The Cold War Atomic Intelligence Game, 1945–70

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"The USSR's elaborate countermeasures were intended to prevent the West from learning about its nuclear program."

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This article is unclassified in its entirety.

Since its inception in the early 1940s and through much of the Cold War, the Soviet atomic project was the focus of a massive intelligence effort by the United States and its allies. Of primary interest were the issues of uranium availability; the production of highly enriched uranium (HEU) and plutonium; nuclear warhead R&D and testing; and the nuclear weapons production and management infrastructure.[1]

Washington needed such information to assess the Soviet nuclear strike capability. Estimates of the Soviet inventories of HEU and plutonium when put together with data on warhead designs would allow CIA analysts to gauge the size and composition of the Soviet nuclear weapons stockpile. Information on Moscow's knowledge of nuclear weapons effects was needed to evaluate the capability of the Soviet Union to design warheads for air-defense and anti-missile missiles and to develop hardened warheads capable of surviving US ballistic missile defenses. Analysis of the impact on the Soviet nuclear weapons program of testing moratoriums and the proposed limited test ban treaty was critical when Washington was developing its position on these issues in the 1950s and 1960s.

In pursuing these objectives, the US atomic energy intelligence effort was global in scope. It involved a wide range of covert operations, exploitation of open source materials, and the use of technical collection systems. While much has been written about US operations against Soviet targets (including in *Studies in Intelligence*), relatively little attention has been given to the USSR's elaborate countermeasures intended to prevent the West from learning about its nuclear program. Based on public information, this article seeks to examine the Soviet nuclear denial and deception (D&D) campaign from 1945 until 1970.

This period is of particular interest. The 1950s and 1960s were the formative years of the Soviet nuclear program. By the end of this period, Moscow had a mature nuclear weapons technology base and a thoroughly integrated and redundant weapons complex, the configuration of which remained largely the same until the end of the Cold War. In many ways, these were also the most dangerous years of the Cold War. The 1962 Cuban missile

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[1] See, for example, "The Soviet Atomic Energy Program," *National Intelligence Estimate 11-2A-65* (Washington, DC: CIA, 19 May 1965). All US intelligence documents referenced in this article were accessed at http://www.ucia.gov or located in the US National Archives in College Park, Maryland.

> “Nuclear facilities were built in 10 closed cities that did not appear on maps.”

crisis and other dramatic events of that period were of critical significance in shaping approaches to national defense, foreign policy, and intelligence that served each country for the balance of the Cold War confrontation.

Protecting Nuclear Secrets

The nuclear weapons program, the crown jewel of Soviet military power, has always been a closely guarded secret. During its early years, the program was directed by the Special Committee chaired by Lavrenti Beria, the head of the Soviet NKVD (People's Commissariat of Internal Affairs). State security generals were appointed to key management positions at nuclear research institutes and production facilities. The NKVD, which eventually became the KGB, played a key role in nuclear safeguards and the physical protection of nuclear facilities.[2] The NKVD also was charged with nuclear construction and had the power to establish and run its own nuclear R&D and production facilities. For example, the Bochvar Institute of Inorganic Materials (VNIINM), responsible for the development of plutonium production and processing technologies, was established in 1944 as the NII-9 research institute in the NKVD system—it was not transferred to the broader nuclear program until October 1945.

The pervasive role of state security organizations in the Soviet atomic effort was due to the program's high priority for national security; the requirement for absolute secrecy; the ability of nuclear managers with state security backgrounds to get things done; and the NKVD's vast resources, which included funding, materiel, and a workforce drawn from the GULAG prison network.

Beria was executed following the death of Stalin in 1953, and subsequent purges of many former and active NKVD/KGB officers reduced the state security presence in the nuclear complex. The program itself was reorganized in June 1953 to become the USSR Ministry of Medium Machine Building (*Minsredmash*, the predecessor of today's Ministry of Atomic Power, *Minatom*), and it started to resemble other ministries of the Soviet military-industrial complex.

The emphasis on secrecy and security in the nuclear area remained, however. To thwart foreign intelligence operations, the Soviet Union built an elaborate, multi-layered system of denial and deception, the main elements of which included the restriction of access to nuclear facilities and personnel, strict information protection measures, an enhanced counterintelligence posture, and technical countermeasures.

Denial of Access

Secrecy considerations were paramount in the development of the nuclear infrastructure. While some research and design laboratories were established in Moscow and other open cities, the more critical fissile material production centers and nuclear weapons research and production facilities were built in 10 closed nuclear cities, which are now known by their Russian acronym ZATO. The construction of the first-line nuclear weapons R&D center (Sarov) and fissile material production facilities (Ozersk, Novouralsk, and Lesnoy) began during 1946–47. Subsequently, they were joined by a cluster of second-line facilities (Snezhinsk, Trekhgorny, Seversk, Zheleznogorsk, Zelenogorsk, and Zarechny), most located in the Urals and western Siberia.

To conceal operations from foreign spies and increase survivability against an atomic bombardment, nuclear cities were built in densely forested areas deep inside the USSR's land mass. The cities did not appear on maps. In non-secret documents, they were assigned

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[2] In the postwar years, prior to becoming the Committee of State Security/KGB in 1954, the Soviet state security organization was known sequentially as the NKGB (People's Commissariat of State Security, 1943–46); MGB (Ministry of State Security, 1946–53); and MVD (Ministry of Internal Affairs, 1953–54). KGB is used in this article for simplicity's sake.

The USSR's 10 Closed Nuclear Cities

New Name	Old Name	CIA Name	Established	Function
Sarov	Arzamas-16	Sarova	1946	Nuclear Weapons R&D Warhead assembly/disassembly
Snezhinsk	Chelyabinsk-70	Kasli	1957	Nuclear Weapons R&D
Ozersk	Chelyabinsk-65 (Chelyabinsk-40)	Kyshtym	1947	Plutonium production Nuclear component manufacturing
Zheleznogorsk	Krasnoyarsk-26	Dodonovo	1950	Plutonium production
Seversk	Tomsk-7	Tomsk	1949	Plutonium production HEU production Nuclear component manufacturing
Novouralsk	Sverdlovsk-44	Verkh-Neivinsk	1946	HEU production
Zelenogorsk	Krasnoyarsk-45	Zaozerniy	1956	HEU production
Lesnoy	Sverdlovsk-45	Nizhnaya Tura	1947	HEU production until late 1950s; then warhead assembly/disassembly
Trekhgorny	Zlatoust-36	Yuryuzan	1952	Warhead assembly/disassembly
Zarechny	Penza-19	Penza	1955	Warhead assembly/disassembly

the names of nearby towns and a numerical suffix. The use of post-box numbers continued until the early 1990s.

D&D considerations at times were decisive in determining the design and location of new nuclear facilities. For example, secrecy was the main factor in moving the first plutonium production complex (now the *Mayak* complex) from the initially proposed remote location near the Ufa River to its current location in Ozersk, near Lake Kyzyltash. According to a letter from the atomic project's science director Igor Kurchatov to Beria:

> *[I]n considering issues related to the construction of Plant 817 [the code-name of the Mayak complex] it was established that water in cooling towers would have a temperature of about 80º C. The resulting steam, which would be inevitably produced in large quantities (especially during winter), would thereby compromise the concealment . . . siting the plant near a lake would simplify the problem considerably because large quantities of water would allow cooling without cooling towers . . . and steam formation would be avoided . . . . The site near Lake Kyzyltash was proposed to the Special Committee. The [main] argument against this site . . . is that the lake could serve as a navigation landmark for aerial reconnaissance. I consider this argument unconvincing because the site is located in the part of the Urals, which, within a small area, contains a very large number of similarly shaped lakes. I therefore urge you to consider moving Plant 817's site to Lake Kyzyltash.*[3]

This was how the closed city of Ozersk and the plutonium complex, a source of several major

[3] Letter from I. V. Kurchatov to L. P. Beria on moving the site of Plant 817 to Lake Kyzyltash, 14 November 1945, [originally] Top Secret/ Special Folder," in Lev Ryabev *et al*., eds., *USSR's Atomic Project II, Book 1* (Moscow: Nauka-Fismatlit, 2000), 354.

Entrance to secret nuclear facilities inside mountain at Zheleznogorsk/Krasnoyarsk-26. (Photo from Russian government brochure)

environmental disasters in the Urals, was established.

The closed cities represented an integral part of the layered security system built around nuclear weapons facilities. Each city occupied a large restricted area—232 square kilometers in the case of Sarov, for example—that was surrounded by double fences. Inside the restricted area were a town for the facility workforce, large wooded areas, and several isolated technical areas that housed primary research and production facilities, testing areas, and support infrastructure. Technical areas within the restricted area were surrounded by their own double or triple fences, which were patrolled by armed guards.[4]

A layer outside the perimeter was designated as a special regime zone, where every resident had to have a permit and a passport. Temporary residence—even overnight accommodation of non-residents—was prohibited. Non-residents could not even pick mushrooms and berries or hunt in the zone. Ex-criminals and other undesirable elements were prevented from residing in the special regime zones.

Critical nuclear facilities were on the government's priority list for "active air defense measures."[5] All military and civilian overflights were prohibited. The U-2 plane piloted on 1 May 1961 by Gary Powers over the plutonium complex in Ozersk (and shot down shortly thereafter by an SA-2 surface-to-air missile near Yekaterinburg) was the first airplane over this facility in the almost 15 years of its operation.

Personnel Isolation

The isolation of construction workers and facility personnel to prevent potential recruitment by foreign spies was another critical security task. The construction force was particularly difficult to control. At least 15 of 114 GULAG camps supported the construction of nuclear facilities.[6] In late 1947, over 20,000 prisoners were working in Ozersk, and about 10,000 were in Sarov. There were over 18,000 prisoners in Novouralsk during 1950–51. Over 27,000 were in Zheleznogorsk in 1953.

The Soviet government adopted several measures to minimize the security risk posed by the prison labor force. The KGB's policy was not to send prisoners with sen-

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[4] As of 1947, according to a decree signed by Stalin, 1,400 KGB guards provided security for the newly established warhead R&D center in Sarov. See USSR Council of Ministers Decree No. 297–130, "On Security Measures for Object No. 550," Top Secret/Special Folder, *USSR's Atomic Project II, Book I*, 459.

[5] "On Air Defense for Facilities of the USSR's GlavStroy and the Academy of Sciences," Protocol No. 74 of the meeting of the Special Committee of the USSR Council of Minister (8 March 1949), Top Secret/Special Folder, in *USSR Atomic Project II, Book 2*, 353.

[6] These 15 camps contained about 100,000 prisoners out of the 2.7 million in the GULAG as of 1950. E. Animitsa, N. Vlasova, E. Dvoryadkina, N. Novikova, and V. Safronov, *Russia's Closed Nuclear Cities: Features of Development and Management* (Yekaterinburg: Urals State Economics University, 2002).

tence terms of less than five years or those with sentences expiring in less than three years to nuclear sites. After completing nuclear construction projects, the prisoners finished their terms at the Vorkuta camps in Siberia, which were famous for their remoteness and harsh conditions. When released from the camps, the prisoners were sent to far away regions in the north and to Central Asia. Only in 1955, after several cooling-off years, were some of them allowed to return to central Russia. According to a journalist's account: "[T]he news spread quickly throughout all GULAG camps that [a nuclear construction assignment] was effectively the same as a death sentence."[7]

"Prisoners from at least 15 GULAG camps supported the construction of nuclear facilities."

Soldiers comprised the other large segment of the nuclear construction force. Once they completed their service, they all had to sign a 25-year non-disclosure agreement. The KGB, the agency in charge of construction, was directed to retain discharged soldiers and to hire them as civilians to work on other special projects.

German and Austrian scientists and engineers, who became involved in the Soviet nuclear program after World War II, presented the Soviet security apparatus with a particularly delicate problem. The program needed their expertise. Yet, it was clear that most of them eventually would go home and become accessible to Western intelligence organizations. Moscow decided to concentrate them to the extent possible at NKVD-run facilities (such as the Sukhumi laboratory on the Black Sea); to exclude German scientists from work that was directly related to nuclear weapons R&D and production; and to institute a two-year cooling-off period prior to repatriation. Even so, German scientists gave the West much of the initial data on the facilities, personalities, and technical directions of the Soviet project.

Tens of thousands of workers and engineers were required to operate the newly built facilities. Personnel selection was under the control of the Communist Party's Central Committee, the Council of Ministers, and regional party organizations. There was a process of double selection of personnel based on recommendations by those already working in the program and background investigations by the KGB and its predecessor organizations.

Closed cities made the job of insulating and controlling nuclear workers relatively straightforward. Upon arrival, new residents received instruction in security procedures and signed a nondisclosure agreement, which, among other things, prohibited them from disclosing information about the city and the nuclear facility; the names of nearby towns, rivers, lakes, and other landmarks; the transportation routes to the area; and other information that could help in locating the city. New workers were also encouraged to limit correspondence and social contacts with people outside the closed cities. Personal phone contacts with

Soviet security poster from 1954, with equivalent of Western slogan "Loose Lips Sink Ships."

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[7] Vladimir Gubarev, "Main Object," *Sovetskaya Belarrusia*, 23 August 2003.

the outside world were prohibited. All correspondence was censored. Generally, people lived and worked behind barbed wire, all aspects of their lives penetrated and controlled by the security services. According to Yuli Khariton, a famous warhead designer from Sarov, "Beria's people were everywhere."[8]

Initially, closed-city residents could leave their areas only for business. On rare occasions, they could go to sanatoriums for medical treatment or leave for family emergencies. Every such trip had to be approved by the security director, and its duration was checked by security officers.

In the 1950s, these security rules were somewhat relaxed. By 1954, facility directors, in coordination with the KGB, could grant permission to selected workers to leave their cities for vacations, medical treatment, or study. Nonetheless, workers willing to spend their vacations inside a city received bonuses amounting to 50 percent of their monthly salaries. All travelers still had to have their travel routes approved and sign nondisclosure agreements. Blanket permission to leave the cities was not issued until 1957, when all residents were issued passes permitting them to leave for one day any time they wanted. By that time, the Soviet Union already possessed a credible nuclear deterrent (including nuclear-armed medium-range ballistic missiles) against the West.

"Uranium was assigned such codenames as lead, tar, phosphorus, bismuth, A-9, and BR-10."

Keeping Technology Secret

Secrecy was a hallmark of Soviet nuclear science and technology. As late as the 1980s:

> *[C]lassification stamps Secret and Top Secret concealed everything even remotely connected with our activities and achievements in high technologies . . . . The stamp For Official Use (DSP) was on every piece of conceivably interesting science and technology information. Only after the Chernobyl disaster . . . was the censorship system forced into permitting publications in the open literature about the real state of the nation's atomic industry.*[9]

Even within this generally secretive environment, the nuclear weapons program existed inside a cocoon of secrecy of its own. Nuclear materials and operations had codenames, which were different at different facilities and which were changed periodically. In the late 1940s and early 1950s, for example, natural uranium was assigned such names as strontium, lead, tar, phosphorus, bismuth, titanium, kremnil, A-9, Azh-9, BR-10, and P-9, while HEU had the codenames of kremnil-1 and moist kremnil.[10]

Compartmentalization of information and operations was near absolute. Mikhail Gladyshev, former chief of the plutonium purification shop at the Mayak complex in Ozersk, has remarked:

> *[A]ctivities of the "regime services," headed by Beria, were very stern and bordered on insanity . . . . Often, there was a threat to the safety of workers . . . . As you see, our work had double risks—losing health and losing freedom. This was the difficult fate of those who made the atomic bomb.*[11]

Information about production outputs was particularly sensitive. According to Gladyshev:

> *[W]e put the [plutonium] paste in a box and transferred it to the consumer plant. How much plutonium was in that box we didn't know and it was not recommended for us to know. Even later, when I was the plant's chief engineer, the plans for plutonium production were known only to the facility's*

[8] D. Holloway, "How the Bomb Saved Soviet Physics," *The Bulletin of the Atomic Scientists*, November/December 1994, 46–55.

[9] Vladislav Larin, *Combine "Mayak"—The Problem for Centuries* (Moscow: KMK, 2001), 8.

[10] *USSR's Atomic Project II, Book 1.*

[11] Mikhail Gladyshev, *Plutonium for the Atomic Bomb*, (Ozersk: PO Mayak, 1992).

> *director, and all documents were prepared in single copies.*[12]

Supported in large part by the fear of punishment—an important consideration, given Stalinist repressions and campaigns to unmask spies and saboteurs—the regime of secrecy was further cemented by genuine patriotism and the sense of purpose among nuclear workers.

Counterintelligence Operations

The USSR's Communist Party and the government called on the KGB to maintain an enhanced counterintelligence posture at nuclear facilities. A 1947 resolution of the USSR Council of Ministers regarding security at the warhead R&D facility in Sarov, for example, directed that, "[I]n order to prevent infiltrations of Object No. 550 (codename of the R&D center] by spies, saboteurs, and other enemies . . . the USSR Ministry of State Security (comrade Abakumov) is obligated to step up its operational and *chekist* work at Object No. 550 and in the areas of Mordov republic and Gorky region adjacent to the special regime zone."[13]

In response, the KGB established a Department K in its headquarters in Moscow and "K" units in the regions.[14] The KGB worked with nuclear facilities to develop suitable cover stories to conceal their true missions, monitored information protection measures, and implemented countermeasures against technical collection systems (see below). It also conducted classic counterintelligence operations involving the penetration of foreign intelligence organizations, working against suspected and confirmed foreign intelligence officers in the Soviet Union, and monitoring nuclear facilities and their surroundings.[15]

"The effectiveness of KGB counterintelligence led, in part, to increasing US reliance on technical collection systems."

According to KGB analysis, its success in preventing the insertion of clandestine agents inside the Soviet Union from the late 1940s to early 1950s forced Western intelligence services to rely on intelligence officers operating under diplomatic cover and agents entering the country via such other legitimate channels as tourism, scientific meetings, and cultural exchanges.[16] This allowed the KGB to focus its operational resources on a relatively small number of targets. In 1961, KGB surveillance against Canadian and British diplomats led to the exposure of Col. Penkovskiy, who had provided the West with information on a range of nuclear-related matters. Later on, according to the KGB's 1967 Annual Report:

> *[I]n the course of counterintelligence countermeasures with regard to enemy intelligence officers under diplomatic cover and other foreigners under suspicion of being affiliated with the enemy's special services, a number of Soviet citizens who established contact with the aim of passing secret information were discovered and unmasked. Among those persons brought to justice were . . . a technician [named Malyshev] from an installation of special significance of the Ministry of Medium Machine-Building.*[17]

Technical Countermeasures

The effectiveness of the KGB's counterintelligence operations, on one hand, and improvements in US signals intelligence, overhead imagery, and nuclear test

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12 *Ibid*.
13 USSR Council of Ministers Decree No. 297-130, "On Security Measures for Object No. 550," Top Secret/Special Folder, in *USSR's Atomic Project II, Book 2*, 459.

14 *History of the Soviet Organs of State Security* (KGB Academy Textbook) (Moscow: KGB, 1977), available at: www.fas.harvard.edu/~hpcws/documents.htm.
15 The KGB agent network played an important role in monitoring Soviet society. In the late-1960s, the network consisted of approximately 166,000 agents, almost three times the 57,000 officers in the KGB corps itself. *The KGB 1967 Annual Report*, available at: http://edition.cnn.com/SPECIALS/cold.war/episodes/21/documents/kgb.report/.

16 *History of the Soviet Organs of State Security*.
17 *The KGB 1967 Annual Report.*

monitoring capabilities, on the other hand, led the US atomic energy intelligence program to rely increasingly on technical collection systems. KGB historians observe that the 1950s marked the beginning of the massive use of novel espionage technologies. In the nuclear energy area, for example, "[T]o locate Soviet atomic facilities . . . American, British, and Canadian intelligence officers and their agents were armed with state-of-the-art radio-electronic equipment, . . . radio-navigational systems . . . . Massive application of modern means of science and technology was a characteristic feature of activities by imperialist intelligences during that period [1953–58]."[18]

In response, the KGB "took measures . . . to bring to further perfection the protection of state secrets from the radio-technical and aerial-space means of reconnaissance of the enemy."[19] At a test site, for example, operations on nuclear devices in the field were conducted under a tent to prevent visual observation.[20] Furthermore, "[T]he organs of military counterintelligence of the KGB did significant work on camouflaging . . . depots of nuclear weapons and other objects from the enemy's space reconnaissance."[21] Moreover, most communications between nuclear facilities and the complex's headquarters in Moscow were by teletype or telephone and involved the use of landlines and microwave systems. These were considerably more difficult to intercept than short-wave radio transmissions, the target of the National Security Agency's listening stations at that time. Particularly sensitive documents, such as production data for the nuclear warhead assembly complex, were hand-delivered by couriers.

"Soviet efforts to reduce venting from underground nuclear tests made US radiological analysis ineffective."

Radiological analysis of radioactive residues from Soviet atmospheric tests, collected by the US Atomic Energy Detection System (USAEDS), was the primary tool for tracking the progress of the USSR's nuclear weapons R&D program and its atomic capabilities during the 1950s and 1960s. Indeed, benchmarked by US nuclear test data, the analysis of Soviet nuclear test residues allowed scientists from US national laboratories to determine the Soviet devices' "design space," yield, efficiency, materials, and other parameters. After 1963, when the United States and the Soviet Union signed the partial test ban treaty prohibiting nuclear explosions above the ground, each country made a transition to underground nuclear testing. The end of atmospheric testing was a major setback to the US intelligence effort. According to *National Intelligence Estimate 11-2A-65*, "[O]ur estimates of Soviet nuclear weapon technology . . . are based almost entirely upon analysis of the tests through 1962 . . . and upon extrapolation from that analysis."[22] The radiological method remained useful to some extent because of radioactive venting from Soviet underground explosions. However, Soviet efforts to reduce venting eventually made the US radiological method ineffective against Soviet targets.

In 1973, the increasing threat from Western technical collection systems caused the Soviet government to establish a new organization, the State Technical Commission, with the main mission of developing and implementing a comprehensive system of countermeasures against technical espionage.[23]

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18 *History of the Soviet Organs of State Security.*
19 *The KGB 1967 Annual Report.*
20 Anatoli Veselovsky, *Nuclear Shield* (Sarov, Russia: VNIIEF, 1999).
21 *The KGB 1967 Annual Report.*
22 *US National Intelligence Estimate 11-2A-65.*
23 "Information Protection–The Task of National Importance," *Vestnik Voennoi Informatsii* (9 January 1994).

Gauging the Effectiveness of Soviet D&D

During the Cold War, US intelligence agencies invested considerable resources and effort to understand and predict Soviet nuclear technologies and policies. Despite the fact that the United States was off by several years in predicting the first Soviet atomic explosion in August 1949, it subsequently enjoyed numerous and remarkable achievements. For example, from the first Soviet explosion through the test series of 1961–62, US intelligence detected and correctly characterized many milestone designs of Soviet fission and thermonuclear weapons.[24] Much of this success was based on the fact that atmospheric nuclear explosions by nature were so powerful that they were physically impossible to contain or conceal.

The Soviet Union also was unable to hide from overhead imagery systems its huge nuclear weapons production infrastructure. By 1965, the US intelligence program had correctly identified and characterized facilities with more obvious nuclear signatures, including all fissile material production centers, some uranium processing facilities, the Sarov warhead R&D center, the serial warhead assembly facilities in Lesnoy and Trekhgorny, and the component manufacturing plant in Zarechny.[25] It appears that some facilities, especially those lacking distinct signatures, escaped detection. It is not clear, for example, that the CIA was aware in the 1960s of the nonnuclear warhead component manufacturing facilities and R&D institutes in Moscow, Yekaterinburg, Novosibirsk, and Nizhni Novgorod.

“By 1965, US intelligence had correctly identified . . . all Soviet fissile material production centers.”

Soviet D&D measures were very effective in preventing the United States from learning

[24] See, for example, “Current and Future Soviet Nuclear Weapons Capabilities,” *CIA Report*, 18 March 1958).

[25] *National Intelligence Estimate 11-2A-65*. Washington knew of the existence of Lesnoy as of 1959 but did not know the nature of its activities until later.

US CORONA satellite image of Soviet uranium enrichment plant in Zelenogorsk/Krasnoyarsk-45 taken on 26 May 1970. (US Dept. of Interior, Geological Survey EROS Data Center, Sioux Falls, SD) what was going on inside the buildings it could easily see from space. For example, US intelligence had a hard time assessing the Soviet program to produce enriched uranium for nuclear weapons and reactors. According to a 1954 National Intelligence Estimate:

> *Only meager evidence is available that is relevant to the isotope separation phase of the program . . . . The absence of sufficient evidence from which to estimate installed or planned isotope separation capacity continues to be one of the most serious gaps in intelligence information on the Soviet atomic energy program.*[26]

More than 10 years later, in 1965, US intelligence observed that while it had reasonably accurate estimates of power inputs into the Soviet gaseous diffusion plants—based on data obtained from overhead imagery and electric grid analysis—its assessments of plant efficiencies and, as a result, production capabilities, were very uncertain.[27] Reliable estimates of plant efficiency would have required detailed knowledge of the Soviet gaseous diffusion technology and plant operations, which stand-off collection systems simply could not deliver.

“The USSR prevented US intelligence from detecting its transition to the more advanced centrifuge uranium enrichment technology.”

Perhaps even more importantly, the USSR succeeded in preventing US intelligence from detecting its transition to the more advanced centrifuge uranium enrichment technology. A 1964 National Intelligence Estimate judged that “[T]he present size of the Soviet gaseous diffusion complex . . . tends to indicate that significant U-235 production by the ultracentrifuge and other methods is unlikely.”[28] In fact, a pilot centrifuge facility had begun operation in Novouralsk in 1957. By 1962, the initial phase of a much larger complex at that site had commenced operations, and by 1964 the entire industrial centrifuge enrichment facility had been completed and was fully operational.

The Soviet government worked hard to keep the centrifuge effort secret. The critical point was the repatriation of the German scientists who had participated in the project. According to Nickolai Sinev, the Soviet chief centrifuge designer during the 1950s:

> *Immediately upon his return from the USSR, Gernot Zippe [a talented engineer from Austria] . . . patents in the West the Soviet invention [the design of a subcritical centrifuge] . . . . Having learned about this plagiarism, the Soviet atomic management decided not to react to this information—to keep quiet in order not to give any indication that the USSR was working on a new, progressive method of uranium enrichment. Let them think that the USSR . . . continued using the inefficient gaseous diffusion method. Indeed, that was the price of the concealment for over 30 years of the industrial deployment of a new economic uranium enrichment technology in the USSR.*[29]

Another participant in the centrifuge program adds bitterly that “the damage to morale and economic damage done by the notorious regime of secrecy, which did not allow the USSR to patent abroad the Soviet centrifuge design, was [enormous].”[30]

In Conclusion

Throughout the Cold War, the United States and its allies mounted a massive atomic

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[26] “The Soviet Atomic Energy Program to mid-1957,” *National Intelligence Estimate 11-3A-54* (Washington, DC: CIA, 16 February 1954).

[27] *National Intelligence Estimate 11-2A-65.*

[28] “The Soviet Atomic Energy Program,” *National Intelligence Estimate 11-2-64* (Washington, DC: CIA, 16 July 1964).

[29] N. M. Sinev, *Enriched Uranium for Atomic Weapons and Power,* (Moscow: TsniiAtomInform, 1991).

[30] A. Plotkina, “The Development and Improvement of the Centrifuge Method to Separate Uranium Isotopes in Russia,” *AtomInform,* no. 6, 1996, 50–53.

energy intelligence effort against the Soviet Union. It was countered with a highly effective, defense-in-depth system of countermeasures. The precise score of this competition is unlikely ever to be established. It is clear, however, that long-range, stand-off technical systems proved to be the best collection sources for the United States, allowing for successful tracking of many aspects of the Soviet nuclear program. Overhead imagery enabled the detection and analysis of critical elements of the Soviet nuclear infrastructure. The USAEDS system, designed to monitor radioactive effluents from nuclear explosions and nuclear material processing, yielded important data on the development of Soviet nuclear weapons science and technology. Because of denial and deception countermeasures, however, the USSR's nuclear program was an exceptionally hard target. The lack of reliable on-the-ground intelligence made it difficult for the West to understand important developments inside the Soviet nuclear complex, which resulted in significant intelligence gaps.

“The score of the US-USSR atomic intelligence competition is unlikely ever to be established.”