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The Soviet Atomic Energy Program

Submitted by the

DIRECTOR OF CENTRAL INTELLIGENCE

Concurred in by the

UNITED STATES INTELLIGENCE BOARD

As indicated overleaf

19 MAY 1965

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The following intelligence organizations participated in the preparation of this estimate:

The Central Intelligence Agency and the intelligence organizations of the Departments of State, Defense, AEC, and NSA.

Concurring:

Director of Intelligence and Research, Department of State

Director, Defense Intelligence Agency

The Atomic Energy Commission Representative to the USIB

Director of the National Security Agency

Abstaining:

The Assistant to the Director, Federal Bureau of Investigation, the subject being outside of his jurisdiction.

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THE SOVIET ATOMIC ENERGY PROGRAM

THE PROBLEM

To estimate the current status and probable future course of the Soviet atomic energy program over the next five to ten years.

CONCLUSIONS

A. In a nuclear test program of more than 15 years duration, the USSR has developed nuclear weapons in a variety of designs and sizes which we believe have yields ranging from fractions of a kiloton up to 100 megatons. Soviet weapons technology has differed from that of the US in certain respects. In thermonuclear weapons, the Soviets have emphasized the development of multimegaton devices rather than relatively small, lightweight lower yield weapons, and have achieved high thermonuclear performance in the multimegaton range. (*Paras. 10-14*)

B. In fission weapons the Soviet program has been directed toward development of reliable, efficient, and economical devices. Our evidence is insufficient to determine whether the Soviets decided not to pursue development of lightweight fission weapons or whether the apparent lack of development in this area is because of our failure to detect the evidence of such a program. However, there have been a number of Soviet tests on which we have little or no data and the Soviets have probably developed and stockpiled a number of fission weapons which we have not identified. (*Paras. 16, 17*)

C. We have detected 11 Soviet underground tests since the test ban treaty took effect in 1963. We believe that most of these were related to thermonuclear rather than fission weapons, possibly directed toward development of [redacted] Analysis of one test which vented indicates that the test device was a relatively clean design with a yield of about 250 KT. Considered in the light of other evidence, this may indicate the existence of a Soviet program to develop clean thermonuclear explosives for both military and peaceful uses. The rate of underground testing detected to date does not indicate that the Soviets have made an extensive effort to improve their fission weapon technology. (*Paras. 15, 18*)

D. The Soviets are continuing an active weapon development program which is almost certainly creating new test requirements. This, together with the active US program of underground testing is probably generating considerable pressures for a vigorous test program. The pace of Soviet underground testing will probably increase. However, we do not believe that research, development, and military requirements will become so pressing as to cause the Soviets to withdraw from the treaty in the near term. (*Para. 26*)

E. In thermonuclear weapon technology, an area in which the Soviets could make significant advances—the submegaton and low megaton yield range—is susceptible to improvement by underground testing. Future improvement in fission devices could be in the direction of further development of small diameter [redacted] warheads. The Soviets could also obtain a limited amount of data on weapons effects by underground testing, but one of their strongest requirements in this area—effects data on high-altitude nuclear explosions—could be met only by atmospheric testing. (*Paras. 27-31*)

F. The Soviets are continuing to expand their facilities for the production of fissionable materials. Our estimates indicate that by 1975 Soviet [redacted] U-235 production will increase by more than one-third, resulting in nearly a four-fold increase in cumulative production by that date. These estimates are subject to wide margins of error. Nevertheless, a significant expansion of these facilities has continued despite Khrushchev's statement to the contrary in April 1964.[1] (*Paras. 1-9, Tables I and II*)

G. In industrial and military applications of power and propulsion reactors, the Soviet program has been characterized by certain technological weaknesses. Inadequate developmental testing has tended

[1] For the views of the Assistant Chief of Naval Operations (Intelligence), Department of the Navy, see the footnote to paragraph 4, page 5.

[redacted]

to degrade operational reliability, chemical engineering has lagged, and capabilities in stainless steel technology has been notably weak. As a result, the Soviets encountered major problems with their first marine propulsion system. This system has been considerably modified and improved and probably will give satisfactory performance in the newer ships and submarines. But the Soviets are still several years behind the US in marine propulsion technology. Technological difficulties, together with economic constraints, have also slowed the Soviet nuclear electric power program. The Soviets are now embarked upon a program of expansion which incorporates many of the power reactor concepts under development in the West, but we doubt that they will achieve their planned expansion to a 2,000 megawatt generating capacity by 1970. (*Paras. 34-40*)

H. Soviet research reactors appear to be adequate in quality and quantity to meet the needs of the atomic energy program, although nuclear research has probably been hampered somewhat by deficiencies in instrumentation and by the limited availability of large fast computers. Reactor research seems directed toward power and propulsion application with emphasis on containment materials, coolants, moderators, and fuels capable of withstanding high irradiation levels and temperatures. (*Paras. 32, 33*)

I. More advanced research in thermoelectricity and thermionics will probably find application in space power supplies, which will eventually permit the use of electric propulsion systems in space. The Soviet program of research on controlled thermonuclear reactions is the world's largest, and Soviet scientists have made major advances in plasma physics. We do not believe, however, that the USSR will achieve a controlled fusion reactor in the next ten years. (*Paras. 43-46*)

DISCUSSION

I. SOVIET PRODUCTION OF NUCLEAR MATERIALS

Uranium Ore and Feed Materials

1. For a number of years, our evidence has indicated that Soviet procurement of uranium ore and concentrates has exceeded the amounts believed to be required by the atomic energy program. But as the result of continued expansion of fissionable materials production, requirements may be rising to a level approaching our estimates of ore procurement. We estimate that, in terms of equivalent uranium metal, total procurement of ore and concentrates had exceeded 200,000 tons by the end of 1964, and that the current procurement rate is over 20,000 tons per year. More than half of this comes from Eastern Europe, East Germany being the major supplier. During 1964, there was probably some expansion of mining and processing facilities within the USSR and in a few of the East European countries.

2. We have identified three facilities for the production of uranium metal and other feed materials: at Elektrostal, near Moscow; at Glazov, just west of the Urals; and at Novosibirsk. These installations probably have sufficient capacity to have processed the ore and concentrates procured by the USSR. We believe that the Soviets have ample uranium metal production capacity to meet their estimated needs over the next ten years. Supplies of other materials essential to the Soviet weapons and reactor programs also appear adequate.

U-235 Production

3. The Soviet capacity for U-235 production has grown steadily since the inception of the program. There are now four large gaseous diffusion complexes in operation: Verkh-Neyvinsk in the Urals, Tomsk in western Siberia, and Angarsk and Zaozerniy in central Siberia. Annual production capacity probably now totals about 42,000 kgs., and we believe that expansion and modernization of production facilities is continuing. Thus, toward the end of the decade, total annual capacity will probably increase to about 57,000 kgs. (These figures are all in terms of production of uranium enriched to 93 percent U-235 content.) Our estimates of total cumulative production through 1975 (Table I) assume that all plants are run at full capacity.

4. Estimated production capacities of Soviet gaseous diffusion plants are based primarily upon estimates of electric power usage and of plant efficiencies. We consider the estimates of electric power inputs for production to date to be reasonably accurate, but considerable uncertainty attaches to the estimates of plant efficiencies. Our judgments on the latter have, in large measure, been extrapolated from information provided by German returnees in the early 1950s.

Plutonium-Equivalent Production

5. There are three plutonium production complexes in the USSR located at Kyshtym in the Urals and near Tomsk and Krasnoyarsk in central Siberia.

6. The Soviets have continued to expand plutonium production facilities even though Khrushchev in April 1964 indicated that such expansion would be curtailed. We believe that there are two large new reactors under construction at Tomsk which will become operational in the 1967-1968 period. In addition, other new production and processing facilities will probably be brought in within the next few years.

Fissionable Materials Available for Weapons Use

7. The principal non-weapons use for fissionable material is as fuel for reactors, but the quantities involved are relatively small. We believe that use of

[2] The Assistant Chief of Naval Operations (Intelligence), Department of the Navy, believes with respect to cumulative U-235 production that there is insufficient evidence to support the production efficiency which would be required by the figures in the estimate. Moreover, in order to arrive at such production figures, he would have to postulate, without supporting evidence, Soviet employment of axial-flow compressors and a new improved barrier in gaseous diffusion plants. His figures are therefore lower. He estimates the total cumulative Soviet production of U-235 as of mid-1965 to be between 100,000 and 200,000 kilograms, with the most probable value about 150,000 kilograms. Even this value assumes incorporation by the Soviets of all possible improvements within the gaseous diffusion technology that is known to have been employed, but excludes the employment of axial flow compressors and new improved barriers.

[3] This term includes both plutonium and tritium (with twelve grams of tritium equivalent to one kg. of plutonium). We have no evidence as to the proportion of plutonium-equivalent production represented by tritium.

U-235 in propulsion, power, and research reactors has involved less than five percent of cumulative production to date. The only significant non-weapons use that we can foresee for plutonium is in fast breeder reactors, but the Soviets apparently plan, at least initially, to use U-235 for this purpose. Future non-weapons use of U-235 will grow considerably, primarily as the result of an expected increase in the nuclear submarine force, but it is likely to remain a small fraction of cumulative production.

8. Other quantities of fissionable materials which are in pipeline or which are in weapons withdrawn from stockpile for quality control or reworking are not considered available for weapons use. In estimating the fissionable material available for weapons use, we have assumed that about 10 percent of total cumulative production will be involved in pipeline, reworking, and quality control checks at any given time.

9. We cannot determine whether the estimated rates of production of plutonium and U-235 are in a ratio compatible with Soviet military requirements.

TABLE I

ESTIMATED FISSIONABLE MATERIALS PRODUCTION
Mid-1962 to Mid-1975

(Cumulative Production in Kilograms)

MID-YEAR	U-235 [a] [b]	PLUTONIUM EQUIVALENT [c]
1962	93,000	[redacted]
1963	123,000	
1964	158,000	
1965	200,000	
1966	246,000	
1967	297,000	
1968	350,000	
1969	406,000	
1970	463,000	
1971	521,000	
1972	578,000	
1973	636,000	
1974	693,000	
1975	750,000	

[a] In terms of uranium enriched to 93 percent U-235 content. As noted in paragraph 4, these estimates involve wide margins of error [redacted]

[b] The Assistant Chief of Naval Operations (Intelligence), Department of the Navy, believes there is a lower total amount of U-235 (see footnote to paragraph 4, page 5).

[c] Includes both plutonium and tritium (1 kilogram of Pu is equivalent to 12 grams of tritium). [redacted]

TABLE II

FISSIONABLE MATERIAL ESTIMATED AVAILABLE FOR WEAPONS USE

Mid-1962 to Mid-1975 [a]

(Cumulative Totals in Kilograms)

Mid-Year	U-235 [b, c]	Plutonium Equivalent [d]
1962	79,000	[redacted]
1963	105,700	
1964	137,200	
1965	170,000	
1966	211,000	
1967	257,000	
1968	305,000	
1969	355,000	
1970	402,000	
1971	454,000	
1972	505,000	
1973	557,000	
1974	604,000	
1975	655,000	

[a] These estimates are based on estimated cumulative production (Table I); they take account of the non-weapons uses of fissionable materials and of the quantities of materials involved in pipeline, in reworking, and in quality control checks (see Paras. 7-8).

[b] In terms of uranium enriched to 93 percent U-235 content.

[c] The Assistant Chief of Naval Operations (Intelligence), Department of the Navy, believes that there is a lower total amount of U-235 (see footnote to paragraph 4). For the amount of U-235 available for weapons use for mid-1965, for example, he would use a base of 150,000 kilograms and apply the 15% factor for non-weapons use, thereby arriving at a figure of 127,000 kilograms.

[d] Includes both plutonium and tritium (one kilogram of Pu is equivalent to 12 grams of tritium).

The current expansion of production facilities indicates that, in the Soviet view, present production of both materials is inadequate. In our estimates of future production, the present ratio is substantially unchanged, but considering the uncertainties involved in those projections, the actual ratio several years hence may be significantly different.

II. THE NUCLEAR WEAPONS PROGRAM

Nuclear Weapons Development

10. From 1949 to the signing of the test ban treaty in 1963, the USAEDS detected 186 Soviet nuclear tests, most of which were conducted at the Semipalatinsk and Novaya Zemlya proving grounds. The devices used in about 20 percent of these tests could not be analyzed. [redacted] In addition to those tests which were detected, we believe that there were a number of tests in the 1949-1963 period which [redacted]

[redacted]

[redacted] Since the signing of the treaty, 11 probable underground nuclear explosions have been detected in the USSR. [redacted] Our estimates of Soviet nuclear weapon technology, therefore, are based almost entirely upon analysis of the tests through 1962 [redacted] and upon extrapolation from that analysis.

Thermonuclear Weapons

11. Between August 1953, when the Soviets detonated their first thermonuclear device, and the end of 1962, about 75 thermonuclear tests were detected. The devices tested ranged in yield from about 150 KT to 55 MT. Their performance demonstrated that the Soviets had developed a highly competent thermonuclear weapon technology, which in some areas differs from that of the US. The Soviets have emphasized the development of multimegaton devices rather than small, lightweight, submegaton weapons, and have achieved high thermonuclear performance in the multimegaton class.

12. [redacted]

13. In the 1961-1962 tests, the Soviets tested devices in the 3-6 MT range, and in yields of about 12, 18, and 24 MT. In addition, the Soviets conducted two tests at even higher yields of clean thermonuclear designs. The highly publicized 100 MT weapon would probably be a larger version of the device tested at 55 MT.

14. [redacted]

15. *Thermonuclear Device Development, 1963-1965.* Since the test ban took effect, [redacted] 15 January 1965. [redacted] test device, which was a relatively clean design with a yield of about 250 KT. We do not believe that this test involved a stockpile weapon or a device which had been previously

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This estimated yield assumes that the tested device was fully tamped in granite. If the device was de-coupled the actual yield would have been greater.

tested. When considered in the light of at least three earlier clean tests, this test may indicate the existence of a program to develop clean thermonuclear explosives with a variety of yields for both military and peaceful uses.

Fission Weapon Development

16. By the end of 1962, the Soviets had developed fission weapons encompassing a variety of yields and their program appears to have been directed toward reliable, efficient and economical devices; considerations of size and weight have evidently been secondary. There are gaps in our knowledge of the Soviet development program. We do not know whether the Soviets decided not to pursue certain lines of development or whether our lack of information is attributable to our failure to detect a number of Soviet tests. [redacted] A significant gap in our knowledge is in the area of small, lightweight fission weapons. We believe that the Soviets have developed and stockpiled a number of fission devices which we have not identified.

17. The 1961-1962 test series provided the Soviets with improved fission weapon capabilities. Significant improvements, embodying reductions in size and diameter were apparent. Some devices resembled others tested earlier, indicating they may have been proof tests of weaponized nuclear systems. [redacted]

18. *Fission Device Development 1963-1965.* Only four tests detected after 1962 have been at yields of 10 KT or less. Two of these, conducted at Novaya Zemlya, were probably not related to weapon development. The other higher yield tests detected since 1962 were probably related to thermonuclear rather than to fission weapon development. Additional tests could have occurred [redacted] The rate of underground testing detected to date, however, does not indicate that the Soviets have made an extensive effort to improve their fission weapon technology since the test ban treaty took effect.

19. *Uncertainties in Fission Weapons Analyses.* The analyses of the Soviet fission weapon capability have been severely handicapped by uncertainties in yield measurements and [redacted]

20. [redacted]

[redacted]

Weapon Types in Stockpile

21. We have only limited direct evidence to indicate which thermonuclear and fission devices are stockpiled. We believe that the majority of the nuclear weapons in the current Soviet stockpile are based on designs subjected to prototype testing in 1958 or earlier.

Soviet Knowledge of Weapon Effects

22. Analysis of Soviet publications and classified effects manuals shows that they have acquired effects data of sufficient scope and quality on air, surface, underwater and underground bursts to be adequate for planning and executing most military operations. From a few airburst weapons in the yield range of 1-3 MT tested at Semipalatinsk in 1955-1957, the Soviets obtained direct information on the effects of high-yield weapons on emplaced military equipment and structures. Since September 1957, they have conducted a large number of airburst tests with yields up to 55 MT at Novaya Zemlya, from which they probably obtained measurements adequate to scale up the lower yield effects data obtained at Semipalatinsk.

23. In 1961 and 1962 the Soviets conducted seven nuclear tests at high altitudes. These tests ranged in yield from about one KT to 1.8 MT and in burst altitude from about 15 kilometers to 325 kilometers. Two of these events were probably vertical launches from the Kapustin Yar range-head; the others involved complex multiple-missile launchings from Kapustin Yar into the Sary Shagan area. Analysis of the multiple-missile tests indicates that they were directly related to development of an anti-missile system. We do not believe that they were designed to obtain information on nuclear kill mechanisms on nosecones under conditions of re-entry; rather, the location of the various missiles relative to the nuclear detonations suggests that they were intended primarily to obtain data on the effects of the fire-ball and nuclear debris cloud blackout on radar systems. The Soviets probably also collected data on other high-altitude nuclear effects, including some information applicable to nuclear kill mechanisms.

24. In the 1958-1959 period, the Soviets published unclassified articles which revealed some understanding of the electromagnetic pulse (EMP) phenomena produced by nuclear explosions. In their 1961-1962 test series, the Soviets may have instrumented a number of low-yield surface tests to measure the EMP effect on military systems and communications equipment. but it appears doubtful that their high yield tests were so instrumented.

25. Although the Soviets have published very little information on construction techniques to harden underground structures against ground shock, they are undoubtedly concerned about the vulnerability of their missile launch complexes to this effect. There is some evidence that the Soviets are interested in the cratering and throw-out phenomena for peaceful purposes as well as for military applications. and they have conducted a number of nuclear and chemi-

cal explosives tests which would have provided data on the effects of cratering explosions.

Future Weapon Development and Testing

26. The Soviets are continuing an active weapon development program. Their weapons laboratories have remained active and almost certainly are creating new test requirements. There are undoubtedly a variety of useful tests the Soviets could now conduct underground both for research and development and for military purposes. This fact together with the active program of US underground testing, (86 tests between 1 August 1963 and 15 May 1965 as compared to only 11 Soviet underground tests detected during the same period) is probably generating considerable pressures on the Soviet leadership for a vigorous test program, and we believe that the pace of Soviet underground testing will increase. However, we do not believe that research, development, and military requirements will become so pressing as to cause the Soviets to withdraw from the Limited Test Ban Treaty in the near term.

27. *Under Present Treaty Restrictions.* If the Soviets have a requirement for high performance submegaton thermonuclear weapons, a few tests at yields higher than those conducted to date would be required. Significant improvements in thermonuclear weapons having yields greater than a few megatons could probably not be achieved through underground testing. However, underground testing could provide information relating to higher yield weapons developments that could become useful if unrestricted testing were to be resumed.

28. In fission devices the Soviets may have a requirement for small diameter [redacted] warheads and if they have not already done so, they may pursue development of weapons in the sub-kiloton or low kiloton yield range.

29. With underground testing the Soviets could attain a limited amount of data on the effect of ground shock upon hardened underground structures, the effects of nuclear radiation upon materials or system components, and the [redacted]

30. *With Unrestricted Testing.* A resumption of unrestricted testing would enable the Soviets to fill gaps in their knowledge of weapons effects and improve their weapons technology. One of the strongest Soviet requirements for atmospheric testing is in the area of high-altitude effects of nuclear weapons. Previous Soviet high-altitude tests, while highly sophisticated in their missile involvement and probably well instrumented, lacked some of the characteristics of tests designed to give detailed information on warhead kill mechanisms and on communications-blackout effects. The Soviets also probably have a need for more information about the effects of ground shock and the electromagnetic pulse from high yield near-surface shots. [redacted]

31. *Under a Total Test Ban.* Even without nuclear testing, the Soviets could make some modest improvements in [redacted] However, the Soviets would be unlikely to stockpile designs that differed greatly from those tested in the past. Only a limited amount of nuclear weapon effects data could be acquired by non-nuclear experiments.

III. THE NUCLEAR REACTOR PROGRAM

Research and Test Reactors

32. Soviet research reactors are, in general, simple in concept, safe in operation, and relatively inexpensive. They are numerous enough to meet present and near future needs of the atomic energy program. The bulk of Soviet research reactors are variants of the same basic design utilizing water moderation. These reactors are used for a wide range of research in the fields of physics, chemistry, radio biology, and medicine. Soviet nuclear research, however, has probably been hampered by deficiencies in instrumentation and by the limited availability of large, fast computers.

33. The Soviets have constructed pulsed and fast neutron reactors of original design which have proved to be valuable research tools. However, in at least three areas—gas-cooled reactors, organic moderated reactors, and molten salt reactors—the Soviets are several years behind the West. The investigations at the known research reactor facilities seem directed at power and propulsion reactor development with emphasis on fuels capable of withstanding high burnup, containment materials, coolants, and moderating materials.

Reactor Engineering

34. In industrial and military applications of power and propulsion reactors, the Soviet program has been characterized by certain technological weaknesses. Inadequate developmental testing of components has tended to degrade operational reliability. Chemical engineering has lagged both in its fundamental and applied aspects; the problem of corrosion which has plagued the Soviet program has been due in large measure to inadequate chemical treatment of water. Soviet capabilities in welding and associated quality control are adequate to meet most requirements, but are far from uniform and have been notably weak in stainless steel technology.

Nuclear Electric Power

35. The Soviet nuclear power program announced in 1956 called for the generation of 2,000 megawatts of electricity by 1960. Progress toward this goal was very slow, however, and as a result of slow technological development and economic considerations, the plan has been revised several times. The Soviets are now implementing a nuclear power program which incorporates many of the power reactor concepts under development in the West. Emphasis has been given to the fast-breeder type, the pressure-tube superheat type, and pressurized-water type reactors. The Soviet program does not include the

sodium-cooled graphite-moderated reactor, the high temperature gas-cooled reactor, or the heavy-water moderated and cooled reactor. They are assisting Czechoslovakia in the design and construction of a hybrid of the latter two types, i.e., a carbon dioxide-cooled, heavy water-moderated reactor, but this project has experienced considerable delay.

36. *Future Plans for Electric Power.* The Soviets claimed that nuclear power generating capacity totaling more than 900 megawatts was in operation as of early 1965, but we believe that the actual figure was somewhat lower. If all current expansion plans were executed on schedule, the total generating capacity would be about 2,000 MWe by 1970. We have evidence, however, that the Soviets have encountered engineering problems and unexpectedly high costs in their nuclear power program, and we doubt that they will attain this capacity by 1970.

37. In mid-1964 construction began on a fast reactor with a capability of generating 350 megawatts of electric power (MWe). This reactor will be used for desalination of sea water and generation of electric power at Shevchenko on the eastern shore of the Caspian Sea. The Soviets claim that this nuclear unit for the desalination facility will be completed in 1969 and will permit a production of about 25 million gallons of water per day to supply the new city and petroleum enterprises now under construction there. The state of Soviet fast reactor technology is such that they probably will not be able to meet their construction deadline. Even so, they are conducting initial design studies for still larger fast reactors, including a very large reactor of 1,000 MWe, which will be cooled by super-critical steam. This type of reactor will probably not be developed before the mid-1970s.

Nuclear Reactors for Marine Propulsion

38. The Soviets encountered major problems with their first marine propulsion system incorporating a pressurized water reactor. Three such reactors were installed in the icebreaker Lenin which was plagued with difficulties, including corrosion of the zirconium-niobium cladding of the fuel elements, collection of corrosion products in the steam pressurizers, stress corrosion in the steam generators, and the need for additional shielding. Soviet nuclear-powered submarines constructed prior to 1963, which used a version of the Lenin propulsion system, evidently encountered similar problems.

39. These earlier nuclear-powered ships have undergone considerable modification, and subsequent improvements have almost certainly been incorporated in the nuclear submarines constructed in recent years. An improvement in performance and reliability of Soviet nuclear propulsion plants is indicated by the operations of the Lenin in the past two years and by some increase in the number of voyages by Soviet nuclear submarines away from home waters. The available evidence, however, indicates that the Soviets are still several years behind the US in marine nuclear propulsion technology.

40. The Soviets have indicated some interest in other types of reactors adaptable to marine propulsion such as liquid-metal cooled and gas cooled reactors, but they have apparently done little research and development in these areas. We believe that they will continue to use pressurized water reactors in their ships and submarines for the next several years. With some modification, such as the substitution of all stainless steel cladding for zirconium-niobium cladding, these should give satisfactory performance. The Soviet capability to fabricate reactors does not appear to be a limiting factor in the nuclear submarine construction program.

Air, Missile, and Space Applications

41. *Aircraft Nuclear Propulsion (ANP).* There is some evidence that in the early 1950s there may have been a program to develop a nuclear propelled aircraft. The Soviets have done research in areas, such as materials development, which could relate to an ANP program, but which would also be applicable to other problems. No installations concerned with an ANP program have been identified in the USSR, and there is no evidence that an experimental flying test bed has been constructed. We cannot exclude the possibility that the Soviets have an active program underway aimed at development of a nuclear powered aircraft, but we consider it unlikely. Research in relevant areas will probably continue, but, considering the cost and complexity of the task, we believe that it would be a number of years before the Soviets could achieve an operational nuclear powered aircraft.[5]

42. *Nuclear Rocket.* No Soviet nuclear rocket program has been identified to date. Research is underway on materials and technologies which would be applicable to such an advanced reactor system. We have, however, no evidence, such as construction of suitable test facilities, which would clearly point in this direction. We believe that, if the Soviets have an active development program underway, they could static test a nuclear rocket engine before the end of the decade.

43. *Nuclear Auxiliary Power Supplies.* The Soviets are conducting research fundamental to the development of nuclear auxiliary power supply systems for use in space. Soviet thermoelectric research and development has been at a high level of achievement for several years. This effort together with extensive

[5] The Assistant Chief of Staff, Intelligence, USAF, considers available evidence does not support a judgment that existence of an active Soviet ANP program is "unlikely." There are indications that an ANP program may have existed in the USSR *since* the early 1950s, although its status and scope are not known. Studies have been conducted in areas which could relate to such a program, including liquid metal coolants and their containment, and materials development. The known studies could apply to the direct or indirect-cycle principle for air-breathing vehicles. Within the presently estimated level of Soviet technology, a broad program for development of nuclear powered air-breathing vehicles, both aircraft and missiles could be undertaken. Concrete evidence of such a program is not available but detailed information is lacking on the content of much of the Soviet R&D program. The ACS/Intelligence, USAF, believes that if the program does exist, a militarily useful nuclear aircraft could become operational about 1970.

[ ]

semiconductor research indicates that the Soviets have a high priority program aimed at the production of thermoelectric power conversion systems using nuclear reactors and semiconductor thermoelectric elements. Soviet thermionic converter research and development has also been pursued on a broad basis and is probably now about on a level with that in the US.[6]

44. The Soviets have designed and constructed experimental radioisotope power supplies and nuclear reactor systems with thermoelectric and thermionic converters, but there is no evidence that they have built an operating system. In 1964 at Geneva, they displayed a model of a nuclear-reactor-thermoelectric converter system with a capacity of 500-800 watts. They could probably achieve an operational space power supply of this type in 2-3 years. We do not believe that they will have an operational thermionic generator before the end of this decade.

45. There is evidence that the Soviets are exploring the use of an indirect liquid sodium turbo-conversion system as a space nuclear power source. However, the Soviets would have to appreciably extend the temperature range of their liquid metal technology to take advantage of the greater efficiencies of a direct turbo-conversion system. On the basis of their previous experience, the Soviets could flight test an indirect turbo-conversion system by the end of the decade. With the advent of a high power nuclear power supply, either direct or indirect cycle, the Soviets would be capable of using electric propulsion systems for primary propulsion in space.

Other Advanced Research

46. *Controlled Thermonuclear Reaction.* The Soviet effort in controlled thermonuclear reactions (CTR) research and in plasma physics is the world's largest, and is continuing to expand. The high priority which the Soviets have attached to this program has attracted the top talent of the USSR. Soviet theoreticians are currently putting great emphasis upon the area of plasma turbulence, and probably have an excellent understanding of basic plasma phenomena. Developments in this field could have applications related to nuclear effects at high altitudes, high powered radars, and re-entry blackout, as well as to magnetohydrodynamic power generators. In the CTR program, the Soviets are actively exploring the possibility of producing an operational controlled fusion reactor. We do not believe, however, that they will achieve such a reactor in the next ten years.

47. *Magnetohydrodynamic (MHD) Power Conversion.*[7] The Soviets have also made a considerable effort in research on MHD systems. Open cycle MHD

[6] A thermoelectric generator of electricity is a conversion device which produces electricity directly from heat by using a temperature gradient to create a voltage difference across a semi-conducting thermoelectric element. A thermionic generator of electricity is a conversion device which produces electricity directly from heat by thermal emission of electrons from a cathode which, in streaming to an anode, produce an electric current.

[7] A technique for the conversion of heat to direct-current electricity by passing an ionized (and hence electrically conductive) gas through a magnetic field.

generators are being developed for use with conventional steam turbine generators, but some work is being done on the closed cycle type which could use a nuclear reactor heat source. We do not believe that the Soviets will develop such a closed cycle MHD system before 1970.

IV. INTERNATIONAL ACTIVITIES

48. The USSR has recently played a more cooperative role in the work of the International Atomic Energy Agency (IAEA) and regularly attends IAEA-sponsored conferences, meetings, and symposia. The quality of the staff supplied by the USSR to IAEA has improved; this is probably explained in part by the Soviet desire to enhance the quality of the scientific information they obtain. There has been a striking shift in the Soviet position on IAEA safeguards—a position that has moved from outright obstructionism to full approval both of the principle and the proposed IAEA safeguard system. However, the Soviets have not agreed to subject any of their nuclear installations to IAEA inspection.

49. The Soviets have concluded bilateral atomic energy arrangements with the United Arab Republic, Finland, Iraq, Indonesia, Ghana, India, Yugoslavia, and Afghanistan. They have given technical assistance and training to these countries in varying degrees, and in a few cases have provided research reactors, but they have provided no power reactors.

50. There have also been exchanges of scientific and technical delegations with a number of countries including the US, the UK, France, and others.

51. Only Communist China received Soviet aid toward the establishment of an independent nuclear program. This assistance, which was ended in 1960, apparently extended to all phases of the program including basic nuclear research, ore prospecting, mining and processing, fissionable materials production, and possibly planning for weapon testing. To other Communist countries the USSR has provided, under bilateral agreements, assistance in reactor construction, the exploration for and exploitation of uranium, the supply of laboratory equipment, and the training of students.

52. Apart from the special case of China, Soviet policy has been directed toward limiting and controlling the nuclear programs of other Communist countries. In 1960, the Standing Committee for the Peaceful Uses of Atomic Energy was created under the Council of Mutual Economic Aid (CEMA). The plan of this Committee was to have a single atomic energy program, with the allocation of a particular task to each member nation. In addition, the USSR established the Joint Institute for Nuclear Research, JINR, at Dubna. With the exception of Yugoslavia, all Asiatic and European Communist Countries are members of JINR and contribute proportionately towards its cost.

ANNEX

I. ORGANIZATION OF THE SOVIET ATOMIC ENERGY PROGRAM

1. The two principal organizations dealing with the Soviet atomic energy program are: The All-Union Ministry for Medium Machine Building (MSM) and the State Committee for the Utilization of Atomic Energy (GKAE). The MSM is responsible for the overall direction of the atomic energy program, including the production of fissionable materials and nuclear weapons. The GKAE is responsible for the non-military uses and industrial applications of the program, scientific research and development in certain areas of applied nuclear energy, and official contacts with the atomic energy programs of foreign countries.

2. The weapons research and development centers are probably under the administrative control of the MSM, but there is undoubtedly military participation at these centers. The nuclear weapons proving grounds and the national nuclear weapons stockpile are probably under military operational control, with technical direction provided by the MSM. The Ministry of Defense is believed to be solely responsible for operational and regional weapons storage facilities located at military bases for direct support of military operation.

3. The GKAE is concerned with nonmilitary applications of atomic energy within the USSR and also with cooperation between the USSR and other countries in the non-military uses of atomic energy. It is concerned with the production and supply of radioactive isotopes, the transportation of radioactive materials, and the problems of radioactive waste disposal. The GKAE controls and coordinates research and development of nuclear reactors and the associated technology, high-energy physics and its research devices (particle accelerators), and controlled thermonuclear research (plasma) and its equipment. Since 1960, the GKAE has gradually assumed administrative control over a dozen or more institutes of the Academies of Sciences which conduct research in these areas of nuclear energy. There is very close coordination between the MSM and the GKAE. The former appears to exercise some measure of control over the institutes of the latter. The interlocking relationship existing between the two atomic energy authorities is evident in the horizontal movement of personnel at all levels.

4. Although we believe that a Soviet PLOWSHARE[*] program exists, the responsible organization has not been identified. We would expect MSM to develop the devices and conduct the tests with some Ministry of Defense assistance. The GKAE is probably responsible for future applications of test results and for coordinating with other organizations.

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[*] A US term for the use of nuclear explosives for peaceful uses.

II. COMMAND AND CONTROL OF NUCLEAR WEAPONS

5. The Presidium of the Central Committee, CPSU, is the source of and the final authority for decisions on overall deployment and use of Soviet nuclear weapons. Classified Soviet documents indicated that Khrushchev would exercise command of the nuclear forces through the Supreme High Command. The present evidence is not sufficient to indicate whether the Presidium, or just its new Chairman, has assumed this role. The decisions of the Presidium and the Supreme High Command are implemented by the Ministry of Defense. The Ministry probably is responsible for the supervision of the organizations which run the storage and logistics systems for nuclear weapons. It also would implement high level decisions to release nuclear weapons to operational military units and to authorize the use of such weapons; the order to release and the authorization for use would probably be transmitted through separate channels. There is no indication in available evidence that the role of the KGB in the command and control systems for nuclear weapons is other than that of furnishing guards units to provide physical security at storage sites.

6. Nuclear weapons allocated to the ground forces are stored in Ministry of Defense depots, which in many cases are located at considerable distances from the operational units. When these units require nuclear weapons, the depots probably receive authorization for release of the weapons from the Ministry of Defense. A similar pattern of control probably exists for the air forces and for the Strategic Rocket Forces, although in these cases the operational storage facilities of the Ministry of Defense are part of the air base or of the missile launching complex. We have no information on the control of nuclear weapons in Soviet naval forces which probably have nuclear weapons on ships at sea as well as in shore storage.

7. [redacted] the USSR has been seriously concerned with the problem of improving its command and control procedures for nuclear weapons. An alert posture would require the Soviets to keep the bulk of their nuclear warheads allocated to Strategic Rocket Forces mated to the missiles, thereby forcing them to forego the use of one of the major means of control in the past—the concentration of nuclear weapons in storage sites under the control of the Ministry of Defense. There are at least three possible methods of control still available to the Soviets for use with these forces: an authentication system, assignment of KGB units to act as a check upon the military, or the installation of permissive links in the weapons to minimize the human problem. We have no evidence as to which, if any, of these methods are employed.

III. NUCLEAR WEAPONS PRODUCTION, STORAGE, AND LOGISTICS

8. We have identified two major nuclear weapon fabrication complexes, located at Nizhnaya Tura and Yuryuzan in the Urals. Each of these include large

nuclear weapons stockpile facilities. In addition, the Kasli R and D facility probably produces some nuclear weapon components, and there is a possible nuclear weapons or component fabrication installation near Penza.

9. The Soviet nuclear weapon logistic system includes two general classes of storage sites: national reserve stockpile facilities, and operational and regional storage sites at military bases in direct support of military operations. The Soviet stockpile program has developed in three well defined stages. Expansion has continued in each class of existing sites and addition of new sites has occurred. In its initial program between 1951 and 1955, the USSR activated a total of about six stockpile sites of all classes, indicating a fairly limited nuclear capability. In the second stage, covering approximately the next three years, at least 18 additional stockpile sites of all classes were activated bringing the total to about 24 at the end of 1958. This expansion was primarily in support of a substantial increase in the nuclear capability of the Soviet strategic bomber force which was then rapidly converting to jet aircraft. Since 1958, a third stage of rapidly accelerated construction has been evident. It has coincided with the deployment of strategic and tactical missiles and with a wider distribution of nuclear weapons among Soviet military forces. During this period the USSR also substantially increased the capacity of existing sites. As the result of these developments the USSR has a comprehensive system of hardened stockpile facilities extending back in successive echelons from forward operational storage sites at military bases to national reserve facilities at remote interior locations. We still have no firm evidence of nuclear warhead storage facilities outside the USSR in Eastern Europe, although persistent reports of the presence of nuclear weapons, particularly in East Germany, have been received. Such storage would be commensurate with the factors of stockpile growth, systems deployment, and readiness requirements.

10. The Soviet nuclear weapons logistic system appears to be largely dependent on rail movement. However, since 1959 they have shown an increasing interest in developing an air logistics system. Helicopter pads are provided at most of the storage sites, and helicopter transport to advanced positions of simulated nuclear weapons for tactical systems has occurred in Soviet military maneuvers.

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