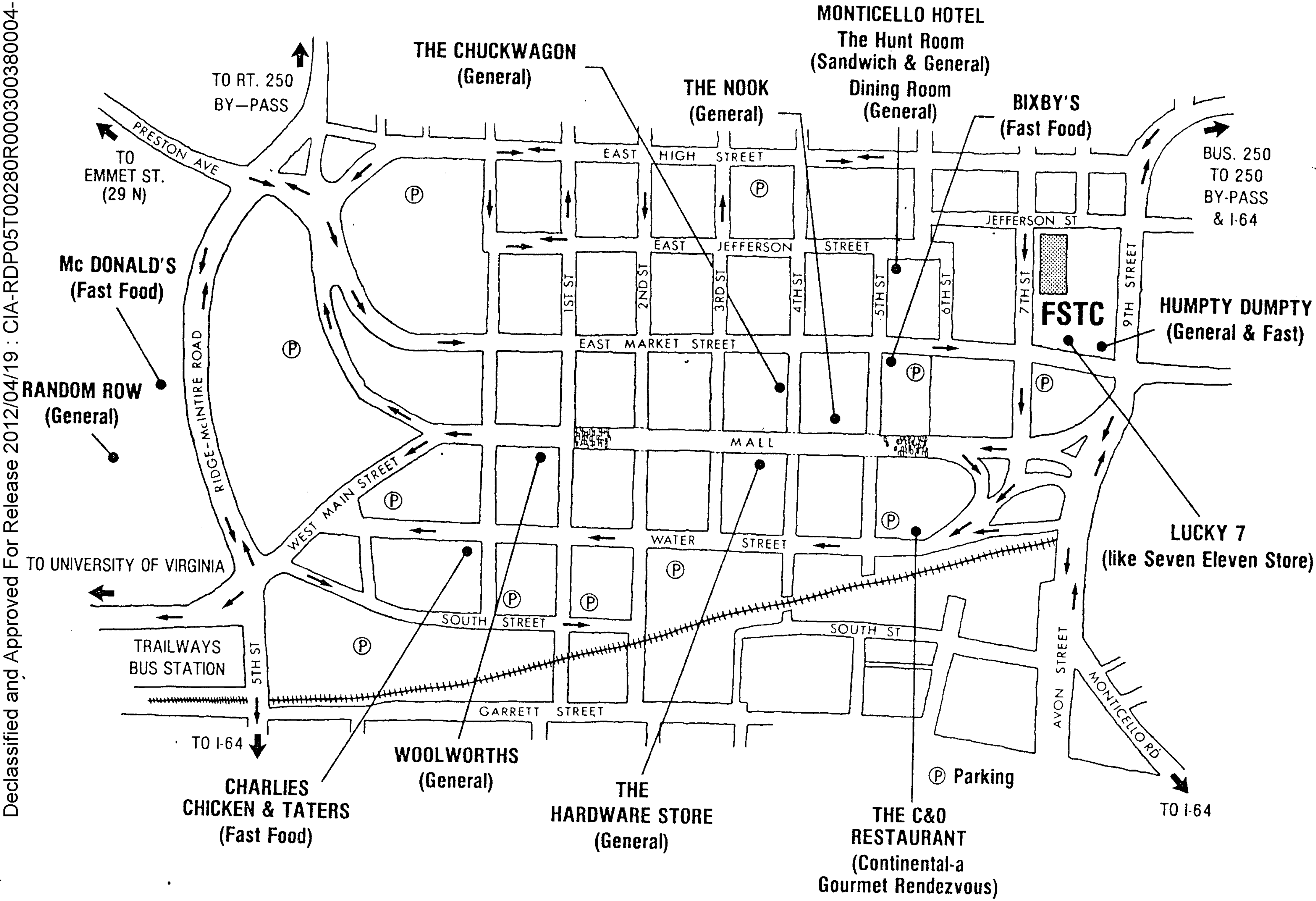
DOWNTOWN CHARLOTTESVILLE
(RESTAURANTS WITHIN WALKING DISTANCE)



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