Soviet Test 184

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The 1962 Soviet Nuclear EMP Tests over Kazakhstan.

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Electromagnetic pulse is a strange and mysterious phenomenon to most of the general public. Even for most of us who have read and studied a lot about EMP over the years, something that is even more strange and mysterious is the Soviet Union's series of nuclear tests in space, most notably the test known only as K-3 or Test 184. These EMP-producing tests were done over a large populated land mass in Kazakhstan. Even though the economic state of Kazakhstan in 1962 was quite primitive by today's standards, it was heavily industrialized and electrified.

One of the problems in writing about Kazakhstan is the names of regions and cities. (To avoid confusion, it is necessary to get this matter out of the way before discussing the EMP tests.) Until 1991, the names used were generally transliterations of the Russian names. After Kazakhstan regained its independence, many of the names were changed, and the use of the Kazakh language began to return, although Russian is still more commonly spoken in most of the country. In English, both Russian and Kazakh names are transliterated (given an English phonetic spelling) since both the Russian and Kazakh languages use the Cyrillic alphabet. More precisely, the Kazakh language has used the Cyrillic alphabet for the past several decades in Kazakhstan. That is changing as the official Kazakh language is transitioning to the Latin alphabet. The target year for completion of the transition to the Latin alphabet is 2025.

There are also some subtle differences in how certain names are transliterated when the Kazakh language is used. The Russians called a region Karaganda, but many Kazakhstanis prefer either Karagandy or Qaraghandy (depending upon the extent they wish to emphasize the precise placement of the tongue at the beginning of the word). Although the **K** spelling is easier for most English-speakers to read, the **Q** emphasizes the correct placement of the tongue at the start of pronouncing the syllable. Reflecting this subtle difference, even **the name of the country is being changed to be written: Qazaqstan**. (Most Kazakhstan place names tend to have a very slight accent on the last syllable.)

RUSSIAN	KAZAKH (older)	KAZAKH (preferred)
Karaganda	Karagandy	Qaraghandy
Sary-Shagan	Saryshagan	Saryshagan
Aqmola	Astana	Astana
Alma-Ata	Almaty	Almaty
Dzhezkazgan	Zhezkazgan	Zhezqazghan

On this page, I will generally use the most commonly accepted Kazakh transliteration (although Russia still leases many of the military and space facilities in Kazakhstan, and Russian is still one of the two official languages and is the dominant language in many areas). There is apparently a lot of disagreement among Kazakhstanis who speak English whether the proper English transliteration of the name of a large city in central Kazakhstan that was strongly affected by the 1962 EMP should be

Karaganda, Karagandy or Qaraghandy. The official seal of the city uses the Kazakh language (more properly the *Qazaq* language), but the Russian pronunciation for the city seems to be much more common. It is much more common to use the Russian spelling and pronunciation for the name of the city (Karaganda), but to use the Kazakh pronunciation of Qaraghandy for the name of the oblast (the state or province). Therefore, I will use the Russian spelling for the name of the city.

Almaty was the capital city of Kazakhstan until December 1997, when the capital was changed to Astana. Astana was known as Tselinograd and Aqmola at various times during the Soviet era (but Astana literally means *capital*). The region around the capital city, however, is still called the Aqmola region.

In early 2019, the name of the city of Astana was officially changed to Nur-Sultan. Many people still refer to it as Astana, and that name will be used on this page for now.

I will try to provide as much accurate information as possible about this series of high-altitude nuclear tests, although there is a considerable amount of information about the EMP effects of these particular tests that I would very much like to know more about. I will also try to be very careful about accuracy since some of the available information is inaccurate, even in respectable publications. and I don't want to add to the confusion. For example, one article that provides a lot of good information, that is mostly consistent with other sources, is "The 'K' Project: Soviet Nuclear Tests in Space" by Anatoly Zak in *Nonproliferation Review*, Vol. 13, No. 1, March 2006. However, that article has the altitudes of some of the 1962 tests wrong, as can be verified with both authoritative United States and Russian sources.

Below is a list of all of the Soviet nuclear tests above an altitude of 12 kilometers. (According to Table 1.21 of Volume 2 of ***The Nuclear Tests of the U.S.S.R.*** edited by V. N. Mikhailov, the Soviet Union launched 25 nuclear tests by rocket, but most of those were detonated near ground level or at low altitudes. A more recent compilation in English from Rosatom, also edited by V. N. Mikhailov, shows 30 Soviet rocket-launched nuclear tests. The Mikhailov/Rosatom compilation in English was once available online, but is now only available as a quite expensive printed book.) (The first nuclear test ever launched by rocket was launched from Kapustin Yar on February 2, 1956 and detonated on the prairie in Kazakhstan in the Kzyl-Orda region near the Aral Sea. That 1956 missile test produced a nuclear explosion with far less than its expected yield, and is often regarded as a failure. A subsequent missile launch from Kapustin Yar at noon on January 19, 1957 detonated at an altitude of 10.37 kilometers over Kazakhstan with a nuclear yield of 10 kilotons. This 1957 test is generally regarded as the first truly successful test of a nuclear missile with an operational warhead.)

Soviet nuclear tests above an altitude of 12 kilometers

DATE	TIME (GMT/UTC)	TEST NUMBER	OPERATION	ALTITUDE (KM.)	WEAPON YIELD
06 September 1961	**06:00 (approx.)**	**Test No. 88**	**Thunderstorm**	**22.7 km.**	**11 kilotons**
06 October 1961	**07:15 (approx.)**	**Test No. 115**	**Thunder**	**41.3 km.**	**40 kilotons**
27 October 1961	unknown	**Test No. 128**	**K-1**	**150 km.**	**1.2 kilotons**
27 October 1961	unknown	**Test No. 127**	**K-2**	**300 km.**	**1.2 kilotons**
22 October 1962	**03:40:45**	**Test No. 184**	**K-3**	**290 km.**	**300 kilotons**
28 October 1962	**04:21:20**	**Test No. 187**	**K-4**	**150 km.**	**300 kilotons**
1 November 1962	**09:12:00**	**Test No. 195**	**K-5**	**59 km.**	**300 kilotons**

The first two 1961 high-altitude tests (Test 88 and Test 115) were launched from Kapustin Yar toward the southwest, and were detonated nearby over Russian territory, about 20 miles southwest of the Russian city of Volgograd (formerly called Stalingrad). EMP effects from those tests have not been publicized, although they must have been large, especially from the *Thunder* test. The September 6, 1961 *Thunderstorm* test used a Soviet AA guided missile to carry the nuclear weapon, which targeted a payload carried by a high-altitude balloon floating at an altitude of 22.7 kilometers. The October 6, 1961 *Thunder* test used the larger R-5 missile to carry the larger 40-kiloton weapon to a higher altitude.

The missiles in the **K Project** were all launched from Kapustin Yar toward the Saryshagan ABM test range just west of the town of Saryshagan. This was a standard missile flight path for Soviet anti-ballistic missile (ABM) tests. (See the map of Kazakhstan below.) The Saryshagan ABM test range contained a number of anti-ballistic missile radar systems, and a major reason for the K Project was to test the effects of nuclear EMP on the ABM radar systems. All of the missiles fired from from Kapustin Yar in the K Project reportedly reached a maximum altitude of about 500 kilometers, with the nuclear weapons being detonated on the last half of the trajectory as the missile was descending in the direction of Saryshagan. All nuclear detonations occurred about 11 minutes after the launch.

During all of the K Project tests, the Saryshagan test range was put on high alert. The families of the Saryshagan military personnel, as well as non-essential military personnel, were restricted to their apartments in the village of ***Priozersk***, which was (and still is) the home of the administrative headquarters of the Saryshagan range on the shore of Lake Balqash about 12 kilometers south of the town of Saryshagan. Priozersk is still not shown on most ordinary maps. In the Soviet era, after a Russian soldier would be assigned to Priozersk, the soldier and his family would often scour maps and atlases trying to find where this city was located, but could find nothing.

Priozersk is still a restricted town (even though it has grown in population to more than 13,000) and foreigners have to get special permission to enter the town (although such permission is occasionally given). If you want a close up look at a satellite view of the village, go to the Wikimapia view of Priozersk. This will take you directly to a clear aerial view centered on the "administrative headquarters and residential area" for the Saryshagan test range in Priozersk. Some photos of Priozersk are here. From the photos, the town looks quite ordinary, but it was often regarded as a beautiful lakeside town when compared to the surrounding extremely desolate and flat prairies of the Saryshagan region.

At the time of the K Project, only risky U-2 flights and expensive spy satellites could peer down on this mysterious town (which was a frequent target of such spy activities). When this page was first written, I had extreme difficulty even finding the exact location of Priozerk. Now, anyone with an internet connection can zoom in and learn many details about this once-secret city. You can also see the control point for entry into Priozersk on the east-west road near the northwest corner of the town. (The control point on the roadway going south is several miles south of the town, and the roadway going off to the northwest appears to be impassable.) In the years from 2008 to 2010, certain government agencies in that part of the world didn't seem to like the idea of *Priozersk* being tagged on Wikimapia. This mysterious town was usually tagged on Wikimapia in Cyrillic, but the tag occasionally disappeared, only to reappear later in a different form. Much of the former secrecy has been lifted, and Priozersk for a short time, even had its own official city web site. (If you want to read any of the Kazakhstan web pages, choose "Pyc" on the page to get the Russian language, while using the Google Chrome browser, which includes a Russian-to-English translator function. Even if the web page has an "English" option, this will often give you better results.) There is now even an English-language Wikpedia page about Priozersk.

According to the *Voice of Russia*, *RIA Novosti* and *Pravda*, Russia is still leasing this Saryshagan test range, and still launches missiles in this Kapustin Yar to Saryshagan trajectory. In one test of a Topol-M missile (known by its NATO name of the SS-27) on November 1, 2005, the missile impacted on the Saryshagan test range. The Topol-M missile has auxiliary engines that fire randomly, to keep the missile on a non-ballistic trajectory to evade traditional ballistic missile defenses. The Topol-M is now deployed in the Russian nuclear arsenal. On December 5, 2010, when Russia performed a successful launch of an older Topol missile that is similar in capabilities the the United States Minuteman missile. That unarmed missile also impacted on target in the Saryshagan area. (Its launch point was reportedly in the Astrakhan region of Russia, which is somewhat to the south of Kapustin Yar, but the missile was approximately following the same trajectory that they have been using for more than a half century.) On December 27, 2013, Russia launched an RS-12M missile from Kapustin Yar to Saryshagan using the exact same flight path as was used for the 1962 Soviet EMP tests, except that the 2013 launch completed its full trajectory and impacted on the Saryshagan missile test range.

An agreement was negotiated in late 2013 between Russia and Kazakhstan giving Kazakhstan more control of the Saryshagan test range. On March 4, 2014, a Topol RS-12M (which has the NATO designation as the SS-25 Sickle) was test fired along the same Kapustin Yar to Saryshagan path. Russia continues to test missiles from their strategic nuclear forces, using dummy warheads, every few months across this same trajectory. According to **Tass**, one such recent test was done on November 17, 2015 using an RS-12M Topol missile.

It is along this same missile path, usually between Zhezqazghan and Saryshagan, that the Soyuz spacecraft returning from the International Space Station generally lands. (Zhezqazghan is sometimes transliterated as **Jezkazgan** to make it easier for English speakers to pronounce.)

There were hundreds of nuclear detonations in Kazakhstan from 1949 through 1989, with most of them occurring in the northeast part of the country, west of the city of Semey, which was called Semipalatinsk during the Soviet era. (The old test area for ground level test is still called Semipalatinsk.)

The soldiers and their families in the Saryshagan area during the K Project tests knew that a large missile with an armed nuclear warhead, minutes from detonation, was being fired right in their direction from two thousand miles away. Although the Saryshagan area was a designated missile test range, the missiles with live nuclear warheads were being fired across a country populated with ordinary civilians during the K Project.

The first two of the K Project high-altitude nuclear tests (in 1961) over Kazakhstan were only 1.2 kilotons, so the EMP could be carefully measured, but apparently did not have much of an impact on the 1961 infrastructure of Kazakhstan. The last three of the series (in 1962) used 300 kiloton thermonuclear warheads. All of the K Project missiles for high-altitude detonations were launched from Kapustin Yar in Russia near the Volga River toward Saryshagan using the R-12 missile. The R-12 was called the **SS-4** by the United States.

The Soviet 1961 high-altitude tests gave the Soviets a sufficient understanding of high-altitude EMP that a Soviet scientific expeditionary ship was stationed near Johnston Island for the 1962 U.S. Starfish Prime high-altitude test in order to gather data. A second Soviet scientific expeditionary ship was stationed at the southern conjugate region (at the opposite end of the earth's magnetic field line from Johnston Island) at a point near Fiji in the South Pacific.

Like the U.S. Starfish Prime test and others, the 1962 Soviet high-altitude tests were monitored by a very large array of scientific instruments, although the Soviets had a much better idea of what to expect, and the EMP phenomenon was a major reason for the project. A number of instrument packages were launched during the K-3 and K-4 tests (Tests 184 and 187) using the Soviet MR-12 meteorological rockets. The small MR-12 rockets were timed to reach their apogee (highest point) of 130 to 140 km. at the moment the nuclear weapon was detonated.

During all of the K Project tests, several rockets of different types with scientific instrumentation packages were launched within minutes of each other from Kapustin Yar, the Baikonur Cosmodrome, and from the Saryshagan test range.

The map below is derived from a United Nations map of Kazakhstan (although, in order to use it here, I am required to state that the United Nations accepts no responsibility for anything on the map). The red circle on the left side of the map shows the Kapustin Yar launch site for all of the Soviet high-altitude tests. The missiles in the K Project were launched along the same path east-southeastward toward Saryshagan, and detonated in space during the descent phase of their trajectory.

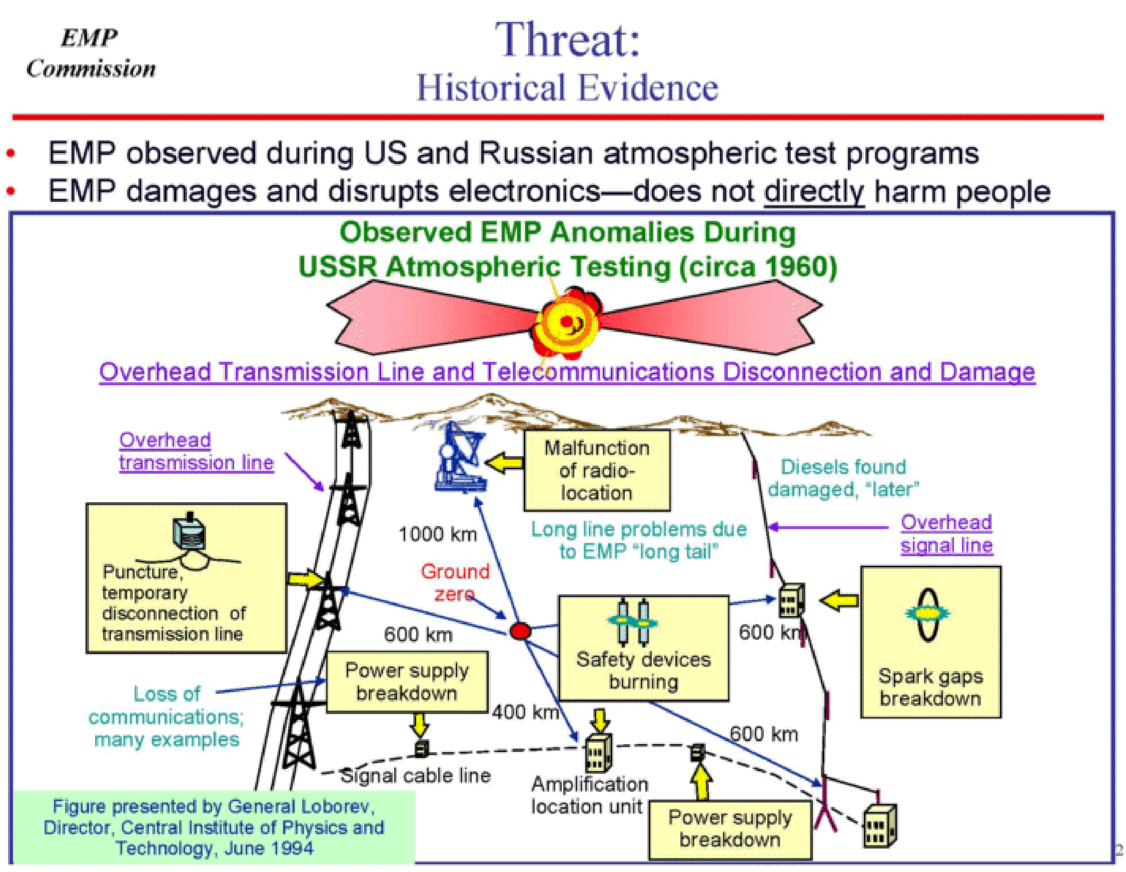
Test 184 was detonated at 290 kilometers above a point that was about 180 kilometers due west of Zhezqazghan (right at the **q** in the city's name on the map below (which is almost the exact center of the map). At an altitude of 290 kilometers above the detonation point in central Kazakhstan, the distance to the horizon would have been more than 1900 kilometers, which would have caused an electromagnetic pulse that covered all of Kazakhstan, with strongest effects near the south central region of Kazakhstan. The world's first spaceport, the Baikonur Cosmodrome, is about 300 kilometers (190 miles) to the southwest of the detonation point, and with the orientation of the geomagnetic field over Kazakhstan, the Baikonur Cosmodrome should have received some of the worst of the EMP effects, although nothing about this has been openly reported. (See the speculations at the bottom of this page for possible effects on the Soviet space program based on documented reports of subsequent spacecraft problems.)

The flight path for the warhead-carrying missiles in all of the K Project detonations is shown by the light blue line going from Kapustin Yar to Saryshagan on the map below. The Test 184 missile exploded west of Zhezqazghan, as scheduled, before completing its trajectory. Although nothing has been openly reported about the location of the other K Project detonations, Test 127 was probably detonated very close to the same point as Test 184. The other K Project detonations were probably along the light blue line between the Test 184 detonation point and Saryshagan, with the lower altitude detonations being closer to Saryshagan.

The illustration just below is a representation of some of the damage from Test 184 (K-3) that was used by the United States EMP Commission. It is essentially the same as Figure 2 in a paper delivered by Vladimir M. Loborev entitled "Up to Date State of the NEMP Problems and Topical Research Directions" at the 1994 EUROEM Conference. The paper is in the conference proceedings entitled **Electromagnetic Environments and Consequences: Proceedings of the European International Symposium on Electromagnetic Environments** Vol. 1, pages 15-21. May 30-June 3, 1994, Bordeaux, France. This conference was the first time that most people, outside of Soviet Defense scientists and engineers, had heard about the EMP problems experienced in Kazakhstan in 1962. These conference proceedings are not in most engineering libraries. I only know of about two engineering libraries in the United States that have this paper. This paper does not go into very much detail, though, beyond what is given in the illustration below, about damage to the civilian infrastructure in Kazakhstan. (In most cases, what the Soviets called a "power supply," we would call a power generating station. There are different words in Russian for "power supply" and "power generating station," but this distinction sometimes doesn't come through on the official translations.)

Many of the additions to Figure 2 in Loborev's paper, as shown in the illustration below, are based upon notes made by Dr. William Radasky of Metatech Corporation at the time of Vladimir Loborev's original oral presentation at the 1994 EUROEM Conference.

It is important to note that the illustration just below is a illustrative representation, and **not a map**. It does not accurately show the geographical directions to the indicated damage.



It was Test 184 that caused most of the problems with the civilian infrastructure in Kazakhstan. Other tests, though, apparently caused some problems -- such as those experienced with military diesel generators. The diesel generator problems usually occurred some time after the detonations due to dielectric breakdown in the generator windings. Loborev said, "The matter of this phenomenon is that the electrical puncture occurs at the weak point of a system. Next, the heat puncture is developed at that point, under the action of the power voltage; as a result, the electrical power source is put out of action very often."

Other known effects of Test 184 were that it knocked out a major 1000-kilometer (600-mile) underground power line running from Astana (then called Aqmola), now the capital city of Kazakhstan, toward the city of Almaty. Some fires were reported. In the city of Karaganda, the EMP started a fire in the city's electrical power plant, which was connected to the long underground power line. The shielded electrical cable was buried 3 feet (90 cm.) underground. (Most details about this underground line are very sketchy, and the reported length seems to be impossibly long for a single length of line carrying any kind of alternating current without some sort of re-generating station.)

The geomagnetic-storm-like E3 component of the EMP (also called MHD-EMP) can easily penetrate into the ground. The E3 component of the Test 184 detonation (caused by the movement of the Earth's magnetic field) began rising immediately after the detonation, but did not reach its peak until 20 seconds after the detonation. The E3 pulse then decayed over the next minute or so. The E3 component only affects equipment connected to long electrical conductors.

The E3 component of the EMP that caused the failure of the underground power cable was 1300 nT/min (nanotelsas per minute) in the Karaganda region during the first 20 seconds after the detonation. For comparison, the solar storm that shut down the entire power grid of Quebec on March 13, 1989 had a magnitude of 480 nT/min, and caused the Quebec power grid to go from normal operation to complete collapse in 92 seconds. Solar storms on other occasions have been known to produce disturbances of 2000 nT/min, and a solar storm on May 14-15 in 1921 produced a disturbance of 4800 nT/min.

If the United States W49 warhead used for the Starfish Prime test had been used in Test 184, the E3 component would have been more than 5000 nT/min in the Karaganda region. According to recent studies, a disturbance in the present-day United States of 4800 nT/min would likely damage about 365 large transformers in the U.S. power grid, and would leave about 40 percent of the U.S. population without electrical power for as long as 4 to 10 years due to the loss of large transformers that would have to be custom-built (many in other countries, especially if power was not available for the two U.S. plants that are able to make these transformers).

It is known from several sources that the EMP from Test 184 started a fire in the Karaganda power plant, but virtually no details have been released about this event. It has sometimes been stated that the power plant was completely destroyed, but the only thing I have found to substantiate this is a sentence in the official notes taken of a meeting between Russian scientists and U.S. scientists at the Lawrence Livermore National Laboratory in February 1995. One sentence in those notes about EMP damage is, "Destruction of the power supply at Karaganda." I have also not been able to find out if the damaged power plant was the only one operating in Karaganda at the time. Karaganda (spelled Qaraghandy on the map above) is a heavily industrialized city, and a center of the regional coal mining industry. It currently has several power plants in the area, but I don't know if there was more than one such facility in operation at the time of Test 184.

(If anyone reading this has knowledge about what Karaganda was like in 1962, and who remembers this event, and speaks English, please email me.)

Wikimapia has a clear satellite view of the main currently-operational Karagandy power plant.

(Remember that I sometimes use the name Karagandy or Qaraghandy because that is the official name of the city in the post-Soviet era. Most people still use the old Russian name of **Karaganda** for the city.)

The EMP from Test 184 also knocked out a major 570 kilometer long overhead telephone line by inducing currents of 1500 to 3400 amperes in the line. The line was separated into several sub-lines connected by repeater stations, each repeater station was 40 to 80 kilometers apart, with most being closer to 80 km. There were numerous gas-filled overvoltage protectors and fuses along the telephone line. **All** of the overvoltage protectors fired, and **all** of the fuses on the line were blown. This was examined in some detail in a paper in a prominent U.S. technical journal of the Institute of Electrical and Electronics Engineering (Greetsai, Vasily N., et.al. "Response of Long Lines to Nuclear High-Altitude Electromagnetic Pulse (HEMP)" *IEEE Transactions on Electromagnetic Compatibility*, Vol. 40, No. 4, November 1998). Although that article has a lot of interesting details about the EMP effects on the overhead communications line, it doesn't have as much detail as I would have like to have seen. Vladimir Loborev is one of Greetsai's co-authors in this paper. (The current level of 1500 to 3400 amperes was mentioned only in verbal reports by Russian scientists at scientific meetings in the U.S., and it was not mentioned in the IEEE report.)

The EMP from Test 184 also damaged radios at about 600 kilometers (360 miles) from the detonation and knocked out a radar about 1000 kilometers (600 miles) from the nuclear explosion.

According to Vasily Greetsai's IEEE paper about damage to a communications line, "The close end of the line was 180 km distant from the surface zero of the burst at an azimuth of 90 degrees and the far end was at a range of 650 km at an azimuth of 50 degrees. The aerial line included both steel and copper wires." The communications lines generally ran along railroad lines or highways, and from other material about the incident, it appears that the beginning of the well-studied communications line was at the city of Zhezqazghan. The far end of the that communications line was 650 kilometers to the northeast of the detonation point.

This information would put the detonation point for Test 184 at coordinates of 47.78 N, 65.329 E.

The far end of the line must have been about 100 kilometers north of Karaganda. There are approximations in the published information that make it impossible to know the exact location of the far end of the line. There are several possible end points that are about 100 kilometers north of Karaganda that would fit the published information pretty closely. (The roadway distance from Zhezqazghan to Karaganda is 474 kilometers.)

Unlike the U.S. high-altitude tests, there were scientists and engineers scattered across the affected area of the high-altitude test over Kazakhstan with equipment for measuring the EMP, and who apparently knew roughly what field strengths to expect. The Greetsai paper, mentioned earlier, states, "In 1962, the then Soviet Union conducted several high-altitude nuclear tests of great yield in Kazakhstan in the course of which were obtained vast facts on the damage levels from HEMP illuminating both military and civil systems."

Most of those "vast facts" are apparently still kept secretly at the Russian Federation Ministry of Defense at the Central Institute of Physics and Technology in Sergiev Posad, Russia. Only a tiny amount of those facts have been publicly released, but those facts have been extremely informative. Russia still leases some very large tracts of land from Kazakhstan. With one very minor exception, Russia has only released EMP damage data only over land that is currently controlled by Kazakhstan. Russia has not published any data on damage that was stated to have occurred in the area where the EMP field strengths would have been the highest during the K Project nuclear tests (which includes the area generally between the Baikonur Cosmodrome and Saryshagan).

The Soviet Defense technologists did not pay any attention to most of the communications lines in Kazakhstan, but a few were carefully studied. The fuses in the communications lines were one ampere fuses of type SN-1. The E1 component of the pulse was reported to have induced currents of 1500 to 3400 amperes in the line, but apparently this did not blow the fuses. This is consistent with my own personal experience with very short, but extremely high-current, pulses in ordinary fuses, and with the data published by major United States fuse manufacturers. An ordinary one ampere fuse will carry sub-millisecond pulses of thousands of amperes without blowing. It is heat that melts the fuse element, and very short pulses, even of extremely high current, do not have enough time to melt the fuse element. The SN-1 fuses used in Kazakhstan were rated to withstand 3600 amperes of a pulse with 5 microsecond rise time and a 10 microsecond fall time. The current pulse induced by the E1 component of the EMP would probably have been much shorter than this.

(The induced current pulse is generally significantly slower than the E1 electric field. For example, the E1 EMP from the 1962 U.S. Starfish Prime test was slowed sufficiently by transformers in the streetlight system in Honolulu that it blew several fairly slowly reacting fuses in the Hawaiian streetlight system, although the E1 electric field pulse lasted less than a microsecond. The E3 component of the Starfish Prime EMP had no reported effect on the Hawaiian power grid because the lines were too short.)

After an extremely short pulse of a very high current in a small fuse, you get a phenomenon known as a *fatigued fuse*, where the straight element of the fuse sags or appears twisted, but is not blown.

The SN-1 fuses were apparently blown by the solar-storm like E3 component of the pulse, which induced currents of 4 amperes on the sub-lines, and which lasted until all of the fuses blew. The slow E3 pulse did not reach its peak until 20 seconds after the detonation.

The current levels of 1500 to 3400 amperes were estimated by examining the gas-filled overvoltage protectors, along with actual field measurements in the general area. The overvoltage protectors were type R-350, with a nominal breakdown rating of 350 volts, however the breakdown voltage for pulse rise times of 2 microseconds is 750 volts. The E1 component of the pulse would have been much faster, and pulses of this speed are not rated with this overvoltage protector. The overvoltage protectors were examined by Soviet scientists, along with with other data and the known characteristics of the line, who estimated that currents in the measured sub-lines were 1500 to 3400 amperes. Computed voltages on the line induced by the EMP were as high as 28,000 volts.

It is clear from the data that has been released on the E1 component of the pulse that the thermonuclear weapon used in Test 184 was particularly inefficient in producing EMP. In all thermonuclear weapons, pre-ionization of the upper atmosphere from the gamma radiation of the first stage of the weapon limits the peak electric field generated by the final burst of energy; and it appears that the peak electric field produced by Test 184 was not much more than 10 kilovolts per meter over any point in Kazakhstan. **If the weapon had been a simple single-stage pure fission weapon of the same yield, the fast E1 component of the pulse would have been 3 to 5 times the intensity.** (Even the W49 thermonuclear warhead used in U.S. Starfish Prime test would have yielded a fast E1 component that was more than twice the intensity of Test 184 at that location.)

The radar and the radios that were damaged in Test 184 were probably all vacuum tube equipment. Other than small consumer transistor radios (which were usually made in Japan during this time and used germanium transistors), the only solid-state devices that were commonly used in 1962 were selenium rectifiers in radio power supplies. The Soviet Union always had difficulty in manufacturing silicon solid-state devices due to their inability to achieve sufficiently accurate temperature control during the fabrication process. Even today, Russia is the leading country in the manufacture of vacuum tubes, with Svetlana tubes of St. Petersburg, Russia claiming to be the largest manufacturer of vacuum tubes in the world.

Although vacuum tubes are highly resistant to EMP damage, many other components in radio and radar equipment using vacuum tubes can be damaged by EMP.

Published reports, including the 1998 IEEE article by Greetsai and others, have stated that there were significant problems with ceramic insulators on overhead electrical power lines during the tests of the K Project. In 2010, a technical report written for a United States government laboratory (Oak Ridge National Laboratory) stated, **"Power line insulators were damaged, resulting in a short circuit on the line and some lines detaching from the poles and falling to the ground."**

One of the stated purposes of the K Project was to obtain more data on the optical dangers of the flash from high-altitude nuclear tests. Most of the United States high-altitude tests were done during the nighttime, but most of the Soviet high-altitude tests were done during the day. A few days after Test 184, two U.S. military personnel sustained a certain amount of permanent retinal damage during the nighttime *Bluegill Triple Prime* high-altitude test over Johnston Island. Tests done during the daytime are much less likely to cause optical damage because the human iris is naturally adjusted to let in much less light. It was quite cloudy over central Kazakhstan during daytime periods of Test 184 and Test 187. Much better optical observations could be made during Test 195. It was determined that, for these 300-kiloton explosions at altitudes of 60 kilometers or greater during the daytime, there is no danger to the the human eye outside of a radius of 60 kilometers of the corresponding "ground-zero" point. During nighttime, however, it was estimated that the radius of optical danger to the human eye from a relatively low high-altitude test such as Test 195 would have been out to 300 kilometers.

As can be seen from the map, there are many long railway tracks in the EMP affected area in Kazakhstan. I have never seen any mention of whether currents in the rails were ever measured. The rail tracks are usually grounded at various points for lightning protection, but this would have been irrelevant for currents induced by the E3 component of the pulse since the rails would be much better conductors than the ground below. The grounding would also have had only a little relevance for currents induced by the fast E1 component. The ground conductivity in Kazakhstan is similar to the ground conductivity in much of the United States.

I don't have any information about how the rails of Kazakhstan at the time were constructed. It is likely that, as in most industrialized countries of the era, the rails were 20-meter long sections connected by fishplates (also called *joint bars*). This type of rail connection would have limited the current levels that would have been induced by the EMP, since the fishplates, and especially the attachments to the fishplates, would not be very good electrical conductors for high currents (as compared to the rails). Modern welded rails would provide much better long conductors of large electrical currents. The voltages on long conductors generated by severe solar storms or the E3 component of nuclear EMP is generally in the range of 5 to 30 volts per mile, so extremely large currents could be induced in welded rails that are hundreds of miles long.

Scientific reports have stated that currents of several hundred amperes can be induced in long underground or above-ground metal pipelines.

Original CIA evaluation of the Soviet high-altitude tests:

Most of the old United States CIA National Intelligence Estimates from the Soviet era have since been de-classified. Two relevant pages from the CIA National Intelligence Estimate dated July 2, 1963 are now available at this site. We now know that the initial guesses made by the United States about the weapon yields of the Soviet high-altitude tests were wrong. In the case of Test 195, it was not even close since the United States estimate was 1.8 megatons (1800 kilotons) instead of its actual yield of 300 kilotons. Weapon yields can be difficult to estimate, though, even when you have instruments near the test site. This was in the darkest days of the Cold War with the Soviets doing everything possible to conceal information about the tests (and also using 1962 detection technology).

The United States originally did not know the names that the Soviets gave to most of their tests, so the United States assigned JOE numbers to all of the Soviet tests (named after Joseph Stalin). So Test 184 was originally known in the United States as JOE-157. Test 187 was called JOE-160, and Test 195 was called JOE-168. Although the weapon yields were wrong, it is likely that most of the other information in the National Intelligence Estimate was correct.

The results of the Soviet high-altitude tests of 1962 were monitored by both the Soviet Cosmos XI satellite and (unexpectedly) by the United States Explorer XV satellite. A primary purpose of the U.S. Explorer XV satellite was to study the artificial radiation belt resulting from the earlier (July 9) U.S. Starfish Prime high-altitude test, but Explorer XV found more radiation belts than expected. According to NASA Technical Note D-2402, "The Effects of High Altitude Explosions" by Wilmont N. Hess, "On October 27, 1962, NASA launched the Explorer XV satellite to study the artificial radiation belt. But before it got in the air there were two artificial belts, and by the time it was up for a day there was a third belt. The Soviets conducted high altitude explosions on October 22 and 28 and then a third one on November 1."

An observer is quoted in the Russian space publication Novosti Kosmonavtiki about the experience of waiting to watch the *Mars 1* launch on November 1, 1962 from near the Baikonur Cosmodrome. It is described as a clear, cold day with a blustery northern wind. In the afternoon, he went into his house to check that his radio receiver was working properly, then went back outside. At 14:15 (2:15 in the afternoon, although official documents give the time as 12 minutes after the hour), suddenly a second sun appeared briefly in the northeastern sky. The flash of the second sun only lasted a second. He rushed back inside his house to check his radio receiver, but there was nothing but silence on all bands for nearly an hour. Finally, the reception returned to normal, and the Mars 1 probe was launched at 19:14 (7:14 p.m.) that evening. (Although the launch of the Mars probe was successful, communications with the probe was lost. The "second sun" was the flash of nuclear test number 195 (K-5), which detonated about 500 kilometers to the northeast of observer quoted in Novosti Kosmonavtiki.)

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*The text above describes aspects of the Soviet high-altitude tests that are based on documented facts. (See the references at the bottom of this page.) The aspects of the Soviet space program described below are also factual, but their connection to the EMP from the 1962 high-altitude tests is **my own speculation**.*

As mentioned earlier, since the K Project high-altitude tests were done so close to the Baikonur Cosmodrome, the launch site for nearly all of the Soviet civilian space flights, including Sputnik 1 and Yuri Gargarin's first manned spaceflight, that I have often wondered if the EMP from the Soviet tests in 1962 did any harm to the spaceflight operations at the Baikonur Cosmodrome. Although I've never found a conclusive answer to this question, and **the following comments are my own speculation**, Soviet space missions did begin experiencing an unusual level of difficulties beginning in mid-October, 1962. Although connection of the technical problems with the space missions and the nuclear EMP is my own speculation, the quotations from NASA, as shown below, about these space missions are unedited factual statements taken from NASA web sites, principally from the NASA National Space Science Data Center.

Also, there was an unusually long period of months without any manned missions after the Soviet EMP tests. The next Soviet human spaceflights after the October, 1962 tests did not occur until the successful dual spaceflights of Valery Bykovsky (Vostok 5) on June 14, 1963 and Valentina Tereshkova (Vostok 6) on June 16, 1963. There have been longer gaps between Soviet manned spaceflights, and there are other possible reasons for the long delay before Vostok 5. Still, the overall pattern of spaceflight delays and failures points to possible EMP problems at Baikonur. The October 22 and October 28 tests must have delivered a large EMP at the Baikonur Cosmodrome. The 1962 Starfish Prime EMP in Hawaii would have been small in comparison, except out over the open ocean. Even the November 1 test (K-5, Test 195) probably delivered a rather large EMP at the Baikonur Cosmodrome.

According to NASA, a unmanned Mars mission launched from Kazakhstan at 17:55:04 UTC on October 24, 1962, designated Sputnik 22, was the first of a series of failures in unmanned launches from the Baikonur Cosmodrome in Kazakhstan.

NASA states, "Sputnik 22 was an attempted Mars flyby mission, presumably similar to the Mars 1 mission launched 8 days later. The intended Mars probe had a mass of 893.5 kg. The spacecraft and attached upper stage, with a total mass of 6500 kg, were launched by an SL-6 into a 180 x 485 km Earth parking orbit with an inclination of 64.9 degrees and either broke up as they were going into Earth orbit or had the upper stage explode in orbit during the burn to put the spacecraft into Mars trajectory. In either case, the spacecraft broke into many pieces, some of which apparently remained in Earth orbit for a few days. (This occurred during the Cuban missile crisis. The debris was detected by the U.S. Ballistic Missile Early Warning System radar in Alaska and was momentarily feared to be the start of a Soviet nuclear ICBM attack.)"

On November 1, 1962, the Mars 1 probe was launched from the Baikonur Cosmodrome. According to NASA, "On 21 March 1963, when the spacecraft was at a distance of 106,760,000 km from Earth on its way to Mars communications ceased, probably due to failure of the spacecraft orientation system." (See the note below about an observer watching nuclear test number 195 from near the Baikonur Cosmodrome on the day of the Mars 1 launch.)

On November 4, 1962, Sputnik 24, another Mars probe, was launched from the Baikonur Cosmodrome. According to NASA, "The complex broke up during the burn to transfer to Mars trajectory. Five large pieces were tracked by the U.S. Ballistic Missile Early Warning System. The geocentric orbit of the presumed booster decayed on 25 December 1962 and the Mars spacecraft orbit decayed and it re-entered Earth's atmosphere on 19 January 1963."

On November 9, 1962, seven previously planned Vostok manned spaceflights (Vostok 7 through Vostok 13) were abruptly cancelled. Although there is no evidence that the reasons for the cancellation of these 7 major space missions were related to any Baikonur EMP damage, the cancellation did occur just after the EMP testing, and the reason for the abrupt cancellation of seven planned spaceflights was never explained.

Successful spy satellite launch on December 22, 1962: NASA says, "Cosmos 12 was a Soviet surveillance satellite launched from Baikonur aboard a Vostok rocket. The capsule was recovered after 8 days." (This was the only successful launch from Baikonur during the two months after the 1962 Soviet EMP tests.)

Sputnik 25 was launched on January 4, 1963 from Baikonur Cosmodrome. NASA says, "The spacecraft was injected into Earth orbit successfully by the SL-6/A-2-e launcher but failed to escape orbit for its trip to the Moon. Its orbit decayed on 5 January 1963 after one day."

Subsequent launches from the Baikonur Cosmodrome returned to a fairly good level of success.

Web References (in Russian):

The Bear Book: **The Nuclear Tests of the U.S.S.R**., Volume 2, Section on High-Altitude Tests. (V.N. Mikhailov, Editor-in-Chief, Institute of Strategic Stability, Rosatom.)

The Kapustin Yar Reference

Novosti Kosmonavtiki, No. 236, (2002), (News of cosmonautics).

For viewing the above references in Russian, I suggest using the **Google Chrome** web browser, which has a built-in translator function. These encyclopedic articles above are written with generally correct grammar, therefore modern electronic translators work quite well.

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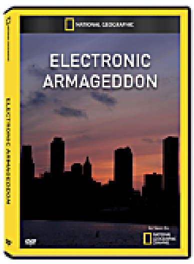

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