NUCLEAR WEAPONS TESTS AND PEACEFUL NUCLEAR EXPLOSIONS BY

THE SOVIET UNION

August 29, 1949 to October 24, 1990

by

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This Working Paper provides a compendium of all known nuclear tests conducted by the Soviet Union.[1] With respect to underground tests, the U.S. and Russia define a test as either a single underground nuclear explosion conducted at a test site, or two or more underground nuclear explosions conducted at a test site within an area delineated by a circle having a diameter of two kilometers and conducted within a period of time of 0.1 second.[2] Moreover, Russia does not include within the definition of a test, experiments with nuclear energy release of about 1 ton (t) of TNT equivalent or less, except for tests resulting in device failures or those carried out for safety purposes. By this definition the total number of tests in the forty-one year period, from 29 August 1949 through 24 October 1990, is 715.

Twenty percent (or 145) of the 715 Soviet tests had multiple explosives (or salvos) resulting in a total of 969 nuclear detonations. By comparison the United States conducted 1,149 detonations in 1,054 tests.[3] The sixty three U.S. salvo tests (six percent of the total), involved 158 detonations. One U.S. test used six explosive devices, two used five, four used four, 14 used three, and 42 used two devices. The 145 Soviet salvo tests involved 254 detonations with eight used for Peaceful Nuclear Explosion (PNE). Two tests used eight devices (Nos. 427 and 715), two used seven, one used six, six used five, 16 used four, three used three, and 85 used two devices.

Table 1 lists the Soviet tests chronologically and provides some basic information about each. Tables 2, 3, and 4 summarize the tests by type, location, and purpose. Table 5 summarizes the tests by year and estimated yield. Table 6 details the approximate locations of the Peaceful Nuclear Explosions and Table 7 lists their purpose.

There are several ways to breakdown the new Soviet data. By type there have been 214 tests in the atmosphere, five at water surface or underwater, and 496

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[1] For revised versions of this work in progress readers' additions and corrections would be appreciated.

[2] *USSR Nuclear Weapon Tests and Peaceful Nuclear Explosions: 1949 through 1990*, The Ministry of the Russian Federation for Atomic Energy and The Ministry of Defense of the Russian Federation (Sarov: Russian Federal Nuclear Center-VNIIEF, 1996). The yield of the tests is the aggregate yield of all explosions in the test.

[3] *United States Nuclear Tests: July 1945 through September 1992*, DOE/NV-209 (Rev 14), December 1994. For summary totals of British, French and Chinese tests see NRDC Nuclear Notebook, *Bulletin of the Atomic Scientists*, May/June 1996, pp. 61-63.

underground. Approximately half (251) of the underground tests have been conducted in vertical shafts and 245 in horizontal tunnels. Of the tests in the atmosphere 177 were "air" explosions in which the fireball did not touch the ground. Thirty two others were "surface" explosions where the device was placed either on the ground or on a tower and the fireball did touch the ground. Four tests were conducted in space and one at high altitude.

By location, 489 tests were conducted in Kazakhstan, 221 in Russia, and five in three other republics. Within Kazakhstan 456 tests were conducted at the Semipalatinsk test site, 340 of them underground and 116 in the atmosphere. At the Russian Novaya Zemlya test site, above the Arctic Circle, there have been 130 tests, 86 in the atmosphere, two at the water surface, three underwater, and 39 underground.

By purpose, 445 of the 559 conducted for military objectives were for weapon development or improvement, 52 for weapons effects, 36 were physics tests to study the phenomena of the explosion, 25 were safety tests to study what would happen in an accident, and one was fired in a military exercise. One hundred twenty four detonations were Peaceful Nuclear Explosions with an additional 32 to develop the devices used in the PNEs.

The total energy release, or yield, is estimated to be 285.4 megatons (Mt), the years 1961 and 1962 alone accounting for 220 Mt or 77 percent of the total. The amount after 1963 is 38 Mt, coincidentally the same amount expended by the U.S. over the same period of time. With regard to yield ranges, 453 tests of the 715 were less than 20 kt, a percentage similar to U.S. and French practices, suggesting that many, if not most, of the tests are of the primaries of two-stage weapons. Prior to the 1963 Limited Test Ban Treaty there were some very large atmospheric tests. The five largest were on October 23 and 30, 1961, August 5, 1962, September 25, 1962 and December 24, 1962. The Russian estimate for the five tests is 127.3 Mt, with the October 30th 1961 test alone accounting for 50 Mt.

In the following sections we discuss the establishment of the test sites, the extensive Soviet PNE program and several types of missile tests. In the Appendix we briefly discuss

United States intelligence efforts to assess what was known about the Soviet bomb program, in part, through the detection of tests.

Establishment of the Test Sites[4]

Semipalatinsk-21

On 21 August 1947 a special resolution was adopted calling for the creation of a site to test the atomic bomb. Igor Kurchatov, the head of the Soviet bomb program selected an isolated spot 160 kilometers west of the city of Semipalatinsk, in Kazakhstan. In the early days it was known as "Test Site Number 2," or just "N 2." In late 1947 military units began to arrive in order to build the facilities to test a device then under development. This garrison was called Moscow-400, and was established on the banks of the Irtysh river, some 60 kilometers east of the center of the test site. Many buildings were constructed to house the personnel and to accommodate the scientific and technical support that was needed. The more recent name was Semipalatinsk-21, or the "Polygon." The secret residential city is called Kurchatov.

With a few exceptions, most of the tests were exploded within a rectangle of about 2,000 square miles (49.700 to 50.125 North by 77.700 to 79.100 East). Tests occurred in three distinct areas--Shagan River, Degelen Mountain, and Konyastan. Most of the tests at Semipalatinsk-21 in the 1960s occurred at Degelen Mountain and were confined to yields less than a few tens of kilotons. After 1968 most of the larger tests (50 kt or larger) were detonated at Shagan River. The last test at Semipalatinsk-21 was conducted on 19 October 1989. On 29 August 1991, in the aftermath of the failed coup attempt against President Gorbachev, the president of the newly independent Kazakhstan, Nursultan A. Nazarbayev, formally closed the test site.

A nuclear test device was left behind on Kazakh soil after the collapse of the Soviet Union, having been placed there in 1991 in expectation of being fired. According to

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[4] The topic is covered in greater detail in Thomas B. Cochran, Robert S. Norris, and Oleg A. Bukharin, *Making the Russian Bomb: From Stalin to Yeltsin* (Boulder, Westview Press, 1995), pp. 46-49. See also V.N. Mihailov, Ye.A. Negin and G.A. Tsyrkov, "Preparation of the Test Site and Testing of the Nuclear Bomb near Semipalatinsk in Kazakhstan," in *Creation of the the First Soviet Nuclear Bomb* (Moscow: Energoatomizdat, 1995), pp. 228-248.

Russian press accounts it was device with an expected yield of 300-tons (0.3 kt), with a plutonium core of one kilogram. It had been emplaced deep in a shaft at the Semipalatinsk test site and could not be retrieved. It was destroyed using chemical high explosive on 31 May 1995.

Novaya Zemlya

The development of thermonuclear weapons led Soviet officials to plan for a new site to test weapons with larger yields. In the early 1950s, and in part as a result of U.S. testing at Bikini Atoll, a special commission of military and technical specialists was established to identify a suitable second test site. The commission proposed the use of the islands of the Novaya Zemlya archipelago, and upon government approval construction started. The Novaya Zemlya test site was officially established by a decree on 31 July 1954. Until the 1963 Limited Test Ban Treaty, Novaya Zemlya was the more important Soviet test site, accounting for 91 of the 221 tests through 1962.

Novaya Zemlya is an archipelago in the Arctic Ocean between the Barents and Kara Seas. It includes two large islands--Northern (Severnyj) and Southern (Yuzhnyj)--divided by the Matochkin Shar Strait, as well as numerous small islands. The area of Severnyj is 48,904 km^2, the area of Yuzhnyj, 33,275 km^2, and the smaller islands some 1,000 km^2 in total.

The southern tip of Novaya Zemlya is at about the same latitude as the northernmost point of Alaska. It is a raw environment with a great deal of snow and arctic winds up to 100 mph, while the islands themselves are rugged and mountainous. Novaya Zemlya is an extension of the Ural Mountains, with maximum height of 1,547 meters above sea level. About half of the surface of Severnyj is taken up by glaciers, the depth of many of which exceed 300 meters. The climate is severe. The coldest month is March, when the average monthly temperature is around -20 degrees Celsius. In August the average temperature is +4.5 degrees Celsius. The average yearly precipitation on the Northern island is 4.5 meters. Complete 24-hour darkness begins around mid-November and lasts several months. The test site itself is 750 km by 150 km, and it totals 90,200 km^2 of which 55,000 km^2 are dry land.

The years 1961 and 1962 were the period of the most intense testing at the Novaya Zemlya test site. In a sixteen month period from September 1961 to Christmas day 1962, 56 atmospheric tests were conducted, some of them very, very large. The largest was a superbomb with a yield of approximately 50 Mt, successfully tested (at one-third its full yield) on 30 October 1961.[5] The total number of tests conducted at Novaya Zemlya is 130, with 86 in the atmosphere, 39 underground, three underwater and two on the water.

Peaceful Nuclear Explosions

The Soviet Union had an extensive Peaceful Nuclear Explosive (PNE) program that began in 1965 and only ended in 1988. One hundred and twenty four of the 715 tests were PNEs. An additional 32 tests were to help develop the special explosive devices that were used in the PNEs. Thus almost 22 percent of the total tests were PNE related. In the U.S. the percentage is two and one-half percent (27 of 1,054).

Almost two-thirds of the PNEs (80) took place in Russia, 31 percent in Kazakhstan (39), two each in Ukraine and Uzbekistan and one in Turkmenistan (See Table 6).

The Purposes of PNEs

Cavity construction. The most numerous PNEs were 42 attempts to develop techniques in underground cavity construction. These efforts began in 1966 and continued to 1984. Of the 42, five at Azgir in 1977-79 apparently were duds (Nos. 472, 475, 495, 508, 512). Of the 37 successes 15 were at Astrakhan (1980-1984), 12 were at Azgir (1966-1979), six in the Uralsk region of Kazakhstan (1983-1984), three in Orenberg, and one at Tyumen. Sometimes two or three devices were fired simultaneously with a combined yield ranging from 21 to 73 kilotons. The largest single device used for cavity construction produced a yield of 103 kt (No. 510). The last six series during the 1980s were characterized by multiple firings on a single day at five

[5] The bomb was exploded at an altitude of four kilometers over Novaya Zemlya using a Tu-95 Bear bomber piloted by A.E. Durnovtsev. Yuli Khariton and Yuri Smirnov, "The Khariton Version," *Bulletin of the Atomic Scientists*, May 1993, p. 30. There is some difference of opinion over whether the full yield of the bomb was 100 Mt or 150 Mt. The bomb was never deployed.

minute intervals. For example, at Astrakhan on 24 September 1983 six 8.5 kt devices were fired over a 25 minute period.

The April 25, 1975 firing at Azgir was conducted within a water filled salt cavity that had already been formed by a prior nuclear explosion of 22 December 1971. The test was to explore the principle of decoupling. It is possible to mask the size of an explosion by setting it off inside a large underground cavity. Over the long and volatile debate about a test ban decoupling was often brought up by some Western opponents as a cheating scenario the Soviet Union might use to hide a test or mask the size of the test. For example a 10 kt device could be made to seem to seismometers recording the data that it was only one kiloton though decoupling.[6]

Deep Seismic Sounding (DSS). Conducting explosions for the purpose of Deep Seismic Sounding was the next most numerous category of PNE. Setting off an explosion to send a sound wave deep into the earth can help determine the geological makeup of a particular area. The Soviets carried out nine DSS profiles[7] from 1971 to 1985. Two more series (Nos. 560 and 687, 699 and 700) were interrupted when all testing was halted. These 39 tests were conducted between 1971 and 1988. The smallest devices used had yields of 2.3 kt while the largest were 22 kt.

Oil and Gas Extraction. Twenty of the PNEs were for the purpose of oil or gas extraction. Explosions with yields up to 15 kt were used to attempt to extract gas and oil in various parts of Russia.

Extinguishing well fires. In five instances nuclear devices were used to extinguish fires that had started in gas or oil wells. Two of these were in Uzbekistan (Nos. 255 and 282), and one each in Turkmenistan (358), Ukraine (363) and Russia (570).

In an unusual use of a nuclear device, even by Soviet standards, a 0.3 kt device was set off in a coal mine in the town of Yunokommunarsk, Ukraine on 16 September 1979. The purported purpose of this was to see if the explosion would clear the mine of

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[6] The U.S. conducted a similar series of decoupling tests. The Salmon test of October 22, 1964 at Hattiesburg, Mississippi used a 5.3 kt device buried at 2717 feet to make a cavity. The Sterling shot of December 3, 1966 used a 380 ton device and was detonated in the cavity.

[7] Globus, Region, Meridian, Gorizout, Meteorit, Kraton, Kimberlit, Rift, Kvarts.

dangerous methane gas. The 8,000 residents of the town, most of whom were miners, were evacuated in a mock civil defense drill. The authorities never told the townspeople about the blast and the next day the miners went back to work. The methane gas soon returned.

Excavation. Five of the PNEs were for large scale excavation purposes, two to make a reservoir on the Semipalatinsk Test Site (Nos. 231, 242) and three for canal building (Nos. 291, 295, 335). The very first PNE was fired on January 15, 1965. A 140 kt device was buried 178 meters deep and produced a reservoir.

The purpose of the PNE of March 23, 1971 was to assist in a project to link the northern Kara Sea to the Caspian sea via the Pechora and Kara Rivers.8 Three devices, each of 15 kt, were exploded at a depth of 200 meters 20 kilometers from the village of Krasnovishersk, which is 300 kilometers northeast of Perm. The blasts created an artificial lake 240,000 square meters in size and 12 meters deep

Other purposes. Two PNEs were conducted to explore ore fragmentation technologies and two for underground waste burial. The purpose of eight PNEs is not clear at this time and will require further research.[9]

The Totsk test of 1954

A unique test was conducted on 14 September 1954 near the small village of Totskoye in the Urals.[10] It was basically a large scale military exercise with a live atomic explosion. The explosion took place about three miles from Totskoye (52.32 North, 52.48 East)600 miles southeast of Moscow near the Kazakhstan border. A 40 kt bomb was released at 8,000 meters from a Tu-4 Bull bomber and exploded at 9:33 am at a height of 350 meters, just prior to the start of the exercise. In these early days of the Cold war the Soviet defense ministry felt it was necessary to gain some experience of how to

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[8] Villages Evacuated After 1976 [sic] Nuclear Blast, AFP, in FBIS-SOV-91-086, 3 May 1991, p. 14.
[9] The eight are Nos. 15, 17, 18, 20, 43, 44, 45, and 51. Numbers 43 and 44 may have to do with dam construction and loosening and moving earth.
[10] Marlise Simons, "Soviet Atom Test Used Thousands As Guinea Pigs, Archives Show," *New York Times*, November 7, 1993, p. 1: Fred Hiatt, "Survivors Tell of '54 Soviet A-Blast, " *Washington Post*, September 15, 1994, p. 30: Joseph Albright (Cox News Service), "Soviets Exposed 50,000 to A-bomb Fallout in '54," *Washington Times*, September 13, 1994, p. A12.

fight on the nuclear battlefield.[11] Marshal Georgy Zhukov and defense ministers from China, Poland, and Yugoslavia watched from an observation tower three miles to the south. A film of the test has been shown in the West, and within Russia veterans have clamored for compensation and an apology.

Approximately 45,000 troops participated involving 600 tanks and mobile artillery units, 500 guns and mortars, 600 armored troop carriers, 320 planes and 6,000 tractors and cars. The fact that an atomic bomb was to be used in the exercise was kept secret from the defense side and the offense side only learned about it the day before. Little was known about the test until recently. The Soviet government denied for many years that a nuclear explosion had taken place claiming it was a simulated blast. In fact there were two other non-nuclear bombs used in the exercise. More recently there have been extensive details published about the test including radiation readings taken at various times.[12]

Missile Tests at Kapustin Yar

At least six tests involved missiles fired from the Kapustin Yar test site. Kapustin Yar is located south of the city of Volgograd (48.4 North latitude, 45.8 East longitude) within European Russia. Throughout the 1950s many Soviet missiles were fired in a southeasterly direction toward the Kyzylkum Desert near the Aral Sea, a distance of approximately 700 miles.

The first of the six was a live fire test on February 2, 1956 in which a R5M was fired from the Kapustin Yar test site with a 300 ton warhead (0.3 kt) detonating near the surface 93 miles east of Aralsk in Kazakhstan. The Western designation for the R5M was the SS-3 "Shyster." The SS-3 was a Medium Range Ballistic Missile with a range of

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[11] The Soviets were not alone in preparing for the nuclear battlefield. Eight Desert Rock exercises were carried out at the Nevada Test Site from 1951 to 1957 involving over 60,000 DOD personnel. Howard L. Rosenberg, *Atomic Soldiers: American Victims of Nuclear Experiments* (Boston: Beacon Press: 1980); John J. Midgley, Jr., *Deadly Illusions: Army Policy for the Nuclear Battlefield* (Boulder: Westview Press, 1986).

[12] First public confirmation came in 1989, Colonel V. Zmitrenko, "The Explosion About Which We Can Now Talk," Krasnaya Zvezda, September 29, 1989, p. 2 Translated in FBIS-SOV-89-200, October 18, 1989, pp. 120-122,;

approximately 750 miles. It entered operational service in late 1956 and was first seen in public in the November 7th parade the following year.

Five other missile tests occurred in 1957, 1958, and 1961 (Nos. 34. 82, 83, 88, 115). While the Russian list does not specify which missiles were involved, or the altitudes at which the detonations occurred, a U.S. intelligence document lists the 1961 explosion of September 6 as, "Above tropopause" (i.e., at the top of the troposphere, or about 10 miles) and the test on October 6 as, "Stratospheric" (i.e., 10-31 miles).[13]

Anti-ballistic missile (ABM) tests

A series of five tests in 1961 and 1962 likely had to do with development of anti-ballistic missile systems. Four of them detonated in space. Two 1.2 kt firings occurred on October 27, 1961. Three 300 kt firings were conducted in the midst of the Cuban Missile crisis of 1962 on October 22 and 28, and November 1.

[13] "Soviet Scientific & Technical Developments of Naval Interest in 1962," *ONI* [Office of Naval Intelligence] *Review*, Vol. 17, No. 4 (April 1962), p. 172.

Appendix: U.S. Intelligence and the Soviet Bomb

Since the dissolution of the Soviet Union there has been a great deal of new information about the atomic bomb program. There have been some notable studies published in Russia as well as some excellent works by Western scholars.[14] One subject that has not yet received much attention is the question of what the United States knew about the Soviet atomic bomb program in the early period of the mid-1940s on through the 1950s. More specifically:

- When did the United States learn important facts about what the Soviets were doing in the nuclear energy field?
- When did U.S. intelligence identify Arzamas-16 as the Los Alamos of the Soviet Union.
- When did it identify Chelyabinsk-70 as the second laboratory?
- When was it able to identify the key administrators and scientists involved in the bomb program?
- What were the specific organizations tasked with tracking these developments within the Central Intelligence Agency, the Atomic Energy Commission, the Department of Defense, and elsewhere?
- How was the material collected, analyzed, and coordinated?
- Which U.S. officials had knowledge of the most sensitive findings about the Soviet atomic energy developments and how was this information shared with the highest policy makers?
- How accurate was U.S. intelligence in keeping track of Soviet atmospheric tests in the 1950s and 1960s, and underground tests from the 1960s on?

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[14] *Sovetskiy Atomnyy Proyekt. Konets Atomnoy Monopolii. Kak Eto Bylo(Soviet Nuclear Program. End of the Nuclear Monopoly. The Way it Was),* by Ye. A. Negin, L.P. Goleusova, G.D. Kulichkov, P.P. Maksimenko and G.S. Okutina (Nizhniy Novgorod—Arzamas-16: Nizhniy Novgorod Publishers, 1995); Richard Rhodes, *Dark Sun: The Making of the Hydrogen Bomb* (New York: Simon & Schuster, 1995); David Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy 1939-1956* (New Haven: Yale University Press, 1994); esp. Chapter 1.

Unfortunately, these questions do not have answers at this time. Many more documents will have to be declassified and histories written before attempts at answers can be made. Nevertheless a few preliminary things can be said.

From the available evidence it appears that for the period from August 1945 to September 1949 U.S. intelligence officials, and the policy makers they served, knew virtually nothing about the Soviet bomb program. As we now know the Soviet Union had only a small scale atomic energy program in the summer of 1945.[15] The question of when the United States thought that the Soviet Union would get the bomb was a perplexing question throughout the late 1940s.

Well before World War II ended consideration had been given to the question of how long it might take another nation to build a bomb. As early as September 30, 1944 Vannevar Bush and James Conant had written a memo to Secretary of War Stimson estimating that it, "would be possible . . . for any nation with good technical and scientific resources to reach our present position in three to four years."[16] The question was raised again during meetings of the Interim Committee in May 1945. At the May 18th meeting the Bush/Conant memo was referred to, and it was at this point that General Leslie Groves countered with his estimate that it would take the Russians twenty years to get the bomb.[17] General Groves was of the belief that uranium was scarce and that the Russians did not have any. Until the mid-1950s it was generally thought that there was a paucity of uranium in the world, and that if it could be kept from the Soviet Union the American monopoly could be prolonged. This misapprehension fueled an intense diplomatic effort by the U.S., in concert with other western nations, to gain control of known supplies.[18]

Only after Hiroshima and Nagasaki did Stalin realize the significance of the bomb and he ordered a crash program to build one as quickly as possible. Over the next few

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[15] Holloway, *Stalin and the Bomb*.

[16] The memo is reproduced in Michael B. Stoff, Jonathan F. Fanton, R.Hal Williams eds., *The Manhattan Project: A Documentary Introduction to the Atomic Age* (Philadelphia: Temple University Press, 1991), p. 78. See also Gar Alperovitz, *The Decision to Use the Atomic Bomb* (New York: Alfred A. Knopf, 1995), pp. 161-162.

[17] Richard G. Hewlett and Oscar E. Anderson, Jr., *The New World, 1939/1946* (University Park:, PA: The Pennsylvania State University Press, 1962), p. 354.

[18] Jonathan E. Helmreich, *Gathering Rare Ores: The Diplomacy of Uranium Acquisition, 1943-1954* (Princeton, NJ: Princeton University Press, 1986).

years tens of thousands of people were involved in building a vast complex of facilities to research, develop, test, and build the bomb. How aware was the U.S. of these activities?

The bureaucratic machinery for estimating Soviet atomic energy developments took some time to be established and then to function. Authority to analyze intelligence on foreign atomic weapons and development was given to the Central Intelligence Group (predecessor to the CIA) in August 1946.[19] The Manhattan Engineer District (MED) had concerned itself with foreign developments in atomic energy. The MED was replaced by the Atomic Energy Commission on January 1, 1947. The files and personnel of the Foreign Intelligence Branch of the MED were transferred to the CIG, with completion on February 18, 1947.[20] In March 1947 the personnel transferred became the Nuclear Energy Group in the Scientific Branch of the Office of Reports and Estimates.

> "They were instructed to conduct and coordinate research and evaluation of nuclear intelligence. They were to prepare estimates of the capabilities and intentions of foreign countries in the field of nuclear energy. They were to represent the Director of Central Intelligence in dealing with the Atomic Energy Commission, to attend to the needs for intelligence, and to be, as it should specify, the point of contact between the Commission and intelligence agencies of the Government."[21]

The National Security Act of 1947, approved by President Truman on July 26, 1947 established the Central Intelligence Agency, and on September 18, 1947 the CIG formally became the CIA.

Though the name changed the work continued. The Nuclear Energy Group struggled throughout 1947, lacking its own ability to collect scientific intelligence and getting almost no help from the State Department or the military services.

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[19] Admiral Leahy to President Truman, 21 August 1946 in Michael Warner, ed., *The CIA Under Harry Truman* (Washington, DC: Center for the Study of Intelligence, Central Intelligence Agency, 1994), pp. 79-80.

[20] Arthur B. Darling, *The Central Intelligence Agency: An Instrument of Government to 1950* (University Park: The Pennsylvania State University Press, 1990), p. 165.

[21] Ibid.

By the end of 1947 there was the Joint Nuclear Energy Intelligence Committee, which on November 21, 1949 became the Joint Atomic Energy Intelligence Committee (JAEIC).[22] The JAEIC was the most senior subcommittee of the Intelligence Advisory Committee (IAC). The JAEIC made estimates of all phases of the Soviet nuclear energy program, and would do so until 1961.[23] "Before 1953 the JAEIC supervised interdepartmental research on Soviet atomic energy matters, drafted the estimate and presented the finished document directly to the DCI and through him to the IAC without reference to the Board of National Estimates."[24]

The Central Intelligence Agency was responsible for supplying the estimate of when the bomb was likely. The first estimate, dated December 15, 1947 had the first bomb doubtful before 1953. In July 1948 Director of Central Intelligence Admiral R. H. Hillenkoetter stated to President Truman that, the "most probable date is believed to be mid-1953."[25] The mid-1953 estimate was repeated on 1 July 1949, and inexplicably again in ORE Intelligence Memorandum 225 of 20 September 1949.[26]

The Long Range Detection Program

While the U.S. may not have known many of the details of the Soviet bomb program it did have in place a technical surveillance program to detect the first explosion. The story of developing and operating this system has recently been told in an excellent book, *Spying Without Spies*.[27]

Debris from the August 29, 1949 explosion was first detected on September 3rd by a specially equipped B-29 from the 375th Air Weather Reconnaissance Squadron stationed at Eielson AFB, Fairbanks, Alaska. Between September 3rd and 16th 92 special

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[22] The following is from Donald P. Steury, ed., *Sherman Kent and the Board of National Estimates* (Washington, DC: History Staff, Center for the Study of Intelligence, Central Intelligence Agency, 1994), pp. 71-72.

[23] Wayne G. Jackson, *Allen Welsh Dulles as Director of Central Intelligence, 26 February 1953-29 November 1961* (CIA Historical Staff, 1973) ,Volume II, pp. 64-71.

[24] Ibid., p. 71.

[25] Holloway, *Stalin and the Bomb*, p. 220.

[26] Warner, ed., *The CIA Under Harry Truman*, pp. 319-320.

[27] Charles A. Ziegler and David Jacobson, *Spying Without Spies: Origins of America's Secret Nuclear Surveillance System* (Westport, Connecticut: Praeger, 1995). See also Doyle L. Northrup and Donald H. Rock, "The Detection of Joe 1," *Studies in Intelligence*, Vol. 10 (Fall 1966), pp. 23-33.

air sampling flights were conducted by the Air Weather Service from Guam to the North Pole and from Japan to the British Isles collecting more than 500 radioactive samples. A minimum of 50 counts per minute was the criteria for concern. Of the more than 500 samples collected 167 of them were above 1,000 counts per minute.

On September 8th as the air mass containing the bomb debris drifted eastward, leaving North America, British authorities were notified. The Royal Air Force flew missions from Gibraltar and elsewhere collecting samples. The U.S. Navy collected rainwater samples at its research station on Kodiak Island, Alaska. After extensive analysis by AEC, Navy, and British scientists there was almost complete consensus by September 14th that a Soviet test had occurred. A prestigious advisory group was quickly convened to review the data which it did on September 19th concluding with earlier assessments that an explosion of a plutonium bomb indeed had occurred, sometime between August 26th and August 29th. After the findings were presented to President Truman he made a public announcement on September 23rd. It would appear that the CIA had not been involved in the deliberations and analysis of the filter paper or it would not have issued its ORE of September 20th.

Many United States officials and scientists had been surprised by the Soviet detonation of August 1949. President Truman said, "I was surprised, of course, that the Russians had made progress at a more rapid rate than was anticipated."[28] Various experts had predicted that it would not happen so soon, though some others were quite accurate.[29] The news that the U.S. monopoly had ended was very troubling to Americans and had widespread ramifications.

Six days after President Truman's public announcement, the Assistant Director for Scientific Intelligence wrote a memo to DCI Hillenkoetter about the inability of the

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[28] Harry S. Truman, *Years of Trial and Hope* (Garden City, NY: Doubleday & Company, Inc., 1956), Volume II, p. 307.

[29] Herbert F. York, *The Advisors: Oppenheimer, Teller and the Superbomb* (San Francisco: W.H. Freeman and Company, 1976), pp. 33-36. In general scientists favored lower estimates [five years] and administrators and politicians leaned toward higher ones Former Manhattan Project head General Leslie Groves had said that it might take twenty years, because of Russia's lack of uranium, and convinced important advisers like James B. Conant. James G. Hershberg, *James B. Conant: Harvard to Hiroshima and the Making of the Nuclear Age* (New York :Alfred A. Knopf, 1993), p. 465.

Office of Scientific Intelligence to accomplish its mission.[30] He stated that the USSR completed an atomic bomb in half the estimated time required, and that with current resources it would be impossible to determine the rate of Soviet bomb production. Intelligence is equally inadequate in the areas of biological and chemical warfare, electronics, aircraft, guided missiles. If we cannot properly assess the state of scientific progress in the USSR it will be impossible to foresee the development of new weapons.

With Soviet possession of the bomb now a dangerous fact of life new assessments had to be made about what impact it had on the security of the U.S. The CIA began to produce estimates on the future growth of the Soviet stockpile and how this increasingly put the U.S. in jeopardy.[31] The first formal estimate specifically addressed to the Soviet nuclear energy program was NIE 11-3-54, published 16 February 1954 and prepared by the JAEIC.[32]

DCI Lt. General Walter Bedell Smith formalized the process by which estimates were produced. Smith was appointed to replace Hillenkoetter in August 1950 (and took office on October 7). He disbanded ORE and created three new offices. The Office of National Estimates (ONE) would produce National Intelligence Estimates (NIE), under the auspices of a Board of National Estimates. Harvard history professor William L. Langer was brought in to head the ONE and be chairman of the Board, and Yale history professor Sherman Kent was recruited to be his deputy in both positions. When Langer left in 1952 Kent replaced him, until he retired in 1967. For over twenty years the Board stood at the center of the analytic part of the intelligence community until it was disbanded in 1973 and replaced by another structure.

In general the intelligence community identified each NIE by a three part numerical code, indicating the geographic area, the topic of the estimate, and the year it was produced. Estimates concerning the Soviet Union were give the geographical designation 11. The topics were many covering such areas as Space, Atomic Energy,

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[30]Memorandum From the Assistant Director for Scientific Intelligence (Machle) to Director of Central Intelligence Hillenkoetter, September 29, 1949, U.S. Department of State, Foreign Relations of the United States, *Emergence of the Intelligence Establishment, 1945-1950* (Washington, 1996), pp. 1012-1016.

[31] ORE 32-50, The Effect of the Soviet Possession of Atomic Bombs on the Security of the United States, 9 June 1950, in Warner, ed.. *The CIA Under Truman*, pp. 327-333.

[32] Jackson, *Allen Welsh Dulles*, p. 65.

Economics, Politics, Strategic Forces, General Purpose Forces, Naval Forces, etc. Thus, the designation 11-2-78 would concern itself with an Estimate about Soviet atomic energy matters produced in 1978.

The CIA has been declassifying hundreds of Soviet estimates from 1946 to 1984, depositing them in the National Archives and reproducing them in published form.[33] Thus far the 11-2 series about Soviet atomic energy matters have not been declassified. Until they are we will not have a clear understanding of what the CIA knew about the details of the Soviet bomb and when it knew it.

Strategic Reconnaissance

Clandestine aerial reconnaissance flights began in late 1946 but were confined to the periphery of the Soviet Union. Some flights strayed over Soviet territory and in several incidents U.S. planes were shot down with pilots captured or killed. The first Presidentially-authorized overflight of the USSR occurred in the midst of the Korean War when a B-47B flew over 800 miles of northeastern Siberia on October 15, 1952.[34] The flight was undertaken to investigate whether the Soviets had transferred Tu-4 Bull bombers to airfields at Mys Schmidta on the Chukchi Sea, and Provideniya on the Chukotskiy Peninsula. From these bases the nuclear bombers could carry out a surprise attack on Alaska. The photography established that Bull bombers were not being staged at the bases.

Proceeding at the same time were various balloon reconnaissance programs, known as Gopher, Moby Dick, and Gentrix.[35] Project Gopher formally began on October

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[33] Scott A. Koch, *Selected Estimates on the Soviet Union, 1950-1959* (Washington, DC: History Staff, Center for the Study of Intelligence, CIA, 1993); Donald P. Steury, ed., *Intentions and Capabilities: Estimates on Soviet Strategic Forces, 1950-1983* (Washington, DC History Staff, Center for the Study of Intelligence, CIA, 1996); *Declassified National Intelligence Estimates in the Soviet Union and International Communism, 1946-1984* (Center for the Study of Intelligence, CIA, 1996).

[34] Donald E. Hillman with R. Cargill Hall, "Overflight: Strategic Reconnaissance of the USSR," *Air Power History* (Spring 1996), pp.28-39. Hillman was the pilot.

[35] Curtis Peebles, *The Moby Dick Project: Reconnaissance Balloons over Russia* (Washington, DC: Smithsonian Institution Press, 1991). A balloon weapon system project known as "Flying Cloud" entered full scale development in March 1953. Payloads considered ranged from leaflets and counterfeit money to chemical and biological weapons. After 41 test flights it was canceled at the end of 1954 . The damage it could inflict was tiny compared to the new H-bombs entering the arsenal. Peebles, *Moby Dick*, pp. 127-131.

9, 1950. Its goal was to provide photographs to "aid in the confirmation or denial of such reports as those of atomic production centers, of new industrial developments of new rail yards, and airfields", as noted in an Air Force memorandum.[36] Moby Dick was ostensibly a weather research project to study high altitude wind currents. The military combined the projects using Moby Dick as a cover for Gopher, and later Genetrix. After an almost five year research and development effort, and training flights across the U.S., operations were set to begin, under a new code name, Project Genetrix, now run by the Strategic Air Command. SAC's 1st Air Division, and its assigned units, were to launch balloons from Western Europe and retrieve them in the Pacific area.

In January and February 1956 448 Genetrix balloons were launched from five sites, two in Germany, and one each in Turkey, Norway and Scotland, to drift over eastern Europe and the Soviet Union. Less than ten percent of the balloons made it to the recovery zones with photographs. Most of the balloons, with their photographic equipment, landed in the Soviet Union. Soviet officials protested vehemently, hardly believing the meteorological cover story. They exhibited the balloons and equipment in Moscow at a press conference on February 9th. On March 1, 1956 Project Genetrix was terminated. Assessments of the value of the photographs ranged from "useful, but not of a vital importance," to a "disaster."[37]

With regard to discovery of atomic energy facilities Genetrix photographs revealed the Krasnoyarsk-26 complex, then referred to as Dodonovo.[38] The photographs must have revealed the large scale building activity that was going on at the time since in 1956 it was not yet operational. We now know that three plutonium production reactors were built underground, in addition to a chemical separation plant to recover the plutonium from the spent fuel. The first reactor began operation in 1958.[39]

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[36] Quoted in Jeffrey Richelson, *American Espionage and the Soviet Target* (New York: William Morrow, 1987), p. 129.
[37] Ibid., pp. 138-139.
[38] Richelson, *American Espionage*, p. 139, quoting Donald E. Welzenbach, "Observation Balloons and Reconnaissance Satellites, *Studies in Intelligence* (Spring 1986), pp. 21-28.
[39] Thomas B. Cochran, Robert S. Norris, and Oleg A. Bukharin, *Making the Russian Bomb: From Stalin to Yeltsin* (Boulder: Westview Press), pp. 149-156.

With hundreds of military facilities and sites in the Soviet Union of keen interest to the Pentagon and intelligence community a plane with greater capabilities than the B-47 or the Canberra would be needed. Between 1954 and 1956 a highly concentrated effort lead to the super secret U-2.[40] The first U-2 mission over the Soviet Union was on July 4, 1956. The U-2 was a civilian program sponsored by the CIA, though Air Force pilots flew the planes. President Eisenhower reviewed and approved every mission over the Soviet Union. Exactly how many U-2 overflights were conducted between 1956 and May 1, 1960 has not been made public. One scholar says "fewer than 30," while another says, that "the fleet of ten U-2s deployed at secret bases around the Soviet periphery made at least two hundred passes over the Soviet Union's most secret military and industrial facilities."[41]

Brugioni tells us that, "In the 1957-1959 period, the targeting of U-2 missions over the USSR was shifted to seek out ICBM production and possible deployment in the Urals and Siberia as well as atomic-energy production and development sites."[42] It is probably in these years as a result of the photography from the U-2 flights that the atomic energy facilities were discovered. Allen W. Dulles, Director of Central Intelligence, told the Senate Foreign Relations Committee in secret hearings several weeks after the downing of the U-2, that,

> "the program has provided valuable information on the Soviet atomic energy program . . . includ[ing] the production of fissionable materials, weapons development and test activities, and the location, type and size of many stockpile sites. . . The photography also has given us our first firm information on the magnitude and location of the U.S.S.R.'s domestic uranium ore and uranium processing activities vital in estimating the

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[40] "As late as May 1960, fewer than 400 people nationwide, including pilots and mechanics, knew about the U-2 and its missions." R. Cargill Hall, "Strategic Reconnaissance in the Cold War," *Prologue* , Vol. 28, No. 2 (Summer 1996), p. 125.

[41] Robert S. Hopkins III, "An Expanded Understanding of Eisenhower, American Policy and Overflights," *Intelligence and National Security*, Vol. 11, No. 2 (April 1996), p. 341; Peter Grose, *Gentleman Spy: The Life of Allen Dulles* (Boston: Houghton Mifflin Company, 1994), p. 470.

[42] Dino A. Brugioni, *Eyeball to Eyeball: The Inside Story of the Cuban Missile Crisis* (New York: Random House, 1991), p. 35

Soviet fissionable material production. We have located national and regional nuclear storage sites and forward storage facilities."[43]

Elsewhere Brugioni says that interest had focused on Kyshtym and that through old maps provided by an American mining engineer they were able to pinpoint it enough for U-2 planners.[44] Kyshtym was one of the sites that Gary Powers planned to fly over on May 1, 1960, when he was shot down.

Atmospheric Sampling

The Soviet Union did not test again until September 24 and October 18, 1951. Soviet scientists called the devices RDS-2 and RDS-3. RDS-2 was a plutonium only device with an estimated yield of 38 kt. Five stockpile combat ready RDS-1 units were produced. Some RDS-2 units were also produced. They were not sent to the Ministry of Defense but rather stored partially assembled in warehouses at Arzamas-16.[45] It would not be until 1954 that series production would begin with later RDS designs that would be transferred to the military.

The United States developed an extensive atmospheric sampling program to detect atmospheric tests and to detect the presence of Krypton-85. When a reactor is used to produce plutonium it gives off the isotope Krypton-85 which is vented into the atmosphere. Calculating the amount that is given off can provide an estimate of plutonium production.

The atmospheric sampling was done by aircraft and by balloon. Peebles recounts two balloon projects in 1957 and 1958.[46] Project Ash Can involved using balloons to collect particulate debris from tests, while Project Grab Bag involved collecting whole air samples. Detachments of the 1110th Air Support Group were based in Sao Paulo, Brazil, the Canal Zone and at four Air Force bases in the U.S. where they launched

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[43] Executive Sessions of the Senate Foreign Relations Committee (Historical Series), Volume XII, 1960 , made public November 1982, p. 285.
[44] Dino A. Brugioni, "The Kyshtym Connection," *Bulletin of the Atomic Scientists*, March 1990, p. 12. The mining engineer was Herbert Hoover.
[45] Negin, et. al., *Soviet Nuclear Program*, Chapter Five..
[46] Peebles, *Moby Dick Project*, pp. 196-198.

balloons to altitudes between 50,000 and 90,000 feet. Between January and the end of June 1957 there were 57 Grab Bag missions launched, with 31 successes. Over the same period of time there were 50 Ash Can missions launched with 25 successes. In 1957 there were only seven Soviet atmospheric tests for that six month period. There were also three British tests during this period and information was gained about them. Data on Ash Can and Grab Bag, or their successors, for the more active testing periods of 1958 and 1961-1962 when 170 Soviet atmospheric tests took place, needs further research.

This is also the case with air filtering programs conducted by the Air Force and the other military services and Pentagon agencies. The full story remains to be told. One part of the Air Force program was Operation Sea Fish.[47] Sea Fish missions took air samples of Soviet tests in 1957 and 1958 using B-36s of the 5th Bomb Wing, based at Travis AFB, California.

A second air filtering mission at the time was Operation Miami Moon. Four specially equipped RB-36 aircraft of the 5th Bomb Wing, detached to Hickham AFB, Hawaii, collected air samples from the British Grapple tests held on Malden Island in May and June 1957. With the knowledge of the British two filtering sorties were flown on May 15, two on May 31 and two on June 19, the dates of the three tests.[48]

An Intelligence Coup

With the collapse of the Soviet Union a more fruitful intelligence gathering opportunity presented itself to the U.S. government. It purchased a gold mine of information from entrepreneurial Russian weapon scientists at Arzamas-16 and the Russian Minister of Atomic Energy. Under Defense Nuclear Agency contract number DNA001-92-C-0179, $288,501 was awarded on February 10, 1993 to the Physical Technological Center (PTC) to write a 17 chapter book about Soviet nuclear testing. PTC was established as a private company and is composed of Russian scientists primarily from Arzamas-16. They opened an account at Crestar Bank in Virginia to deposit the contract payments.

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[47] *History of the Fifteenth Air Force*, January-June 1957, pp. 259-264.
[48] Ibid., pp. 264-270.

The statement of work outlines what each chapter should contain and how many words it should be. The entire book, at a minimum, was to be 129,000 words long. The list *USSR Nuclear Weapons Tests and Peaceful Nuclear Explosions 1949 through 1990*, which is the basis for this Working Paper, is only a small part of what was provided to the Pentagon under this contract The book has been completed and it is undoubtedly a very interesting and informative book. While Russian scientists acting in their private capacity can sell Russian government information to the United States, unfortunately U.S. taxpayers, who paid for the work, and Russian citizens (and former Soviets citizens) who paid for the Soviet test program will not be able to read it. The contract specifies that information can be released only by agreement of both parties.

To give some appreciation of the range and scope of the book what follows are verbatim excerpts from the instructions in the Statement of Work.

Chapter 1. 1992: Peace and Nuclear Weapons.

Discuss the general issues specifically the Russian perspective of the role of nuclear weapons in the new world order, the perspectives of the control of nuclear weapons and other non-proliferation issues, including the relationship between nuclear weapon, politics and nuclear tests. (minimum 3000 words)

Chapter 2, Nuclear Testing in the USSR, 1949-1990

Present and discuss the data on USSR nuclear explosions conducted in the period from 1949 to 1990. The information shall be presented in tables with a accompanying text discussing the details of each test as follows. The main table shall list nuclear tests done in the USSR in Chronological order, noting the date and time of the explosion, the region and area of the test, the type of test (airborne, underground, etc.), general characteristic of testing purposes (development testing, military effect testing, peaceful nuclear test, etc.), data (in some cases) on explosion yield (yield range), blasting height (for atmospheric explosions), blasting depths (LPS for underground explosions), on main organizations participating in testing, as well as on the environmental situation during and after testing. For convenience the tables shall be presented in groups according to the

nuclear testing sites: Semipalatinsk test site; Novaya Zemlya test sites; "Galit"; Other nuclear explosions. The materials shall also contain the data on settlements (and distances from them) near which the nuclear explosions took place. (minimum 9000 words).

Chapter 3. Testing the First Atomic Bomb in the USSR

Present and discuss the details of the operation and actual conduct of the test of the first atomic USSR bomb (RDS-1) including the test objectives and the preparation for the nuclear test itself on August 29, 1949.

This shall include information about the people who were engaged in this work, the process of the transportation and delivery to the test site and its preparation before the nuclear test, discussion of the testing organization, and a detailed discussion of the evaluation of the nuclear explosion damaging effects study on evaluation of the results of the nuclear explosion. (minimum 10,000 words)

Chapter 4. Testing the First Thermonuclear Weapon in the USSR: 1953 and 1955

The chapter shall contain two sections: the first one concerning the detailed information of the 1953 test and the other - similar information on the 1955 test, - i.e. the first Soviet thermonuclear charges. This shall include the data and details of objectives, preparation, plan and conduct of the test with reminiscence discussion by the original participants on this historical testing preparation, conducting the tests and reminiscences of the participants. (minimum of 10,000 words)

Chapter 5: The State System for Organizing Nuclear Testing in the USSR

This shall include information on the structure of the USSR state organization for nuclear testing, the interaction of ministries and agencies, leading organizations participating in the testing, test sites, high governmental organizations involved, and regional authorities. (minimum 10,000 words)

Chapter 6: The Specific Nature of Nuclear Test Sites and Staging Areas in the USSR

This chapter shall characterize the Semipalatinsk test site, the Novaya Zemlya test site, the Galit site and other special sites where peaceful nuclear explosions took place.

This chapter shall include maps of the location of test sites, living camps of the personnel, and neighboring settlements of each of the test sites. A brief history of the origin and development of the tests sites.

This shall include a detailed discussion of the Novaya Zemlya, Semipalatinsk and "Galit" test sites including such information as the test techniques used at each site, the type of geology and the issues of containment for each site. A brief history of the origin and development of each test site.

These test sites shall be characterized, with maps of the "Galit" site well locations, and the living camps of personnel and neighboring settlements at all sites. Unique geological peculiarities of each of the sites and a brief history of the origin and development of the test sites and the conducted works is included.

For each test site the typical climate and meteorological conditions (season and average annual temperatures, precipitation amount, number of sunny days, typical directions and velocity of wind), geological conditions (ground compositions, physical-technical properties of rocks, character and type of fractured rock massive, available tectonic cracks and ruptures), hydrological conditions (water-bearing horizon, underground water migration, water-bearing layer output, available reservoir, rivers, etc.) will be presented. Environmental safety issues will be discussed for the test sites with account of the criteria for medium- and low-level waste disposal, studies of rock properties and characteristics formed under the explosion conditions , hydrological, climatic and geographic conditions. Specific data will be presented for the sites where peaceful nuclear explosions were conducted outside the test sites and "Galit" site.

This chapter shall include the facts about the outer media radioactivity (ground water, air, and vegetation) over the territory and outside Semipalatinsk and Novaya Zemlya test sites. (minimum 10,000 words)

Chapter 7: Atmospheric Nuclear Testing: Technologies, Environmental Effects and Safety Measures

Important environmental effects which occur in atmospheric and surface nuclear explosions shall be presented in this chapter. Issues such as shock-waves and seismic effects as well as light and penetrating radiation at nuclear explosion and radioactive injury of atmosphere and earth surface at ground zero and explosion cloud trace shall be discussed in detail. Various environmental damages shall be characterized. Nuclear testing safety criteria shall be presented and discussed, including issues such as safety measures in testing preparation.

Important issues shall be discussed such as safety and atmospheric/ground nuclear explosion effect reduction (detonation techniques, meteorological forecast and certain weather conditions, training of radiation safety service, announcement of the test site personnel and population, removal activities) are included.

The chapter shall include data on nuclear explosions in the atmosphere. The information is on specific aspects of high altitude atmospheric nuclear explosions over 50 kilometers to study military effects and shall contain the following:

A. Describe the test results of the nuclear weapon effects/environments on radar, communications and optical sensor system performance, and describe the impacts of the atmospheric test results on Soviet decision making vis-à-vis their deployment of a BMD system.

B. Describe the impacts of Soviet test data on Soviet prediction capability, provide examples of such capability and describe Soviet weapon test parameters, i.e., yield, burst, altitude and location, time, x-ray fraction and temperature, fission fraction, hydro yield, etc....

C. Describe the reasons for Soviet tests. What were the system impacts, effects on design and phenomenology prediction? Describe and provide the Soviet diagnostic data obtained in the test series such as radar propagation, optical signals, ionosonde and radiometric measurements, tracking beacon and describe the effects of nuclear tests on Soviet HF communications links. Also, describe the experimental configurations.

D. Describe the effects on and diagnostic or experimental data obtained from Soviet satellites.

E. Describe the Soviet's reasons for carrying out the high altitude tests in daylight instead of in dark.

F. Describe and provide the data obtained on radar clutter, scintillation effects, dispersion, diffraction and distortion, discrimination, attenuation, detection, etc.

G. Describe and provide the data obtained on optical (UV, visible and infrared) backgrounds, including intensities, time dependence, structure locations, etc....

This shall also include recollections of the original participants in the surface and atmospherics tests. (minimum 12,000 words)

Chapter 8: Underground Nuclear Testing: Technologies, Environmental Effects and Safety Measures

This chapter shall include the USSR concept of undergro8und nuclear testing techniques. Characterization of emplacement holes, mining techniques, and well and tunnel equipment for experiment preparation.

The chapter shall emphasize the main underground nuclear explosion environmental effects including seismic effects, early time radiation effects (radiation output, thermal output), explosion cavity formation including vaporization regime, melt regime and rock destruction, concentrated radioactivity burial in the place of an explosion.

Various environmental injuries will be characterized and underground nuclear explosion safety criteria and test preparation safety measures will be discussed.

This chapter shall discuss USSR measures of safety and underground nuclear explosion effect reduction (selection of the emplacement holes, the line of least resistance (LLR) characteristics, stemming installation system, organization activities) are included.

The chapter shall contain information on diagnostics issues in underground nuclear explosions including specific data on underground nuclear explosions used to study military effects.

Methodology and technology shall be presented to study underground nuclear explosion effects on rock masses and the resulting potential tunnel and cavity venting including the direct examination immediately after the explosion. Recollections of some

participants in certain underground nuclear tests shall be included. (Minimum 5,000 words)

Chapter 9: Military Exercises During Nuclear Testing

This chapter shall discuss the organization, course and results of military training which took place over the territory of Defense Ministry Totsk camps with nuclear explosions. The reminiscences of the participants will also be included. (Minimum 8,000 words)

Chapter 10: The Uses of Nuclear Explosions for the National Economy (Peaceful Nuclear Explosions)

This chapter shall present the development and application of the peaceful nuclear explosion concept including nuclear explosion applications for seismic probing, excavations to extract minerals, reservoir formation, channeling, gas and oil production increase, gas flare extinguishing, formation of underground cavities, rock stresses removal in shafts, and isotope production are included.

Safety measures of the peaceful nuclear explosions shall be discussed.

This chapter presents the participant recollections about preparatory activities and peaceful nuclear explosions of various types.

Peaceful nuclear explosions application perspective shall be discussed as well as possible international cooperation in this field. (Minimum 10,000 words)

Chapter 11: Nuclear Explosions as Tools for Scientific Research

The chapter shall include information on the physical process occurring in nuclear charges and on diagnostic equipment development including investigation of substance equations of state. Test results for nuclear explosion effect on rock, including ground vaporization and melting characteristics in the ground explosion, the formation of cavities, rock vaporization, melting and fracture areas in the underground explosion, the radionuclide content in rock melt, physical-chemical properties and processes of

condensed radioactive explosion product formation in the central zone for various rock types. (Minimum 5,000 words)

Chapter 12: Military and Political Aspects of Nuclear Testing

This chapter shall include a detailed discussion of the issues of nuclear testing and nuclear weapon modernization as well as nuclear weapon safety and security issues, nuclear explosion military effects study, nuclear arsenal limitations. Treaty limits for nuclear testing shall be discussed and nuclear testing and moratorium influences on nuclear proliferation or nonproliferation by third world countries, the importance of modern control measures for nuclear testing, the effect of the political and military effects of banning nuclear testing and the nuclear policy, affecting the nuclear policy are considered. (Minimum 5,000 words)

Chapter 13: Joint Soviet-American Experiment at Semipalatinsk Test Site

This chapter shall include and document Soviet participants in this historical experiment [and] recall the activities which were directed to the joint monitoring of underground nuclear testing.

The general problems of the necessity and possibility of verification measures are discussed for different levels of explosion yield limitation. (Minimum 5,000 words)

Chapter 14: Overall Results of the Environmental Condition at the Semipalatinsk Test Site and Adjacent Areas

Radiation, medical/biological and environmental requirements shall be presented for the unified system of radiation environment monitoring of Semipalatinsk Test Site. The data shall be presented for the outside test site territories contaminated with Strontium-90, Cesium-137 and Plutonium. Radionuclide concentration in fresh water were measured. Aerosol monitoring was done in ground air layer around the test site. Underground water migration was estimated from the areas of the test site. The complex sanitary-environmental observation program for Semipalatinsk Test Site will be discussed and include the significance of physical, chemical, biological and social factors.

Included in this chapter will be the reminiscences of those who took part in the analysis of radio-environmental situation around Semipalatinsk Test Site. (Minimum 8,000 words)

Chapter 15: Overall Results of the Environmental Condition at the Novaya Zemlya Test Site and Adjacent Areas

15-year radiation monitoring results shall be presented for vast north Russia territories, including Novaya Zemlya archipelago, i. Vajgatch, i. Dikson, s-i. Taimyr, Yugorski, Yamal, cities Ambartchik, Norilsk, Komi Republic, Yamalo-Nenetzki district.

Radioactive fallout trace projections were obtained over RF territory as a result of atmospheric testing at the test site. Fallout density of Cesium-137 and Strontium-90 was measured: exposure dose is in 10-15 micro-r/h range.

The requirements for a unified radiation monitoring system for Novaya Zemlya Test Site shall be presented and discussed.

The chapter shall present the reminiscences of those engaged in radio-environmental analysis around the Novaya Zemlya Test Site. (Minimum 5,000 words)

Chapter 16: The Social Aspects of Protecting of Nuclear Testing Participants

This chapter shall present and discuss the existing measures used to provide protection for USSR nuclear test participants including the various techniques and procedures used to provide the final measures used and how they evolved. (Minimum 4,000 words)

Chapter 17: Containment

The Contractor shall provide the scientific and technical services, the equipment, materials and facilities, to fully document the containment systems philosophy, requirements and design, and the containment results of FSU underground nuclear test. Special requirements associated with the task are detailed in the paragraph that follows.

The Contractor shall provide a comprehensive historical document of the Former Soviet Union weapons program experiences in containment of underground nuclear tests.

As a preliminary requirement, the Contractor must document the former Soviet Union underground nuclear test containment experience. The technical Annex would address the following subjects related to the Soviet containment experience to include:

Test Program Organization

Test Execution Authority

Containment (or test) Review and Approval Process

Containment Requirements

- Release to the Environment
- Sample Protection and Recovery

Containment Designs

- Containment Vessels and/or Materials
- Stemming Materials (grout, concrete, backfill, etc.)
- Mechanical Closures

Siting Criteria

- Test Sites
- Formation Description
  - Rock Mass Properties
  - Physical properties (Grain density, bulk density, porosity, angle of internal friction, compressive strength, shear strength, Hugoniots, etc,)
  - Fracture characteristics (pre-and postshot, fracture density, aperture, etc.)
  - In Situ stress
  - Hydrologic properties
  - Depth of Water Table
  - Nature of Geologic Structure, Geometry
  - Local and Regional Hydrology
- Characterization Studies
- Event Separation
- Depth of Burial

Facility Construction

- Tunnels

- Mined Cavities
- Containment Plugs (e.g. self-sealing, etc.)
- Grouting (Pressure grouting, post structure grouting, etc.

Test Evaluation

Diagnostics

- Tunnel Conditions (activity, pressure, temperature, gas concentrations, etc.
- Ground Motion, Stress, Velocity, etc.
- Cavity (size, pressure, temperature, gas composition, etc.)

Post-Event Activities/Operations

- Ground Surface
- Drill Back
- Tunnel Reentries
- Block Motions and Fracturing
- Displacements
- Stemming Conditions

Materials Testing

- Laboratory
  - Static and dynamic mechanical tests
  - Physical properties
  - High pressure EOS
- In-Situ
  - Borehole logs
  - Explosive
- Mineralogy
- Calculational Analyses and Modeling
  - Threat Models
  - Rock Models
  - Ground Motion
  - Fluid Hydrofracture
  - Fluid Diffusion

Cavity Collapse

Model Verification (comparison with data)

In addition to these issues the Technical Annex shall address any additional concerns considered relevant to the documentation of the Former Soviet Union nuclear test containment experience. (Minimum 10,000 words)

Table 1
USSR Nuclear Tests and Peaceful Nuclear Explosions (1949-1990)

N	Date (MT)	Location	Type	Purpose	Yield Range, kt
1949 Program					
1	08/29/49	STS	surface	NWR	22
First Soviet nuclear test; first nuclear explosion at STS; first surface test					
1951 Program					
2	09/24/51	STS	surface	NWR	38
3	10/18/51	STS	air	NWR	42
First Soviet air test; aerial bomb drop					
1953 Program					
4	08/12/53	STS	surface	NWR	400
First Soviet thermonuclear explosion; the highest yield surface nuclear explosion					
5	08/23/53	STS	air	NWR	28
6	09/03/53	STS	air	NWR	5.8
7	09/08/53	STS	air	NWR	1.6
8	09/10/53	STS	air	NWR	4.9
1954 Program					
9	09/14/54	Totsk, MoD test site, Orenburg	air	ME	40
10	09/29/54	STS	air	NWR	0.2
11	10/01/54	STS	air	NWR	0.03
12	10/03/54	STS	air	NWR	2
13	10/05/54	STS	surface	NWR	4
14	10/08/54	STS	air	NWR	0.8
15	10/19/54	STS	surface	NWR	<0.001
16	10/23/54	STS	air	NWR	62
17	10/26/54	STS	air	NWR	2.3
18	10/30/54	STS	surface	NWR	10
1955 Program					
19	07/29/55	STS	surface	NWR	1.3
20	08/02/55	STS	surface	NWR	12
21	08/05/55	STS	surface	NWR	1.2
22	09/21/55	NTSNZ	underwater	WIE	3.5
First test at NTSNZ					
23	11/06/55	STS	air	NWR	250
24	11/22/55	STS	air	NWR	1,600
1956 Program					
25	02/02/56	near Aralsk, Kazakstan	surface	WIE	0.3
First surface nuclear explosion with missile launch from MTR					
26	03/16/56	STS	surface	NWR	14
27	03/25/56	STS	surface	NWR	5.5

28	08/24/56	STS	surface	NWR	27
29	08/30/56	STS	air	NWR	900
30	09/02/56	STS	air	NWR	51
31	09/10/56	STS	air	NWR	38
32	11/17/56	STS	air	NWR	900
33	12/14/56	STS	air	NWR	40
1957 Program					
34	01/19/57	MTR	air	WIE	10
First air nuclear explosion with missile launch from MTR					
35	03/08/57	STS	air	NWR	19
36	04/03/57	STS	air	NWR	42
37	04/06/57	STS	air	NWR	57
38	04/10/57	STS	air	NWR	680
39	04/12/57	STS	air	NWR	22
40	04/16/57	STS	air	NWR	320
41	08/22/57	STS	air	NWR	520
42	08/26/57	STS	air	SAM	0.1
43	09/07/57	NTSNZ	surface	FMS	32
44	09/13/57	STS	air	NWR	5.9
45	09/24/57	NTSNZ	air	NWR	1,600
46	09/26/57	STS	air	NWR	13
47	10/06/57	NTSNZ	air	NWR	2,900
48	10/10/57	NTSNZ	underwater	WIE	10
49	12/28/57	STS	air	NWR	12
1958 Program					
50	01/04/58	STS	air	NWR	1.3
51	01/17/58	STS	air	NWR	0.5
52	02/23/58	NTSNZ	air	NWR	860
53	02/27/58	NTSNZ	air	NWR	250
54	02/27/58	NTSNZ	air	NWR	1,500
55	03/13/58	STS	air	NWR	1.2
56	03/14/58	STS	air	NWR	35
57	03/14/58	NTSNZ	air	FMS	40
58	03/15/58	STS	air	NWR	14
59	03/18/58	STS	air	FMS	0.16
60	03/20/58	STS	air	NWR	12
61	03/21/58	NTSNZ	air	NWR	650
62	03/22/58	STS	air	NWR	18
63	09/30/58	NTSNZ	air	NWR	1,200
64	09/30/58	NTSNZ	air	NWR	900
65	10/02/58	NTSNZ	air	NWR	290
66	10/02/58	NTSNZ	air	FMS	40
67	10/04/58	NTSNZ	air	NWR	9

68	10/05/58	NTSNZ	air	NWR	15
69	10/06/58	NTSNZ	air	NWR	5.5
70	10/10/58	NTSNZ	air	NWR	68
71	10/12/58	NTSNZ	air	NWR	1,450
72	10/15/58	NTSNZ	air	NWR	1,500
73	10/18/58	NTSNZ	air	NWR	2,900
74	10/19/58	NTSNZ	air	FMS	40
75	10/19/58	NTSNZ	air	NWR	<0.001
76	10/20/58	NTSNZ	air	NWR	440
77	10/21/58	NTSNZ	air	NWR	2
78	10/22/58	NTSNZ	air	NWR	2,800
79	10/24/58	NTSNZ	air	NWR	1,000
80	10/25/58	NTSNZ	air	NWR	190
81	10/25/58	NTSNZ	air	FMS	<0.1
82	11/01/58	MTR	air	WIE	10
83	11/03/58	MTR	air	WIE	10
1961 Program					
84	09/01/61	STS	air	NWR	16
85	09/04/61	STS	air	NWR	9
86	09/05/61	STS	air	NWR	16
87	09/06/61	STS	air	NWR	1.1
88	09/06/61	MTR	air	WIE	11
89	09/09/61	STS	surface	SAM	0.38
90	09/10/61	NTSNZ	air	NWR	2,700
91	09/10/61	NTSNZ	air	NWR	12
92	09/10/61	STS	air	NWR	0.88
93	09/11/61	STS	air	NWR	0.3
94	09/12/61	NTSNZ	air	NWR	1,150
95	09/13/61	NTSNZ	air	NWR	6
96	09/13/61	STS	air	NWR	0.001 - 20
97	09/14/61	STS	surface	NWR	0.4
98	09/14/61	NTSNZ	air	NWR	1,200
99	09/16/61	NTSNZ	air	NWR	830
100	09/17/61	STS	air	NWR	20-150
101	09/18/61	NTSNZ	air	NWR	1,000
102	09/18/61	STS	surface	SAM	0.004
103	09/18/61	STS	air	NWR	0.75
104	09/19/61	STS	surface	SAM	0.03
105	09/20/61	STS	air	NWR	4.8
106	09/20/61	NTSNZ	air	NWR	150-1,500
107	09/21/61	STS	air	NWR	0.8
108	09/22/61	NTSNZ	air	NWR	260
109	09/26/61	STS	air	NWR	1.2

110	10/01/61	STS	air	NWR	3
111	10/02/61	NTSNZ	air	NWR	250
112	10/04/61	STS	air	NWR	13
113	10/04/61	NTSNZ	air	NWR	1,500 - 10,000
114	10/06/61	NTSNZ	air	NWR	4,000
115	10/06/61	MTR	air	WIE	40
116	10/08/61	NTSNZ	air	NWR	15
117	10/11/61	STS	underground tunnel V-1	FMS	1
		First Soviet underground test; first underground test at STR and first underground tunnel test			
118	10/12/61	STS	air	NWR	15
119	10/17/61	STS	air	NWR	6.6
120	10/19/61	STS	air	NWR	0.001 - 20
121	10/20/61	NTSNZ	air	NWR	1,450
122	10/23/61	NTSNZ	underwater	WIE	4.8
123	10/23/61	NTSNZ	air	NWR	12,500
124	10/25/61	NTSNZ	air	NWR	300
125	10/25/61	STS	air	FMS	0.5
126	10/27/61	NTSNZ	water surface	WIE	16
127	10/27/61	MTR	space	WIE	1.2
		First Soviet space explosion			
128	10/27/61	MTR	space	WIE	1.2
129	10/30/61	STS	air	NWR	0.09
130	10/30/61	NTSNZ	air	NWR	50,000
		The highest yield Soviet test			
131	10/31/61	NTSNZ	air	NWR	5,000
132	10/31/61	NTSNZ	air	NWR	150-1,500
133	11/01/61	STS	air	NWR	2.7
134	11/02/61	NTSNZ	air	NWR	120
135	11/02/61	NTSNZ	air	NWR	280
136	11/02/61	STS	air	NWR	0.6
137	11/03/61	STS	surface	SAM	<0.001
138	11/03/61	STS	air	NWR	0.9
139	11/04/61	NTSNZ	air	NWR	15
140	11/04/61	NTSNZ	air	NWR	150-1,500
141	11/04/61	NTSNZ	air	NWR	6
142	11/04/61	STS	surface	NWR	0.2
		1962 Program			
143	02/02/62	STS	underground tunnel A-1	WIE	0.001-20
		First Soviet underground explosion for WIE			
144	08/01/62	STS	air	NWR	2.4
145	08/03/62	STS	air	NWR	1.6
146	08/04/62	STS	air	NWR	3.8
147	08/05/62	NTSNZ	air	NWR	21,100

148	08/07/62	STS	surface	NWR	9.9
149	08/10/62	NTSNZ	air	NWR	150-1,500
150	08/18/62	STS	air	NWR	7.4
151	08/18/62	STS	air	NWR	5.8
152	08/20/62	NTSNZ	air	NWR	2,800
153	08/21/62	STS	air	NWR	20-150
154	08/22/62	NTSNZ	air	NWR	1,600
155	08/22/62	NTSNZ	water surface	NWR	6
156	08/22/62	STS	air	NWR	3
157	08/23/62	STS	air	NWR	2.5
158	08/25/62	NTSNZ	air	NWR	1,500-10,000
159	08/25/62	STS	air	NWR	0.001-20
160	08/27/62	NTSNZ	air	NWR	4,200
161	08/27/62	STS	air	NWR	11
162	08/31/62	STS	air	FMS	2.7
163	09/02/62	NTSNZ	air	NWR	80
164	09/08/62	NTSNZ	air	NWR	1,900
165	09/15/62	NTSNZ	air	NWR	3,100
166	09/16/62	NTSNZ	air	NWR	3,250
167	09/18/62	NTSNZ	air	NWR	1,350
168	09/19/62	NTSNZ	air	NWR	1,500-10,000
169	09/21/62	NTSNZ	air	NWR	2,400
170	09/22/62	STS	surface	SAM	0.21
171	09/24/62	STS	air	NWR	1.2
172	09/25/62	STS	surface	NWR	7
173	09/25/62	NTSNZ	air	NWR	19,100
174	09/27/62	NTSNZ	air	NWR	>10,000
175	09/28/62	STS	air	FMS	1.3
176	10/07/62	NTSNZ	air	NWR	320
177	10/09/62	STS	air	NWR	8
178	10/09/62	NTSNZ	air	NWR	15
179	10/10/62	STS	air	NWR	9.2
180	10/13/62	STS	air	NWR	4.9
181	10/14/62	STS	air	NWR	0.001-20
182	10/20/62	STS	air	NWR	6.7
183	10/22/62	NTSNZ	air	NWR	8,200
184	10/22/62	MTR	space	WIE	300
185	10/27/62	NTSNZ	air	NWR	260
186	10/28/62	STS	air	NWR	7.8
187	10/28/62	MTR	space	WIE	300
188	10/28/62	STS	air	NWR	7.8
189	10/29/62	NTSNZ	air	NWR	360
190	10/30/62	STS	air	NWR	1.2

191	10/30/62	NTSNZ	surface	NWR	280
192	10/31/62	STS	air	NWR	10
193	11/01/62	STS	air	NWR	3
194	11/01/62	NTSNZ	air	NWR	240
195	11/01/62	MTR	high altitude	WIE	300
196	11/03/62	NTSNZ	air	NWR	390
197	11/03/62	NTSNZ	air	NWR	45
198	11/03/62	STS	air	NWR	4.7
199	11/04/62	STS	air	NWR	8.4
200	11/05/62	STS	surface	WIE	0.4
201	11/11/62	STS	surface	NWR	0.1
202	11/13/62	STS	surface	NWR	<0.001
203	11/14/62	STS	air	NWR	12
204	11/17/62	STS	air	NWR	18
205	11/24/62	STS	surface	SAM	<0.001
206	11/26/62	STS	surface	SAM	0.031
207	12/01/62	STS	air	NWR	2.4
208	12/18/62	NTSNZ	air	NWR	110
209	12/18/62	NTSNZ	air	FMS	69
210	12/20/62	NTSNZ	air	NWR	8.3
211	12/22/62	NTSNZ	air	NWR	6.3
212	12/23/62	NTSNZ	air	NWR	430
213	12/23/62	NTSNZ	air	NWR	8.3
214	12/23/62	NTSNZ	air	NWR	2.4
215	12/23/62	STS	surface	SAM	<0.001
216	12/24/62	STS	surface	SAM	0.007
217	12/24/62	STS	surface	SAM	0.028
218	12/24/62	NTSNZ	air	NWR	1,100
219	12/24/62	NTSNZ	air	NWR	24,200
220	12/25/62	NTSNZ	air	NWR	3,100
221	12/25/62	NTSNZ	air	NWR	8.5
		Last Soviet air test			
			1964 Program		
222	03/15/64	STS	tunnel A-6	WIE	20-150
223	05/16/64	STS	tunnel A-4	NWR	20-150
224	06/06/64	STS	tunnel V-2	FMS	0.001-20
225	07/19/64	STS	tunnel A-5	FMS	20-150
226	08/18/64	STS	tunnel A-8Sh	NWR	0.001-20
227	09/18/64	NTSNZ	tunnel G	FMS	0.001-20
		First underground tunnel test at NTSNZ			
228	09/30/64	STS	tunnel A-6Sh	FMS	0.001-20
229	10/25/64	NTSNZ	tunnel B	TIC	0.001-20
230	11/16/64	STS	tunnel 3-5	TIC	20-150

1965 Program					
231	01/15/65	STS	"Chagan" shaft 1004	IE	140
		First industrial nuclear explosion; first shaft nuclear tets at STS; the cratering explosion Reservoir: 49.9 79.0			
232	02/04/65	STS	tunnel A	FMS	0.001-20
233	03/03/65	STS	tunnel Hz-3	NWR	0.001-20
234	03/27/65	STS	tunnel V-2P	NWR	0.001-20
235	03/30/65	Bashkir ASSR, RSFSR	"Butan-1" shaft 617 "Butan-2" shaft 618		
		First salvo explosion in two shafts; first nuclear explosion within the program of oil recovery intensification Oil			
236	05/11/65	STS	tunnel A-P	NWR	0.001-20
237	06/10/65	Bashkir ASSR, RSFSR	"Butan" shaft 622	IE	7.6
		Oil			
238	06/17/65	STS	tunnel Zh-1	TIC	0.001-20
239	07/29/65	STS	tunnel A-1Sh	FMS	0.001-20
240	09/17/65	STS	tunnel 1	NWR	0.001-20
241	10/08/65	STS	tunnel 3-1	NWR	0.001-20
242	10/14/65	STS	Sary Uzen shaft 1003	IE	1.1
		Second cratering nuclear explosion Reservoir			
243	11/21/65	STS	tunnel Zh-2	NWR	29
244	12/24/65	STS	tunnel 3-3	TIC	0.001-20
1966 Program					
245	02/13/66	STS	tunnel E-1	TIC	125
		The highest yield tunnel explosion at STS			
246	03/20/66	STS	tunnel 11	NWR	100
247	04/21/66	STS	tunnel A-4P	TIC	0.001-20
248	04/22/66	Azgir, Kazakh SSR	shaft A-1	IE	1.1
		First nuclear explosion on the Azgir area; first nuclear explosion on cavity production in rock salt Cavity: 47.86 47.72			
249	05/07/66	STS	tunnel 25	TIC	4
250	06/29/66	STS	tunnel 3-6	TIC	20-150
251	07/21/66	STS	tunnel 25	NWR	20-150
252	08/05/66	STS	tunnel 17	NWR	0.001-20
253	08/19/66	STS	tunnel 3-1P	TIC	0.001-20
254	09/07/66	STS	tunnel Zh-1P	FMS	0.001-20
255	09/30/66	Urta-Bulak, Uzbek SSR	shaft 1-s	IE	30
		First employment of a nuclear explosion for gas spouter shaft closure Torch: 38.8 64.5			
256	10/19/66	STS	tunnel 13	NWR	20-150
257	10/27/66	NTSNZ	tunnel A-1	NWR	150-1,500
258	10/27/66	NTSNZ	tunnel A-2	NWR	150-1,500

259	10/29/66	STS	tunnel G	NWR	0.001-20
260	11/19/66	STS	tunnel Zh-3P	NWR	0.001-20
261	12/03/66	STS	tunnel 14	NWR	0.001-20
			tunnel 14	TIC	0.001-20
		First salvo nuclear explosion in a single tunnel			
262	12/18/66	STS	shaft 101	TIC	20-150
1967 Program					
263	01/30/67	STS	tunnel 611	NWR	0.001-20
			tunnel 611	NWR	0.001-20
264	02/26/67	STS	tunnel 21	FMS	20-150
265	03/25/67	STS	tunnel 19	NWR	0.001-20
			tunnel 19	WIE	0.001-20
266	04/20/67	STS	tunnel 25P	TIC	20-150
267	05/28/67	STS	tunnel 11P	TIC	0.001-20
			tunnel 11P	TIC	0.001-20
268	06/29/67	STS	tunnel 703	NWR	0.001-20
269	07/15/67	STS	tunnel 506	TIC	0.001-20
270	08/04/67	STS	tunnel 18	NWR	0.001-20
			tunnel 18	NWR	0.001-20
271	09/02/67	STS	tunnel 13P	NWR	0.001-20
272	09/16/67	STS	shaft 102	NWR	0.001-20
273	09/22/67	STS	shaft 105	NWR	10
274	10/06/67	Tyumen' region, RSFSR	"Tavda" shaft	IE	0.3
		Cavity: 57.7 65.3			
275	10/17/67	STS	tunnel B	TIC	0.001-20
			tunnel B	TIC	0.001-20
276	10/21/67	NTSNZ	tunnel A-4	NWR	150-1,500
			tunnel A-5	NWR	20-150
		First salvo explosion in two tunnels			
277	10/30/67	STS	tunnel 501	NWR	0.001-20
278	11/22/67	STS	shaft 106	NWR	0.001-20
279	12/08/67	STS	tunnel 507	NWR	0.001-20
1968 Program					
280	01/07/68	STS	tunnel 810	TIC	0.001-20
281	04/24/68	STS	tunnel 505	NWR	0.001-20
282	05/21/68	Pamuk, Uzbek SSR	shaft	IE	47
		Torch: 38.916 65.159			
283	05/23/68	STS	tunnel 504	NWR	<0.001
284	06/11/68	STS	tunnel 605	NWR	0.001-20
285	06/19/68	STS	shaft 1053	FMS	0.001-20
286	07/01/68	Azgir, Kazakh SSR	shaft A-II	IE	27
		Cavity: 47.9 47.9			

287	07/12/68	STS	tunnel 608	NWR	0.001-20
			tunnel 608	NWR	0.001-20
288	08/20/68	STS	tunnel A-7	NWR	0.001-20
			tunnel A-7	SAM	<0.001
290	09/29/68	STS	tunnel E-2	WIE	60
291	10/21/68	STS	"Tel'kem" shaft 2308	IE	0.24
		Third cratering nuclear explosion Canal			
292	10/29/68	STS	tunnel 504P	NWR	0.001-20
293	11/07/68	NTSNZ	tunnel A-3	NWR	<0.001
			tunnel A-3	NWR	150-1,500
			tunnel A-3	NWR	150-1,500
		First salvo explosion in single tunnel at NTSNZ			
294	11/09/68	STS	tunnel 606	TIC	0.001-20
295	11/12/68	STS	"Tel'kem-2" shaft 2305	IE	0.24
			"Tel'kem-2" shaft 2306	IE	0.24
			"Tel'kem-2" shaft 2307	IE	0.24
		Fourth cratering nuclear explosion Canal			
296	12/18/68	STS	tunnel 508	TIC	0.001-20
		1969 Program			
297	03/07/69	STS	tunnel ZG-2P	NWR	20-150
298	04/04/69	STS	tunnel 19P	NWR	0.001-20
299	04/13/69	STS	tunnel 24P	TIC	0.001-20
300	05/16/69	STS	tunnel 709	NWR	0.001-20
301	05/31/69	STS	shaft 108	NWR	0.001-20
302	07/04/69	STS	tunnel 710	TIC	0.001-20
			tunnel 710	NWR	0.001-20
303	07/23/69	STS	tunnel 801	NWR	16
304	09/02/69	Perm' region, RSFSR	"Grifon" shaft 1001	IE	7.6
		Oil: 57.415 54.860			
305	09/08/69	Perm' region, RSFSR	"Grifon" shaft 1002	IE	7.6
		Oil: 57.365 55.108			
306	09/11/69	STS	tunnel 503	TIC	0.001-20
			tunnel 503	TIC	0.001-20
307	09/26/69	Takhta-Kugulta, Stavropol' territory, RSFSR	shaft	IE	10
		Nuclear explosion employment for gas extraction intensification Gas: 45.890 42.472			
308	10/01/69	STS	tunnel 607	NWR	0.001-20
			tunnel 607	NWR	0.001-20
309	10/14/69	NTSNZ	tunnel A-7	NWR	20-150
			tunnel A-7	NWR	150-1,500

			tunnel A-9	NWR	150-1,500
310	10/30/69	STS	tunnel 506P	SAM	0.001-20
311	11/27/69	STS	tunnel 511	TIC	0.001-20
312	11/30/69	STS	shaft 1054	NWR	125
313	12/06/69	Mangyshlak, Kazakh SSR	shaft 2-T	IE	30
		43.832 54.783			
314	12/28/69	STS	shaft 107	NWR	40
315	12/29/69	STS	tunnel Sh-1	TIC	0.001-20
1970 Program					
316	01/29/70	STS	tunnel 802	WIE	0.001-20
			tunnel 802	WIE	0.001-20
317	02/18/70	STS	tunnel Sh-2	SAM	<0.001
318	03/27/70	STS	tunnel 610	TIC	0.001-20
319	05/27/70	STS	tunnel Sh-3	NWR	0.001-20
320	06/25/70	Orenburg region, RSFSR	"Magistral shaft" 1T-2S	IE	2.3
		First nuclear explosion to create the reservoirs for gas storage Cavity: 52.201 55.700			
321	06/28/70	STS	tunnel 510	NWR	20-150
322	06/28/70	STS	tunnel 705	TIC	0.001-20
			tunnel 705	NWR	0.001-20
323	07/21/70	STS	shaft 104	NWR	0.001-20
324	07/24/70	STS	tunnel 120	NWR	0.001-20
325	09/06/70	STS	tunnel 502	NWR	0.001-20
326	09/06/70	STS	tunnel 8	TIC	0.001-20
327	10/14/70	NTSNZ	tunnel A-6	NWR	150-1,500
			tunnel A-6	NWR	150-1,500
			tunnel A-6	NWR	150-1,500
328	11/04/70	STS	shaft 125	TIC	0.001-20
329	12/12/70	Mangyshlak, Kazakh SSR	shaft 6T	IE	80
		43.851 54.774			
330	12/17/70	STS	tunnel 193	NWR	20-150
331	12/23/70	Mangyshlak, Kazakh SSR	shaft 1-T	IE	75
		43.827 54.846			
1971 Program					
332	01/29/71	STS	tunnel 114	WIE	0.001-20
333	03/22/71	STS	tunnel 510P	TIC	20-150
334	03/22/71	STS	tunnel 807	NWR	0.001-20
335	03/23/71	Perm' region, RSFSR	"Taiga"		
			shaft 1B	IE	15
			shaft 2B	IE	15
			shaft 3B	IE	15
		Fifth excavation explosion Canal: 61.287 56.466			

336	04/09/71	STS	tunnel 148/1	NWR	0.23
337	04/25/71	STS	tunnel 706	NWR	90
338	05/25/71	STS	tunnel 119	NWR	0.001-20
339	06/06/71	STS	shaft 110	NWR	16
340	06/19/71	STS	shaft 129	NWR	0.001-20
341	06/30/71	STS	shaft 1056	NWR	0.001-20
342	07/02/71	Komi ASSR, RSFSR	"Globus" shaft GB-4	IE	2.3
		First nuclear explosion in seismic probing program			
		DSS: 67.66 62.00			
343	07/10/71	Komi ASSR, RSFSR	"Globus" shaft GB-3	IE	2.3
		DSS: 64.168 55.183			
344	09/19/71	Ivanovo region, RSFSR	"Globus" shaft GB-1	IE	2.3
		DSS: 57.777 41.098			
345	09/27/71	NTSNZ	tunnel A-8	NWR	150-1,500
			tunnel A-8	NWR	150-1,500
			tunnel A-8	NWR	150-1,500
			tunnel A-8	NWR	150-1,500
346	10/04/71	Arkhangelsk region, RSFSR	"Globus" shaft GB-2	IE	2.3
		DSS: 61.613 47.116			
347	10/09/71	STS	shaft 111	NWR	12
348	10/21/71	STS	shaft 127	NWR	23
349	10/22/71	Orenburg region, RSFSR	"Sapfir" shaft E-2	IE	15
		Cavity: 51.575 54.536			
350	11/29/71	STS	tunnel 105	NWR	0.001-20
			tunnel 105	NWR	0.001-20
351	12/15/71	STS	tunnel 157	WIE	0.001-20
352	12/22/71	Azgir, Kazakh SSR	shaft A-III	IE	64
		Cavity: 47.872 48.222			
353	12/30/71	STS	tunnel 809	NWR	0.001-20
354	12/30/71	STS	tunnel 609	NWR	20-150
		1972 Program			
355	02/10/72	STS	shaft 1007	NWR	16
356	03/10/72	STS	tunnel 201	NWR	0.001-20
			tunnel 201	NWR	0.001-20
357	03/28/72	STS	tunnel 191	NWR	0.001-20
			tunnel 191	TIC	0.001-20
			tunnel 191	SAM	<0.001
358	04/11/72	Mary, Turkmen SSR	"Crater" shaft	IE	15
		Torch: 37.367 61.996			
359	04/20/72	STS	tunnel 505P	SAM	<0.001
360	06/07/72	STS	tunnel 110	NWR	0.001-20
361	06/07/72	STS	tunnel 601	WIE	0.001-20
362	07/06/72	STS	tunnel 157-M	WIE	0.001-20

363	07/09/72	Ukrainian SSR	"Fakel" shaft	IE	3.8
		Torch: 49.78 35.40			
364	07/27/72	NTSNZ	shaft Yu-3	FMS	0.001-20
365	08/16/72	STS	tunnel 708	WIE	8
366	08/20/72	Kazakh SSR	"Region" shaft R-3	IE	6.6
		DSS: 49.462 48.179			
367	08/26/72	STS	shaft 132	NWR	0.001-20
368	08/28/72	NTSNZ	tunnel A-16	NWR	150-1,500
			tunnel A-16	NWR	20-150
			tunnel A-16	NWR	150-1,500
			tunnel A-16	NWR	150-1,500
369	09/02/72	STS	shaft 128	NWR	2
370	09/04/72	Murmansk region, RSFSR	"Dnepr-1" tunnel	IE	2.1
		First nuclear explosion for testing of ore crushing technology			
		Ore: 67.689 33.445			
371	09/21/72	Orenburg region	"Region" shaft R-1	IE	2.3
		DSS: 52.127 51.994			
372	10/03/72	Kalmyk ASSR, RSFSR	"Region" shaft R-4	IE	6.6
373	11/02/72	STS	shaft 1061	NWR	165
		The highest yield underground explosion at STS (shaft)			
		DSS: 46.848 45.010			
374	11/24/72	Orenburg region, RSFSR	"Region" shaft R-2	IE	2.3
		DSS: 52.179 51.067			
375	11/24/72	Kazakh SSR	"Region" shaft R-5	IE	6.6
		DSS: 51.84 64.15			
376	12/10/72	STS	tunnel 3-2	NWR	0.001-20
			tunnel 140	NWR	20-150
		First salvo explosion in two tunnels at STS			
377	12/10/72	STS	shaft 1204	TIC	140
378	12/28/72	STS	tunnel 25PP	NWR	0.001-20
		1973 Program			
379	02/16/73	STS	tunnel 113	NWR	20-150
380	04/19/73	STS	shaft 131	NWR	0.001-20
381	07/10/73	STS	tunnel 806	NWR	0.001-20
			tunnel 806	NWR	0.001-20
			tunnel 806	NWR	<0.001
382	07/23/73	STS	shaft 1066	TIC	150-1,500
383	08/15/73	Kazakh SSR	"Meridian" shaft MN-3	IE	6.3
		DSS: 42.711 67.410			
384	08/28/73	Kazakh SSR	"Meridian" shaft MN-1	IE	6.3
		DSS: 50.55 68.39			
385	09/12/73	NTSNZ	tunnel V-1	NWR	1,500-10,000
			tunnel V-1	NWR	150-1,500

			tunnel V-1	NWR	150-1,500
			tunnel V-1	NWR	150-1,500
		The highest yield Soviet underground test			
386	09/19/73	Kazakh SSR	Meridianshaft MN-2	IE	6.3
		DSS: 45.63 67.85			
387	09/20/73	STS	shaft 1267	NWR	<0.001
388	09/27/73	NTSNZ	shaft Yu-4	FMS	20-150
389	09/30/73	Orenburg region, RSFSR	Sapfirshaft E-3	IE	10
		DSS: 51.608 54.582			
390	10/26/73	Bashkir ASSR, RSFSR	Kama-2shaft	IE	10
		First nuclear explosion on oil and chemical industrial waste water burial			
		Waste: 53.656 55.38			
391	10/26/73	STS	tunnel 205	WIE	0.001-20
392	10/27/73	NTSNZ	shaft Yu-1	NWR	1,500-10,000
		The highest yield underground shaft test			
393	11/04/73	STS	shaft 1069	NWR	0.001-20
394	12/14/73	STS	shaft 1064	NWR	20-150
395	12/31/73	STS	tunnel 21P	NWR	0.001-20
		1974 Program			
396	01/30/74	STS	tunnel 603	WIE	0.001-20
			tunnel 603	WIE	0.001-20
			tunnel 603	WIE	0.001-20
		The test is referred to as salvo explosion due to its specifics, however the burst time difference was more than 0.1 second			
397	02/28/74	STS	tunnel 110P	SAM	<0.001
398	04/16/74	STS	shaft 1301	NWR	0.001-20
399	05/16/74	STS	tunnel 176	NWR	0.001-20
400	05/31/74	STS	shaft 1207	TIC	20-150
401	06/25/74	STS	tunnel 3-1PP	WIE	0.001-20
402	07/08/74	Bashkir ASSR, RSFSR	"Kama-1" shaft	IE	10
		Waste: 53.68 55.10			
403	07/10/74	STS	tunnel 195	NWR	0.001-20
404	07/29/74	STS	shaft 1050	NWR	0.001-20
405	08/14/74	Tyumen' Region, RSFSR	"Gorizont" shaft G-2	IE	7.6
		DSS: 68.913 75.899			
406	08/29/74	Komi ASSR, RSFSR	"Gorizont" shaft G-1	IE	7.6
		DSS: 67.233 62.119			
407	08/29/74	NTSNZ	tunnel A-11	NWR	150-1,500
			tunnel A-11	NWR	150-1,500
			tunnel A-11	NWR	20-150
			tunnel A-11	NWR	0.001-20
			tunnel A-11	NWR	150-1,500
408	09/13/74	STS	tunnel 179	WIE	0.001-20

409	10/02/74	Jakutsk ASSR, RSFSR	"Kristall" shaft	IE	1.7
		66.1 112.65			
410	10/16/74	STS	shaft 1005	WIE	0.001-20
411	11/02/74	NTSNZ	shaft Yu-5N	NWR	1,500-10,000
412	11/28/74	STS	shaft 215	NWR	0.001-20
413	12/07/74	STS	"Lazurit" shaft R-1	IE	1.7
414	12/16/74	STS	tunnel 709P	NWR	0.001-20
415	12/16/74	STS	tunnel 148/5	IE	3.8
416	12/27/74	STS	shaft 1058	NWR	20-150
			1975 Program		
417	02/02/75	STS	tunnel 163	WIE	0.001-20
			tunnel 163	WIE	0.001-20
			tunnel 163	WIE	0.001-20
418	02/02/75	STS	tunnel 156	WIE	0.001-20
419	03/11/75	STS	tunnel 101	NWR	0.001-20
420	04/24/75	Azgir, Kazakh SSR	shaft A-11-2	IE	0.35
		First repeated nuclear explosion in rock salt cavity formed by a previous nuclear explosion			
421	04/27/75	STS	shaft 1205	NWR	20-150
422	06/08/75	STS	tunnel 165	TIC	0.001-20
423	06/30/75	STS	shaft A	NWR	0.001-20
424	07/15/75	STS	tunnel 133	NWR	0.001-20
			tunnel 133	NWR	0.001-20
425	08/07/75	STS	tunnel 122	NWR	0.001-20
			tunnel 123	NWR	0.001-20
426	08/12/75	Jakutsk ASSR, RSFSR	"Gorizont" shaft G-4	IE	7.6
		DSS: 70.8 127.1			
427	08/23/75	NTSNZ	tunnel A-10	WIE	150-1,500
			tunnel A-10	WIE	0.001-20
			tunnel A-10	WIE	150-1,500
			tunnel A-10	WIE	0.001-20
			tunnel A-10	NWR	20-150
			tunnel A-10	NWR	150-1,500
			tunnel A-10	NWR	150-1,500
			tunnel A-10	NWR	20-150
		First salvo explosion with the maximum number (8) of detonations at NTSNZ			
428	09/29/75	Krasnoyarsk territory, RSFSR	"Gorizont" shaft G-3	IE	7.6
		DSS: 69.592 90.396			
429	10/05/75	STS	tunnel 192	NWR	0.001-20
430	10/18/75	NTSNZ	shaft Yu-6N	NWR	150-1,500
			shaft Yu-6N	NWR	150-1,500
		First salvo explosion in a single shaft at NTSNZ			
431	10/18/75	NTSNZ	shaft Yu-7	NWR	150-1,500

432	10/21/75	NTSNZ	tunnel A-12	NWR	150-1,500
			tunnel A-12	NWR	150-1,500
			tunnel A-12	NWR	20-150
			tunnel A-12	NWR	150-,1500
			tunnel A-12	NWR	150-1,500
433	10/29/75	STS	shaft 1206	NWR	20-150
434	12/13/75	STS	tunnel 604	NWR	0.001-20
435	12/25/75	STS	shaft 1067	NWR	20-150
1976 Program					
436	01/15/76	STS	tunnel 115	NWR	0.001-20
437	03/17/76	STS	tunnel 608P	NWR	0.001-20
438	03/29/76	Azgir, Kazakh SSR	shaft A-III-2	IE	10
		Cavity: 49.6 45.0			
439	04/10/76	STS	tunnel 609P	NWR	0.001-20
440	04/21/76	STS	shaft 1201	NWR	0.001-20
441	04/21/76	STS	tunnel 101P	NWR	0.001-20
442	05/19/76	STS	tunnel 163P	NWR	0.001-20
443	06/09/76	STS	shaft 1075	NWR	0.001-20
444	07/04/76	STS	shaft 1062	NWR	20-150
445	07/23/76	STS	tunnel 185	NWR	0.001-20
446	07/29/76	Azgir, Kazakh SSR	shaft A-IV	IE	58
		Cavity: 47.782 48.120			
447	08/04/76	STS	shaft 133	NWR	0.001-20
448	08/28/76	STS	shaft 1202	NWR	20-150
449	09/29/76	NTSNZ	tunnel A-14	NWR	20-150
			tunnel A-14	NWR	20-150
450	10/20/76	NTSNZ	tunnel A-15	NWR	0.001-20
			tunnel A-15	NWR	0.001-20
			tunnel A-15	FMS	0.001-20
			tunnel A-15	SAM	<0.001
451	10/30/76	STS	tunnel 143	WIE	0.001-20
452	11/05/76	Jakutsk ASSR, RSFSR	"Oka" shaft 42	IE	15
		61.528 112.712			
453	11/23/76	STS	shaft 1207bis	NWR	20-150
454	12/07/76	STS	shaft 1304	NWR	20-150
			shaft 1304	NWR	0.001-20
		First salvo explosion in single shaft at STS			
455	12/07/76	STS	shaft 1209	NWR	0.001-20
456	12/30/76	STS	tunnel 706P	NWR	0.001-20
			tunnel 706P	NWR	0.001-20
1977 Program					
457	03/29/77	STS	tunnel 707	NWR	0.001-20
			tunnel 707	NWR	0.001-20

			tunnel 707	SAM	<0.001
458	03/29/77	STS	shaft 130	NWR	20-150
459	04/25/77	STS	tunnel 604P	NWR	0.001-20
460	05/29/77	STS	shaft 1400	NWR	20-150
461	06/29/77	STS	shaft 1080	NWR	0.001-20
462	07/26/77	Krasnoyarsk territory, RSFSR	"Meteorit" shaft M2	IE	15
		DSS: 69.532 90.583			
463	07/30/77	STS	tunnel 175	NWR	0.001-20
			tunnel 175	NWR	0.001-20
464	08/11/77	Chita region, RSFSR	"Meteorit" shaft M5	IE	8.5
		DSS: 50.923 110.761			
465	08/17/77	STS	tunnel 111	NWR	0.001-20
466	08/21/77	Krasnoyarsk territory, RSFSR	"Meteorit" shaft M3	IE	8.5
		DSS: 64.223 99.577			
467	09/01/77	NTSNZ	tunnel A-17	NWR	0.001-20
			tunnel A-17	NWR	0.001-20
			tunnel A-17	NWR	0.001-20
			tunnel A-17	NWR	20-150
468	09/05/77	STS	shaft 1079	NWR	20-150
			shaft 1079	FMS	0.001-20
469	09/10/77	Irkutsk region, RSFSR	"Meteorit" shaft M4	IE	7.6
		DSS: 57.294 106.240			
470	09/30/77	Azgir, Kazakh SSR	shaft A-V	IE	10
		Cavity: 48.145 47.850			
471	10/09/77	NTSNZ	tunnel A-7P	NWR	0.001-20
472	10/14/77	Azgir, Kazakh SSR	shaft A-II-3	IE	0.1
		Cavity			
473	10/29/77	STS	tunnel 136	NWR	0.001-20
			tunnel 136	FMS	0.001-20
474	10/29/77	STS	shaft 1214	NWR	20-150
475	10/30/77	Azgir, Kazakh SSR	shaft A-II-4	IE	0.01
		Cavity			
476	11/12/77	STS	shaft 1073	NWR	0.001-20
477	11/27/77	STS	tunnel 18P	NWR	0.001-20
478	11/30/77	STS	shaft Glubokaya	NWR	20-150
			shaft Glubokaya	NWR	0.001-20
479	12/26/77	STS	tunnel 803	NWR	0.001-20
480	12/26/77	STS	tunnel 123P	NWR	0.001-20
			tunnel 122P	NWR	<0.001
			tunnel 122P	NWR	0.001-20
			tunnel 122P	NWR	0.001-20
1978 Program					
481	03/19/78	STS	shaft 2691	NWR	0.001-20

482	03/26/78	STS	tunnel 701	NWR	0.001-20
			tunnel 701	NWR	0.001-20
483	04/22/78	STS	tunnel 204	NWR	0.001-20
			tunnel 204	NWR	0.001-20
			tunnel 204	NWR	0.001-20
484	05/24/78	STS	tunnel 185P	SAM	<0.001
485	05/29/78	STS	tunnel 133P	WIE	0.001-20
486	06/02/78	STS	tunnel 185PP	SAM	<0.001
487	06/11/78	STS	shaft 1010	NWR	20-150
488	07/05/78	STS	shaft 1077	NWR	20-150
489	07/28/78	STS	tunnel 104	NWR	20-150
			tunnel 104	NWR	0.001-20
			tunnel 104	NWR	0.001-20
			tunnel 104	NWR	0.001-20
			tunnel 104	NWR	0.001-20
		Salvo nuclear explosion with the maximum number of detonations (5) at STS			
490	08/09/78	Jakutsk ASSR, RSFSR	"Kraton" shaft KR-4	IE	22
		DSS: 65.918 112.560			
491	08/10/78	NTSNZ	tunnel A-18	NWR	0.001-20
			tunnel A-18	NWR	0.001-20
			tunnel A-18	NWR	0.001-20
			tunnel A-18	NWR	0.001-20
			tunnel A-18	NWR	20-150
			tunnel A-18	FMS	0.001-20
492	08/24/78	Jakutsk ASSR, RSFSR	"Kraton" shaft KR-3	IE	22
493	08/29/78	STS	tunnel 107	NWR	0.001-20
			tunnel 107	NWR	0.001-20
			tunnel 107	SAM	<0.001
494	08/29/78	STS	shaft 1228	NWR	20-150
495	09/12/78	Azgir, Kazakh SSR	shaft A-II-5	IE	0.008
		Cavity			
496	09/15/78	STS	shaft 1211	NWR	20-150
497	09/20/78	STS	tunnel 605P	WIE	0.001-20
498	09/21/78	Krasnoyarsk territory, RSFSR	"Kraton" shaft KR-2	IE	15
		DDS: 66.541 86.252			
499	09/27/79	NTSNZ	tunnel A-19	NWR	20-150
			tunnel A-19	NWR	0.001-20
			tunnel A-19	NWR	0.001-20
			tunnel A-19	NWR	0.001-20
			tunnel A-19	NWR	0.001-20
			tunnel A-19	NWR	0.001-20
			tunnel A-19	SAM	<0.001
500	10/08/78	Jakutsk ASSR, RSFSR	"Vyatka" shaft 43	IE	15

		Oil: 61.523 112.883			
501	10/15/78	STS	tunnel 200ASM	WIE	0.001-20
502	10/17/78	Azgir, Kazakh SSR	shaft A-VII	IE	20-150
			shaft A-VII	IE	0.001-20
		First salvo nuclear explosion on the Azgir area (total energy release - 73 kt)			
		Cavity			
503	10/17/78	Tyumen' region, RSFSR	"Kraton" shaft KR-1	IE	22
		DSS: 63.143 63.392			
504	10/31/78	STS	tunnel 194	FMS	0.001-20
505	11/04/78	STS	shaft 1302	NWR	20-150
			shaft 1302	NWR	0.001-20
506	11/29/78	STS	shaft 1222	NWR	20-150
			shaft 1222	NWR	0.001-20
507	11/29/78	STS	tunnel 162	NWR	0.001-20
508	11/30/78	Azgir, Kazakh SSR	shaft A-II-6	IE	0.06
		Cavity			
509	12/14/78	STS	tunnel 113P	NWR	0.001-20
510	12/18/78	Azgir, Kazakh SSR	shaft A-IX	IE	103
		Cavity: 47.787 48.192			
511	12/20/78	STS	tunnel 803P	NWR	0.001-20
			tunnel 803P	NWR	0.001-20
		1979 Program			
512	01/10/79	Azgir, Kazakh SSR	shaft A-II-7	IE	0.5
		Cavity			
513	01/17/79	Azgir, Kazakh SSR	shaft A-VIII	IE	0.001-20
			shaft A-VIII	IE	20-150
		Total energy release - 65 kt			
		Cavity: 47.883 48.128			
514	02/01/79	STS	shaft 1006	NWR	0.001-20
515	02/16/79	STS	shaft 109	NWR	0.001-20
			shaft 2803	NWR	0.001-20
516	03/23/79	STS	tunnel 115P	SAM	<0.001
517	04/10/79	STS	tunnel 115PP	SAM	<0.001
518	05/06/79	STS	tunnel 701P	NWR	0.001-20
			tunnel 701P	NWR	0.001-20
519	05/31/79	STS	tunnel 141	NWR	0.001-20
			tunnel 141	NWR	0.001-20
			tunnel 141	NWR	0.001-20
			tunnel 136P	NWR	0.001-20
520	06/12/79	STS	tunnel 115PPP	SAM	<0.001
521	06/23/79	STS	shaft 1223	NWR	20-150
522	07/07/79	STS	shaft 1225	NWR	20-150
			shaft 1225	NWR	0.001-20

523	07/14/79	Azgir, Kazakh SSR	shaft A-XI	IE	0.001-20
			shaft A-XI	IE	0.001-20
			shaft A-XI	IE	0.001-20
		Total energy release - 21 kt			
		Cavity: 47.813 48.097			
524	07/18/79	STS	shaft 2613	NWR	0.001-20
525	07/18/79	STS	tunnel 195P	FMS	0.001-20
526	08/04/79	STS	shaft 1085	NWR	0.001-20
			shaft 1085	NWR	20-150
527	08/12/79	Jakutsk ASSR, RSFSR	"Kimberlit" shaft KM-4	IE	8.5
		DSS: 61.872 122.185			
528	08/18/79	STS	shaft 1226	NWR	20-150
			shaft 1226	NWR	0.001-20
529	09/06/79	Krasnoyarsk territory, RSFSR	"Kimberlit" shaft KM-3	IE	8.5
		DSS: 64.097 99.565			
530	09/16/79	Ukrainian SSR	"Klivah" mine	IE	0.3
		48.366 38.500			
531	09/24/79	NTSNZ	tunnel A-32	NWR	20-150
			tunnel A-32	NWR	0.001-20
			tunnel A-32	NWR	0.001-20
532	09/27/79	STS	tunnel 175P	WIE	0.001-20
533	10/04/79	Tyumen' region, RSFSR	"Kimberlit" shaft KM-1	IE	22
		DSS: 60.677 71.501			
534	10/08/79	Jakutsk ASSR, RSFSR	"Sheksna" shaft 47	IE	15
		Oil: 61.854 113.090			
535	10/18/79	STS	tunnel 128	NWR	0.001-20
			tunnel 128	NWR	0.001-20
536	10/18/79	NTSNZ	tunnel A-20	NWR	20-150
			tunnel A-20	NWR	0.001-20
			tunnel A-20	NWR	20-150
			tunnel A-20	NWR	0.001-20
537	10/24/79	Azgir, Kazakh SSR	shaft A-X	IE	0.001-20
			shaft A-X	IE	20-150
		Last nuclear explosion at Azgir (total energy release - 33 kt)			
		Cavity: 47.806 48.158			
538	10/28/79	STS	shaft 1224	NWR	0.001-20
			shaft 1224	NWR	20-150
539	11/30/79	STS	tunnel 192P	NWR	0.001-20
540	12/02/79	STS	shaft 1309	NWR	0.001-20
		STS	shaft 1309	FMS	20-150
541	12/21/79	STS	tunnel 802P	NWR	0.001-20
542	12/23/79	STS	shaft Glubokaya - 1	NWR	20-150
			shaft Glubokaya - 1	NWR	0.001-20

1980 Program					
543	03/14/80	STS	tunnel 603P	SAM	<0.001
544	04/04/80	STS	shaft 126	NWR	0.001-20
545	04/10/80	STS	tunnel 181	NWR	0.001-20
			tunnel 181	NWR	0.001-20
546	04/25/80	STS	shaft 1071	NWR	0.001-20
			shaft 1071	NWR	0.001-20
547	05/22/80	STS	tunnel 173	NWR	0.001-20
			tunnel 173	NWR	0.001-20
			tunnel 173	NWR	0.001-20
548	06/12/80	STS	shaft 1083	NWR	20-150
549	06/16/80	Baskhir ASSR, RSFSR	"Butan" shaft 1	IE	3.2
		Oil			
550	06/25/80	Baskhir ASSR, RSFSR	"Butan" shaft 3	IE	3.2
		Oil			
551	06/25/80	STS	tunnel 127	NWR	0.001-20
552	06/29/80	STS	shaft 1227	NWR	0.001-20
			shaft 1227	NWR	0.001-20
			shaft 1227	NWR	20-150
553	07/31/80	STS	tunnel 902	NWR	0.001-20
			tunnel 902	NWR	0.001-20
554	09/14/80	STS	shaft 1220	NWR	20-150
555	09/25/80	STS	tunnel K-1	WIE	0.001-20
556	10/08/80	Astrakhan' region, RSFSR	"Vega" shaft 1T	IE	8.5
		Cavity: 46.708 48.215			
557	10/11/80	NTSNZ	tunnel A-25	NWR	20-150
			tunnel A-25	NWR	0.001-20
			tunnel A-25	NWR	0.001-20
			tunnel A-25	NWR	20-150
			tunnel A-30	NWR	0.001-20
			tunnel A-30	NWR	0.001-20
			tunnel A-30	NWR	0.001-20
558	10/12/80	STS	shaft 1087	NWR	20-150
			shaft 1087	NWR	20-150
559	10/23/80	STS	tunnel 204P	NWR	0.001-20
560	11/01/80	Krasnoyarsk territory, RSFSR	"Batolit" shaft BT-1	IE	8
		DSS: 60.882 97.568			
561	12/05/80	STS	tunnel 204PP	NWR	0.001-20
562	12/05/80	STS	tunnel 111P	NWR	0.001-20
			tunnel 111P	NWR	0.001-20
			tunnel 111P	NWR	0.001-20
563	12/10/80	Tyumen' region, RSFSR	"Angara" shaft	IE	15
		Oil: 61.686 66.999			

564	12/14/80	STS	shaft 1086	NWR	0.001-20
			shaft 1086	NWR	0.001-20
			shaft 1086	NWR	20-150
565	12/26/80	STS	tunnel 3-2P	NWR	0.001-20
566	12/27/80	STS	shaft 1303	NWR	20-150
			shaft 1303	NWR	0.001-20
1981 Program					
567	03/25/81	STS	tunnel 603-PP	SAM	<0.001
568	03/29/81	STS	shaft 1234	NWR	0.001-20
			shaft 1234	FMS	0.001-20
			shaft 1234	FMS	0.001-20
569	04/22/81	STS	shaft 1232	NWR	20-150
			shaft 1232	NWR	0.001-20
			shaft 1232	NWR	0.001-20
570	05/25/81	Arkhangelsk region, RSFSR	"Pirit" shaft	IE	37.6
		Torch: 68.205 53.656			
571	05/27/81	STS	shaft 1203	NWR	0.001-20
572	06/06/81	STS	tunnel 603-PP	SAM	<0.001
573	06/30/81	STS	tunnel 187	NWR	0.001-20
			tunnel 187	NWR	0.001-20
574	07/17/81	STS	tunnel 106	NWR	0.001-20
575	08/14/81	STS	tunnel 184	NWR	0.001-20
			tunnel 184	NWR	0.001-20
			tunnel 184	NWR	0.001-20
576	09/02/81	Perm' region, RSFSR	"Geliy" shaft 401	IE	3.2
		Oil: 60.622 55.589			
577	09/13/81	STS	shaft 1233	NWR	20-150
578	09/26/81	Astrakhan' region, RSFSR	"Vega" shaft 2T/2	IE	8.5
		Cavity: 46.784 48.248			
579	09/26/81	Astrakhan' region, RSFSR	"Vega" shaft 4T/2	IE	8.5
		Cavity: 46.768 48.278			
580	10/01/81	NTSNZ	tunnel A-23	NWR	20-150
			tunnel A-23	NWR	0.001-20
			tunnel A-23	NWR	0.001-20
			tunnel A-23	NWR	0.001-20
581	10/16/81	STS	tunnel 136-PP	SAM	<0.001
582	10/18/81	STS	shaft 1236	NWR	20-150
			shaft 1236	NWR	0.001-20
583	10/22/81	Krasnoyarsk territory, RSFSR	"Shpat" shaft ShP-2	IE	8.5
		DSS: 63.789 97.548			
584	11/20/81	STS	tunnel 103	NWR	0.001-20
			tunnel 103	NWR	0.001-20

585	11/29/81	STS	shaft 1237	NWR	0.001-20
			shaft 1237	NWR	0.001-20
			shaft 1237	NWR	0.001-20
586	12/22/81	STS	tunnel 135	NWR	0.001-20
			tunnel 135	NWR	0.001-20
			tunnel 135	NWR	0.001-20
587	12/27/81	STS	shaft 1312	NWR	20-150
588	02/19/82	STS	tunnel 150	NWR	0.001-20
			tunnel 150	NWR	0.001-20
589	04/25/82	STS	shaft 1219	FMS	20-150
			shaft 1219	FMS	20-150
			shaft 1219	FMS	20-150
590	06/25/82	STS	tunnel 196	WIE	0.001-20
			tunnel 196	NWR	0.001-20
591	07/04/82	STS	shaft 1321	NWR	0.001-20
			shaft 1321	NWR	20-150
			shaft 1321	NWR	0.001-20
592	07/31/82	Irkutsk region, RSFSR	"Rift" shaft RF-3	IE	8.5
		DSS: 53.813 106.13			
593	08/23/82	STS	tunnel 14P	NWR	0.001-20
			tunnel 14P	NWR	0.001-20
594	08/31/82	STS	shaft 1317	NWR	0.001-20
			shaft 1317	NWR	0.001-20
595	09/04/82	Krasnoyarsk territory, RSFSR	"Rift" shaft RF-1	IE	16
		DSS: 69.206 81.647			
596	09/21/82	STS	tunnel 203	NWR	0.001-20
			tunnel 203	NWR	0.001-20
597	09/25/82	Krasnoyarsk territory, RSFSR	"Rift" shaft RF-4	IE	8.5
		DSS: 64.311 91.834			
598	10/10/82	Jakutsk ASSR, RSFSR	"Neva" shaft 66	IE	15
		Oil: 61.553 112.864			
599	10/11/82	NTSNZ	tunnel A-37	NWR	0.001-20
			tunnel A-37	NWR	20-150
			tunnel A-37	NWR	0.001-20
			tunnel A-37	NWR	0.001-20
600	10/16/82	Astrakhan' region, RSFSR	"Vega" shaft 3T	IE	13.5
		Cavity: 46.730 48.157			
601	10/16/82	Astrakhan' region, RSFSR	"Vega" shaft 5T	IE	8.5
		Cavity: 46.748 48.216			
602	10/16/82	Astrakhan' region, RSFSR	"Vega" shaft 6T	IE	8.5
		Cavity: 46.754 48.270			
603	10/16/82	Astrakhan' region, RSFSR	"Vega" shaft 7T	IE	8.5
		Cavity: 46.743 48.213			

604	12/05/82	STS	shaft 1314	NWR	20-150
			shaft 1314	NWR	0.001-20
605	12/25/82	STS	tunnel 172	NWR	0.001-20
			tunnel 172	NWR	0.001-20
606	12/26/82	STS	shaft 1415	FMS	20-150
			shaft 1415	NWR	20-150
1983 Program					
607	03/11/83	STS	tunnel 150P	SAM	<0.001
608	03/30/83	STS	tunnel 177	NWR	0.001-20
609	04/12/83	STS	tunnel 186	WIE	0.001-20
610	05/30/83	STS	tunnel 215	FMS	0.001-20
			tunnel 215	NWR	0.001-20
611	06/12/83	STS	shaft 1320	NWR	20-150
			shaft 1320	NWR	0.001-20
612	06/24/83	STS	tunnel 176P	NWR	0.001-20
613	07/20/83	Kazakh SSR	"Lira" shaft 1T	IE	15
		Cavity: 51.308 53.27			
614	07/20/83	Kazakh SSR	"Lira" shaft 2T	IE	15
		Cavity: 51.340 53.27			
615	07/20/83	Kazakh SSR	"Lira" shaft 3T	IE	15
		Cavity: 51.314 53.29			
616	08/18/83	NTSNZ	tunnel A-40	NWR	20-150
			tunnel A-40	NWR	0.001-20
			tunnel A-40	NWR	0.001-20
			tunnel A-40	TIC	0.001-20
			tunnel A-40	SAM	0.001-20
617	09/11/83	STS	tunnel K-2	WIE	0.001-20
618	09/24/83	Astrakhan' region, RSFSR	"Vega" shaft 8RT	IE	8.5
		Cavity: 46.816 48.291			
619	09/24/83	Astrakhan' region, RSFSR	"Vega" shaft 9RT	IE	8.5
		Cavity: 46.817 48.279			
620	09/24/83	Astrakhan' region, RSFSR	"Vega" shaft 10RT	IE	8.5
		Cavity: 46.860 48.272			
621	09/24/83	Astrakhan' region, RSFSR	"Vega" shaft 11RT	IE	8.5
		Cavity: 46.780 48.300			
622	09/24/83	Astrakhan' region, RSFSR	"Vega" shaft 12RT	IE	8.5
		Cavity: 46.796 48.297			
623	09/24/83	Astrakhan' region, RSFSR	"Vega" shaft 13RT	IE	8.5
		Cavity: 46.837 48.231			
624	09/25/83	NTSNZ	tunnel A-21	NWR	20-150
			tunnel A-21	NWR	0.001-20
			tunnel A-21	NWR	0.001-20
			tunnel A-21	WIE	0.001-20

625	10/06/83	STS	shaft 1325	NWR	20-150
			shaft 1325	NWR	0.001-20
626	10/26/83	STS	shaft 1307	NWR	20-150
627	11/02/83	STS	tunnel 203P	NWR	0.001-20
628	11/20/83	STS	shaft 1235	NWR	0.001-20
			shaft 1235	NWR	0.001-20
629	11/29/83	STS	tunnel 216	NWR	0.001-20
630	11/29/83	STS	tunnel 180	NWR	0.001-20
			tunnel 180	NWR	0.001-20
631	12/26/83	STS	tunnel 129	FMS	0.001-20
1984 Program					
632	02/19/84	STS	shaft 1331	NWR	20-150
633	03/07/84	STS	shaft 1308	NWR	20-150
634	03/29/84	STS	shaft 1335	NWR	20-150
635	04/15/84	STS	tunnel 190	NWR	20-150
			tunnel 190	NWR	0.001-20
636	04/25/84	STS	shaft 1316	NWR	20-150
			shaft 1316	NWR	0.001-20
637	05/26/84	STS	shaft 1414	NWR	20-150
			shaft 1414	NWR	0.001-20
638	07/14/84	STS	shaft 1344	NWR	20-150
			shaft 1344	NWR	0.001-20
639	07/21/84	Kazakh SSR	"Lira" shaft 4T	IE	15
		Cavity: 51.356 53.249			
640	07/21/84	Kazakh SSR	"Lira" shaft 5T	IE	15
		Cavity: 51.374 53.257			
641	07/21/84	Kazakh SSR	"Lira" shaft 6T	IE	15
		Cavity: 51.353 53.271			
642	08/11/84	Komi ASSR, RSFSR	"Kvarts" shaft K-2	IE	8.5
		DSS: 65.025 55.187			
643	08/25/84	Tyumen' region, RSFSR	"Kvarts" shaft K-3	IE	8.5
		DSS: 61.876 72.092			
644	08/26/84	NTSNZ	tunnel A-100	WIE	0.001-20
645	08/27/84	Murmansk region, RSFSR	tunnel "Dnepr-2"	IE	1.7
			tunnel "Dnepr-2"	IE	1.7
		Ore: 67.774 33.688			
646	08/28/84	Perm' region, RSFSR	"Geliy" shaft 402	IE	3.2
		Oil: 60.826 57.472			
647	08/28/84	Perm' region, RSFSR	"Geliy" shaft 403	IE	3.2
		Oil: 60.796 57.544			
648	09/09/84	STS	tunnel 132	WIE	0.001-20
			tunnel 132	WIE	0.001-20
			tunnel 132	WIE	0.001-20

			tunnel 132	WIE	0.001-20
649	09/18/84	Kemerovo region, RSFSR	"Kvarts" shaft K-4	IE	10
		DSS: 55.870 87.446			
650	10/18/84	STS	tunnel 200M-bis	WIE	0.001-20
651	10/25/84	NTSNZ	tunnel A-26	NWR	0.001-20
			tunnel A-26	NWR	0.001-20
			tunnel A-26	NWR	0.001-20
			tunnel A-26	NWR	20-150
652	10/27/84	Astrakhan' region, RSFSR	"Vega" shaft 14RT	IE	3.2
		Cavity: 46.857 48.098			
653	10/27/84	Astrakhan' region, RSFSR	"Vega" shaft 15RT	IE	3.2
		Cavity: 46.842 48.08			
654	10/27/84	STS	shaft 1323	NWR	20-150
655	11/23/84	STS	tunnel 803bis	NWR	0.001-20
			tunnel 803bis	NWR	0.001-20
			tunnel 803bis	NWR	0.001-20
656	12/02/84	STS	shaft 1411	NWR	20-150
			shaft 1411	NWR	0.001-20
657	12/16/84	STS	shaft 1313	NWR	20-150
			shaft 1313	NWR	0.001-20
658	12/28/84	STS	shaft 1353	NWR	20-150
			shaft 1353	TIC	0.001-20
1985 Program					
659	02/10/85	STS	shaft 1340	NWR	0.001-20
			shaft 1340	NWR	0.001-20
			shaft 1340	NWR	20-150
660	04/25/85	STS	shaft 1319	NWR	20-150
			shaft 1319	NWR	20-150
661	06/15/85	STS	shaft 1341	NWR	20-150
			shaft 1341	NWR	0.001-20
			shaft 1061bis	NWR	0.001-20
662	06/18/85	Tyumen' region, RSFSR	"Benzol" shaft	IE	2.5
		Oil: 60.17 72.50			
663	06/30/85	STS	shaft 1354	NWR	0.001-20
			shaft 1354	NWR	20-150
664	07/11/85	STS	tunnel 175-PP	NWR	0.001-20
665	07/19/85	STS	tunnel 901	NWR	0.001-20
666	07/19/85	Arkhangelsk region, RSFSR	"Agat" shaft	IE	8.5
		DSS: 65.970 40.863			
667	07/20/85	STS	shaft 1322	NWR	20-150
668	07/25/85	STS	tunnel 152	NWR	0.001-20
			tunnel 152	NWR	0.001-20
			tunnel 152	SAM	0.001-20

			tunnel 152	SAM	0.001-20
1987 Program					
669	02/26/87	STS	tunnel 130	FMS	0.001-20
670	03/12/87	STS	shaft 1315	NWR	0.001-20
			shaft 1315	NWR	0.001-20
671	04/03/87	STS	shaft 1318	NWR	20-150
672	04/03/87	STS	tunnel 208	NWR	0.001-20
			tunnel 208	NWR	0.001-20
			tunnel 208	NWR	0.001-20
673	04/17/87	STS	shaft 1384	NWR	20-150
			shaft 1384	NWR	0.001-20
			shaft 1384	NWR	0.001-20
674	04/19/87	Perm' region, RSFSR	"Geliy" shaft 404	IE	3.2
		Oil: 60.250 57.083			
675	05/06/87	Perm' region, RSFSR	"Geliy" shaft 405	IE	3.2
		Oil: 60.813 57.548			
676	05/06/87	STS	tunnel 164	FMS	0.001-20
677	06/06/87	STS	tunnel 138	FMS	0.001-20
678	06/20/87	STS	shaft 1326	NWR	20-150
			shaft 1326	NWR	0.001-20
679	07/07/87	Jakutsk ASSR, RSFSR	"Neva" shaft 68	IE	15
		Oil: 61.501 112.803			
680	07/17/87	STS	tunnel 168	FMS	20-150
681	07/24/87	Jakutsk ASSR, RSFSR	"Neva" shaft 61	IE	15
		Oil: 61.478 112.757			
682	08/02/87	NTSNZ	tunnel A-37A	NWR	0.001-20
			tunnel A-37A	NWR	0.001-20
			tunnel A-37A	NWR	20-150
			tunnel A-37A	FMS	0.001-20
			tunnel A-37A	SAM	0.001-20
683	08/02/87	STS	shaft 1348	NWR	0.001-20
			shaft 1348	NWR	20-150
			shaft 1348	NWR	20-150
684	08/12/87	Jakutsk ASSR, RSFSR	"Neva" shaft 101	IE	3.2
		Oil: 61.455 112.760			
685	09/18/87	STS	tunnel 132P	WIE	0.001-20
			tunnel 132P	SAM	0.001-20
686	10/03/87	Kazakh SSR	"Batolit" shaft BT-2	IE	8.5
		DSS: 47.605 56.227			
687	10/16/87	STS	tunnel K-85	WIE	0.001-20
688	11/15/87	STS	shaft 1332	NWR	20-150
			shaft 1332	NWR	0.001-20

689	12/13/87	STS	shaft 1355	NWR	0.001-20
			shaft 1355	NWR	20-150
690	12/20/87	STS	tunnel 164P	FMS	0.001-20
691	12/27/87	STS	shaft 1388	NWR	20-150
			shaft 1388	NWR	0.001-20
1988 Program					
692	02/06/88	STS	tunnel 168P	NWR	0.001-20
			tunnel 168P	SAM	<0.001
			tunnel 168P	SAM	<0.001
693	02/13/88	STS	shaft 1361	NWR	20-150
			shaft 1361	NWR	0.001-20
694	04/03/88	STS	shaft 1336	NWR	20-150
695	04/22/88	STS	tunnel 704	WIE	0.001-20
696	05/04/88	STS	shaft 1359	FMS	20-150
697	05/08/88	NTSNZ	tunnel A-24	WIE	20-150
			tunnel A-24	WIE	0.001-20
			tunnel A-24	WIE	0.001-20
698	06/14/88	STS	shaft 1421	NWR	0.001-20
699	08/22/88	Tyumen' region, RSFSR	"Rubin" shaft RN-2	IE	1.5
		DSS: 66.316 78.548			
700	09/06/88	Arkhangelsk region, RSFSR	"Rubin" shaft RN-1	IE	8.5
		Last USSR industrial nuclear explosion			
		DSS: 61.331 47.955			
701	09/14/88	STS	shaft 1350	FMS (JVE)	20-150
702	10/18/88	STS	tunnel 034	WIE	0.001-20
703	11/12/88	STS	shaft 1412	NWR	0.001-20
704	11/23/88	STS	tunnel 169/1	NWR	0.001-20
			tunnel 169/1	FMS	0.001-20
			tunnel 169/1	SAM	<0.001
705	12/04/88	NTSNZ	tunnel A-27	NWR	20-150
			tunnel A-27	NWR	0.001-20
			tunnel A-27	NWR	0.001-20
			tunnel A-27	WIE	0.001-20
			tunnel A-27	SAM	<0.001
706	12/17/88	STS	shaft 1346	NWR	20-150
			shaft 1346	NWR	0.001-20
707	12/28/88	STS	tunnel 901P	NWR	0.001-20
			tunnel 901P	NWR	0.001-20
1989 Program					
708	01/22/89	STS	shaft 1328	NWR	0.001-20
			shaft 1328	NWR	20-150
709	02/12/89	STS	shaft 1366	NWR	20-150
710	02/17/89	STS	tunnel 139	NWR	0.001-20

711	07/08/89	STS	shaft 1352	NWR	20-150
712	09/02/89	STS	shaft 1410	NWR	0.001-20
			shaft 1410		0.001-20
713	10/04/89	STS	tunnel 169/2	WIE	0.001-20
714	10/19/89	STS	shaft 1365	NWR	20-150
			shaft 1365	NWR	0.001-20
			shaft 1365	NWR	0.001-20
		Last test at the STS			
715	10/24/90	NTSNZ	tunnel A13-N	NWR	20-150
			tunnel A13-N	NWR	0.001-20
			tunnel A13-N	NWR	0.001-20
			tunnel A13-N	NWR	0.001-20
			tunnel A13-N	NWR	0.001-20
			tunnel A13-N	NWR	<0.001
			tunnel A13-N	NWR	<0.001
			tunnel A13-N	SAM	<0.001
		Last USSR nuclear test			

Note: The geographic names of the nuclear test and explosion locations correspond to their names during the existence of the USSR.

The dates correspond to the Moscow Time (MT) calendar.

The Comments row gives mainly type features for certain nuclear tests.

Table 2
Soviet Nuclear Tests by Type, 1949-1990

Underground	Shaft	251
	Tunnel	245
	Subtotal	*496*
Atmospheric	Air	177
	Surface	32
	Space	4
	High Altitude	1
	Subtotal	*214*
Water/Underwater		5
	Total	**715**

Table 3
Soviet Nuclear Tests by Location, 1949-1990

At Test Sites	Semipalatinsk (1949-1989)	456
	Novaya Zemyla (1955-1990)	130
		586
Outside Test Site	Russia	91
	- Europe (59)	
	- Asia (32)	
	Kazakhstan	33
	Ukraine	2
	Uzbekestan	2
	Turkmenistan	1
		129
	Total	**715**
	Kazakhstan	489
	Russia	221
	Ukraine	2
	Uzbekestan	2
	Turkmenistan	1
	Total	**715**

Table 4
Soviet Nuclear Tests by Purpose, 1949-1990

Purpose	Number of Tests	Number of Nuclear Charges and Nuclear Devices
NWR = *Weapon Development or Modification*	445	637
WIE = *Weapons Effects*	52	69
FMS = *Physics Tests*	36	47
SAM = *Safety Tests*	25	42
ME = *Military Exercise*	1	1
Total for military purposes	***559***	***796***
UE = *PNE*	124	135
TIC = *Development of Devices for Use in PNE*	32	38
Total for peaceful purposes	***156***	***173***
TOTAL	**715**	**969**

Table 5
Total Energy Release of the USSR Nuclear Tests and Nuclear Explosions for Peaceful Purposes

	Nuclear Test Energy Release				
Years	**STS**	**NTSNZ**	**Industrial explosions and Azgir**	**"Kapustin Yar", "Totsk", "Aralsk" regions**	**Total**
1949	20	–	–	–	20
1950	–	–	–	–	0
1951	80	–	–	–	80
1952	–	–	–	–	0
1953	440	–	–	–	440
1954	80	–	–	40	120
1955	1,870	<10	–	–	1,880
1956	1,970	–	–	<10	1,980
1957	1,680	4,540	–	10	6,230
1958	80	16,130	–	20	16,230
1959	–	–	–	–	0
1960	–	–	–	–	0
1961	140	86,240	–	50	86,430
1962	220	132,710	–	900	133, 830
1963	–	–	–	–	0
1964	90	20	–	–	110
1965	250	0	10	–	260
1966	420	1,400	30	–	1,850
1967	220	260	<10	–	490
1968	120	330	60	–	510
1969	270	540	60	–	870
1970	150	2,200	160	–	2,510
1971	300	2,450	130	–	2,880
1972	450	1,130	40	–	1,620
1973	310	7,820	40	–	8,170
1974	150	3,430	30	–	3,610
1975	210	4,190	20	–	4,420
1976	300	140	80	–	520
1977	350	130	50	–	530
1978	620	240	270	–	1,130
1979	960	280	170	–	1,410
1980	600	130	40	–	770

Nuclear Test Energy Release					
Years	**STS**	**NTSNZ**	**Industrial explosions and Azgir**	**"Kapustin Yar", "Totsk", "Aralsk" regions**	**Total**
1981	610	140	70	–	820
1982	470	80	90	–	640
1983	440	250	90	–	780
1984	1,130	110	80	–	1,320
1985	450	0	10	–	460
1986	0	0	0	–	0
1987	1,000	150	40	–	1,190
1988	670	220	20	–	910
1989	300	0	0	–	300
1990	0	70	0	–	70

Table 6
Soviet Peaceful Nuclear Explosions by Location, 1965-1988

Russia (80)				
	Europe (48)	Astrakham	1980-1984	15
		Perm	1969-1987	8
		Bashkir	1965-1980	6
		Orenburg	1970-1973	5
		Arkhangelsk	1971-1988	4
		Komi	1971-1984	4
		Murmansk	1972, 1984	2
		Stavropol	1969	1
		Ivanovo	1971	1
		Kalmik	1972	1
		Kemerevo	1984	1
	Asia (32)	Jakutsk	1974-1987	12
		Krasnoyarsk	1975-1982	9
		Tyuemn	1967-1988	8
		Irkutsk	1977, 1982	2
		Chita	1977	1
Kazakhstan (39)		Azgir	1966-1979	17
		Semi	1965-1974	7
		Uralsk	1983-1984	6
		Mangishlak	1969-1970	3
		Kustonay	1972	1
		Tselinograd	1973	2
		Djezkazgan	1973	1
		Aktyubinsk	1987	1
		?	1972	1
Uzbekistan			1966, 1968	2
Ukraine			1972, 1979	2
Turkmenistan			1972	1
		Total		**124**

Table 7
Soviet Peaceful Nuclear Explosions by Purpose, 1965-1988

Cavity Construction	42
Deep Seismic Sounding	39
Oil and Gas Extraction	20
Extinguish Wells (torch)	5
Carral Building	3
Reservoir	2
Ore Fragmentation	2
Waste Burial	2
Coal Mine	1
Unknown Purpose	8
Total	**124**