~~TOP SECRET~~

NATIONAL INTELLIGENCE ESTIMATE

NUMBER 11-2A-56

THE SOVIET ATOMIC ENERGY PROGRAM

Submitted by the

DIRECTOR OF CENTRAL INTELLIGENCE

The following intelligence organizations participated in the preparation of this estimate: The Central Intelligence Agency and the intelligence organizations of the Departments of State, the Army, the Navy, the Air Force, The Joint Staff and the Atomic Energy Commission.

Concurred in by the

INTELLIGENCE ADVISORY COMMITTEE

on 5 September 1956. Concurring were the Special Assistant, Intelligence, Department of State; the Assistant Chief of Staff, Intelligence, Department of the Army; the Director of Naval Intelligence; the Director of Intelligence, USAF; the Deputy Director for Intelligence, The Joint Staff; and the Atomic Energy Commission Representative to the IAC. The Assistant Director, Federal Bureau of Investigation, abstained, the subject being outside of the jurisdiction of his Agency. See appropriate footnotes, however, for the dissenting views of the Director of Naval Intelligence and the Deputy Director for Intelligence, The Joint Staff.

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NATIONAL INTELLIGENCE ESTIMATE

JOINT ATOMIC ENERGY INTELLIGENCE COMMITTEE

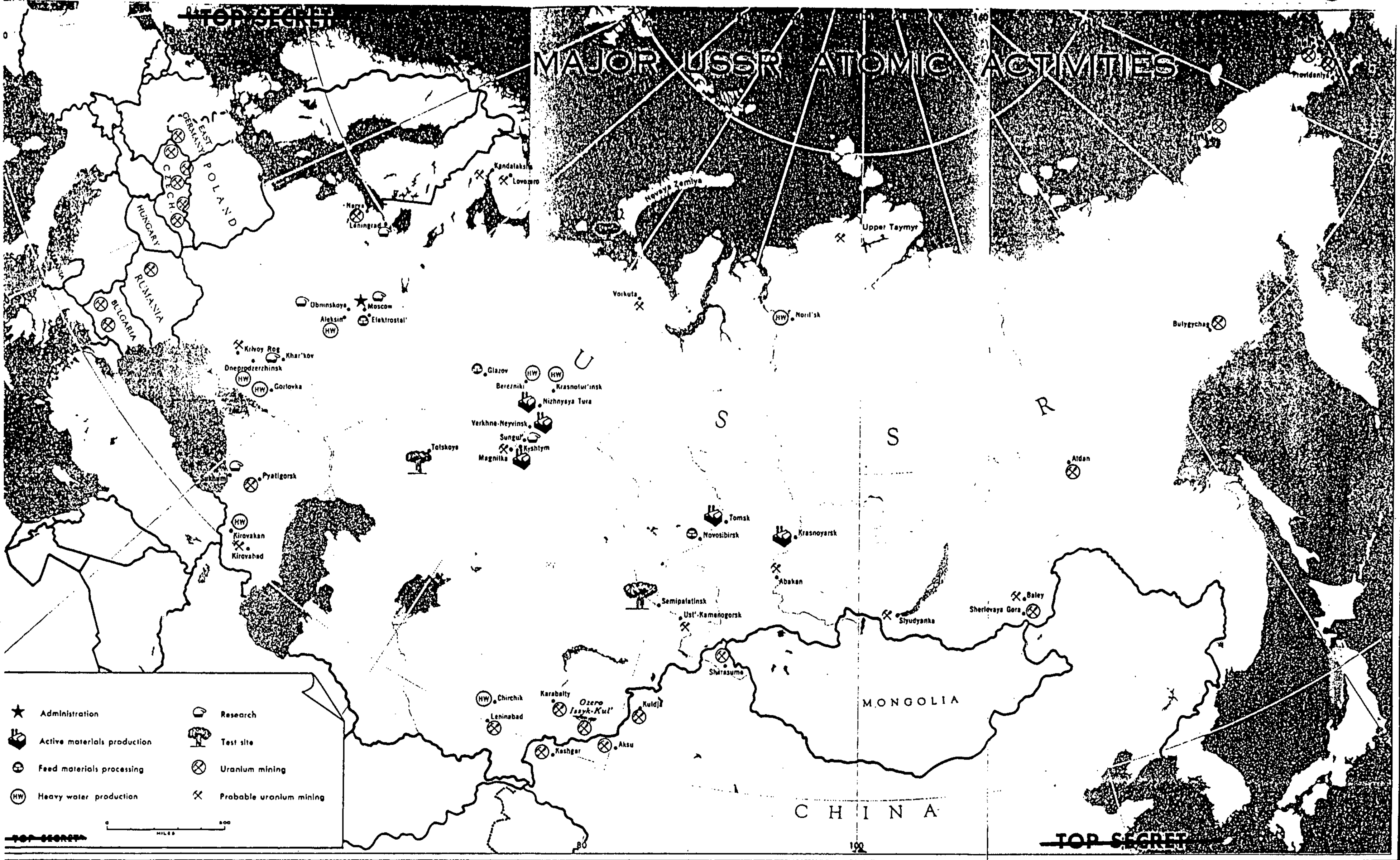
THE SOVIET ATOMIC ENERGY PROGRAM

NIE 11-2A-56

5 September 1956

This estimate was prepared and agreed upon by the Joint Atomic Energy Intelligence Committee, with footnotes by Navy and Joint Staff members, which is composed of representatives of the Departments of State, Army, Navy, Air Force, the Atomic Energy Commission, the Joint Staff and the Central Intelligence Agency. The FBI abstained, the subject being outside of its jurisdiction.

A group of expert consultants working with the Joint Atomic Energy Intelligence Committee have reviewed this estimate and generally concur with it. The estimate, with footnotes, was approved by the Intelligence Advisory Committee on 5 September 1956.



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THE SOVIET ATOMIC ENERGY PROGRAM

THE PROBLEM

To estimate the current status and future course of the Soviet atomic energy program on the basis of information available from all sources.

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THE SOVIET ATOMIC ENERGY PROGRAM SUMMARY 1/

I. SIGNIFICANT DEVELOPMENTS

1. A highly significant development since the publication of the 1955 estimate, was the airburst on 22 November 1955 of a thermonuclear weapon which yielded about 1.6 megatons. It is highly probable that this marked the effective beginning of a Soviet multi-megaton nuclear weapons capability. From the above and other tests we estimate that the USSR is developing and stockpiling a versatile group of nuclear weapons ranging from very low-yield warheads to high-yield thermonuclear weapons.

2. In addition, as a result of new evidence, we have revised our previous estimates of Soviet production of uranium-235 upward by a factor of about four. 2/ This revision together with the 22 November test leads us to the estimate that the USSR now has a significant multi-megaton weapons capability and will have a major capability in the near future. Our plutonium production estimates are about the same as those in last years estimate.

3. The Soviets have displayed considerable progress in nuclear electric power reactor development. We estimate they are capable of meeting the ambitious goals of the Sixth Five-Year Plan for 2000-2500 MW of installed nuclear electric power capacity by the end of 1960, but this achievement will require a very high priority effort. The state of their reactor technology also indicates that the USSR has a capability for developing propulsion applications.

1/ The Director of Naval Intelligence does not concur in the figures contained herein for the estimated production of U-235 and for the estimated production of plutonium after 1959. These figures are believed to be too high in view of the following considerations: (Footnote 1/ continued on next page).

2/ See Footnote to Paragraph 5, page 3.

II. PRODUCTION OF FISSIONABLE MATERIALS

4. Uranium-235. The first Soviet isotope separation plant employed the gaseous diffusion process; was located at Verkhneivinsk in the Urals, and was put into partial operation beginning in late 1948. This plant did not initially attain its design performance due to corrosion problems, in-leakage of air, and rather poor barrier.[

]The nature of this work and the results attained indicate both an understanding of gaseous diffusion processes and a sophistication of engineering design. On this basis we estimate that the Soviets achieved a considerable increase in the over-all efficiency of their gaseous diffusion plant operations after 1951. However, our limited knowledge of the rate at which many of the design improvements investigated were incorporated in the operating plants necessitates a degree of uncertainty in the estimates of plant operating efficiencies.

1/ (Footnote 1/ continued from Page 1)

a. The assumption that all unaccounted-for electric power in the three potential U-235 isotope separation sites has been utilized by the Soviets for production of U-235 by gaseous diffusion is not justified by the evidence. The Soviet plant efficiency in the estimate of isotope separation is based on assumptions as to barrier availability and improvements, stripping of tailings, operating pressures, compressor drive improvement, and associated techniques. These assumptions cannot be supported by the Office of Naval Intelligence.

b. The expansion of plutonium production after 1959 rests on an assumption of Soviet capability to place in effect a dual-purpose plutonium-power reactor program of extensive scope and complexity. There is no evidence that the Soviets have perfected a dual-purpose reactor which will efficiently produce both power and plutonium simultaneously. The Director of Naval Intelligence believes that years of research and development will be necessary before this goal can be achieved.

The Director of Naval Intelligence believes that for planning purposes a more practical magnitude of cumulative quantities of U-235 would be in a range below that of the minus 50% lower limit of this estimate.

5. Our estimates of U-235 production have been obtained by applying estimated plant efficiency in terms of power requirements per kilogram of product to the average electric power estimated to be available for isotope separation in the areas of possible Soviet gaseous diffusion sites. The uncertainties connected with both of these factors are sufficiently large that as a maximum the Soviet gaseous diffusion capacity could approach the feed materials potential of the uranium ore supply which is estimated to greatly exceed for several years the feed requirements for both the estimated plutonium and U-235 programs. On the other hand, U-235 production could have been much lower than that estimated, if less electric power were consumed or the plants did not operate at the efficiencies estimated. Thus the uncertainty in the estimate of cumulative Soviet production of U-235 up to 1956 is very large but probably does not exceed $\pm$ 50% of the estimated values. Our estimate of future U-235 production is subject to many variables which are dependent primarily on Soviet plans and decisions and is therefore less reliable than the estimate of the 1956 cumulative production. (See Table I) 3/

3/ The Deputy Director for Intelligence, The Joint Staff believes that the new intelligence does not adequately support the estimate of U-235 cumulative production through 1955. The estimate of efficiency of Soviet isotope separation operations is composed of scant specific intelligence information and uncertain assumptions as to when certain improvements were made in Soviet plants. Due to the many, varied and complex uncertainties involved, a more practical figure for planning purposes of cumulative U-235 production through 1955 would be one in the lower range of uncertainty, approaching the minus 50% lower limit.

The same reasons, plus a lack of intelligence on Soviet plans and programs in the atomic energy field, lead him to conclude that the estimate of U-235 available by mid-1959 and subsequent dates reflects projections and extrapolations under very uncertain conditions, rather than a valid figure for planning purposes.

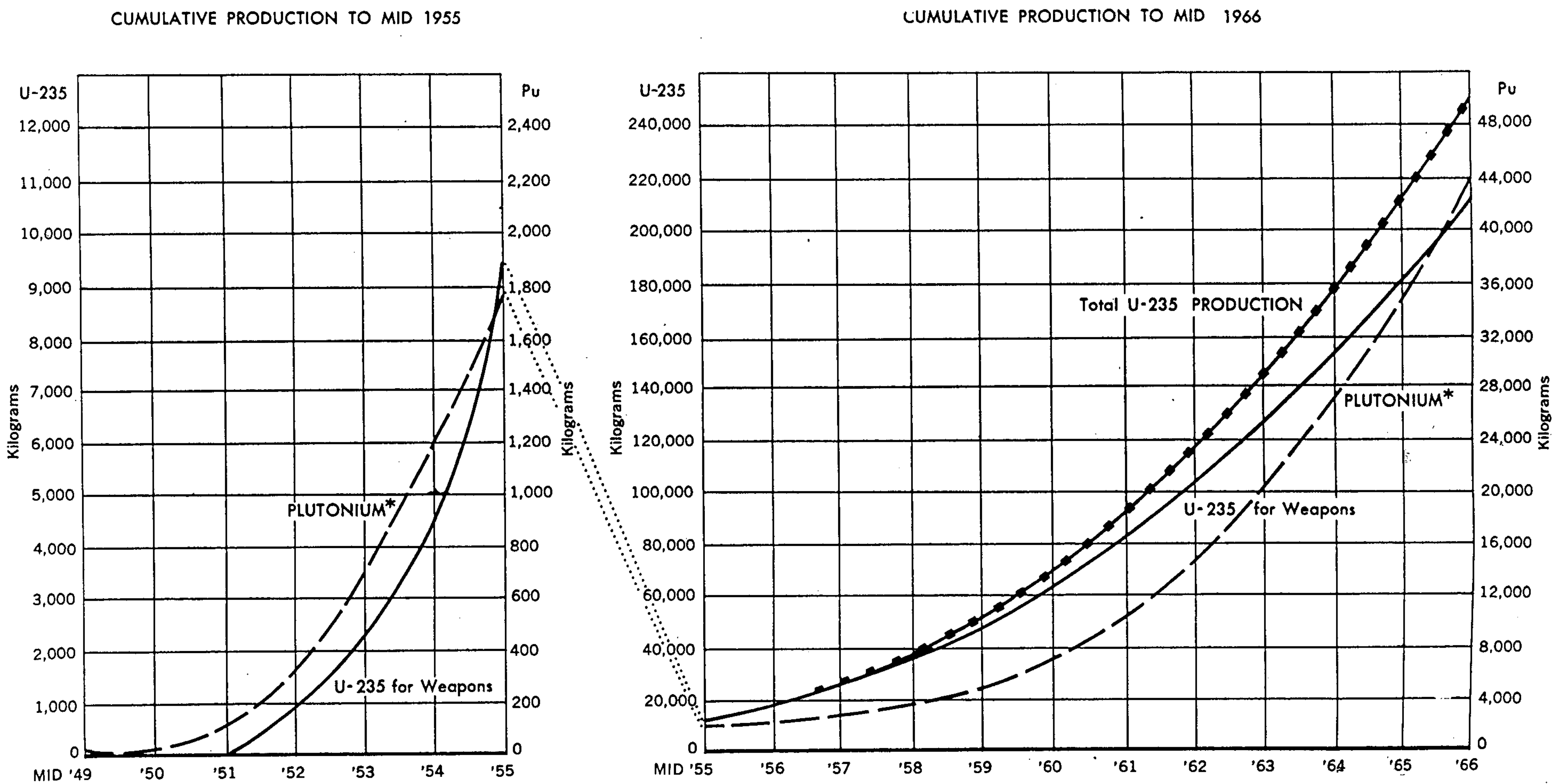
The above conclusions are applicable throughout the remainder of this estimate whenever estimates of U-235 or weapons fabricated from this metal are discussed.

6. <u>Production of Plutonium and Uranium-233</u>. Estimates of Soviet plutonium production are based on a large body of information including the amounts of uranium metal available for plutonium production,[ ] and the timetables of site construction and availability of materials. Much of the information is of such a nature that it gives only an idea of the total reactor power available to the USSR. No distinction can be made as to the portions of this power used for the production of plutonium, U-233, tritium, or any other isotope which the USSR may desire. Therefore production estimates are hereafter given in terms of plutonium equivalent.

SOVIET PRODUCTION OF FISSIONABLE MATERIALS

Read Left Columns for U 235 Production

Read Right Columns for Plutonium Production



*Only insignificant fraction needed for non-weapons program.

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TABLE I

III. NON-WEAPONS PROGRAM

7. During the past year, a significant amount of information has been published on the non-military aspects of the Soviet atomic energy program. This release began with the Moscow and Geneva Conferences and propagandized those phases of atomic research and development in which the USSR seeks to rival the Western nations. It is encouraging the interchange of scientists and nuclear information in the "peaceful uses of atomic energy".

8. The Soviet nuclear electric power program, which is of considerable magnitude, appears designed to establish a claim for world leadership, to produce fissionable materials, and to gain experience toward future economically competitive electric power. The Soviet Union is engaged in design and development of almost a dozen types of reactors ranging in power from 50 to 200 electrical megawatts for the production of electric power as part of the 1956-60 Five-Year Plan. This program, which calls for a total capacity of 2000-2500 megawatts of electric power, is within Soviet capability but will require a high priority effort for its achievement. One small reactor began producing electric power from nuclear energy in June 1954 and has been given wide publicity by the USSR as the "first in the world". This reactor, while inefficient, is useful for experimental studies of power reactor operation. The announced Soviet nuclear electric power program will require an increasingly greater percentage of the total uranium-235 available but will produce as a by-product plutonium or possibly U-233 and tritium.

9. The Soviet program of atomic aid to the satellite nations, announced in January 1955, proposes the construction of research reactors and supporting facilities in East Germany, Czechoslovakia, Poland, Hungary, Communist China and possibly in Bulgaria and Rumania. The amount of fissionable materials required for this research program would place a negligible drain on the estimated Soviet fissionable material stockpile. The completion of this Soviet aid program, which was probably undertaken primarily for its political value, will not give the satellites the capability to produce weapons on their own.

10. On the basis of known Soviet reactor experience we estimate they could produce a nuclear propulsion reactor suitable for surface ship or submarine application by 1956-57. We have almost no information on the Soviet aircraft nuclear propulsion reactor program but

estimate that it probably will not progress beyond the research phase prior to 1958. Assuming this propulsion progress, the amount of fissionable material required to support the program will not subtract appreciably from the material estimated to be available for weapon production.

IV. NUCLEAR WEAPON PROGRESS

11. As a result of the airburst (approximately 4500' altitude) on 22 November 1955, we believe that the Soviets are now beginning to stockpile thermonuclear weapons with yields of about 2 MT. Since the fabrication of megaton weapons probably did not commence until after 22 November 1955, it is unlikely that the Soviets could have more than a few of these weapons by the beginning of 1956.

12. The USSR is now capable of increasing the yield of the 22 November 1955 type weapons to about 10 MT by further developmental advances. Future developments will probably lead to increasing the nuclear efficiency, yields, and deliverability of high yield weapons. We estimate that prototypes of high yield missile warheads could be tested by 1957-58.

13. Soviet interest in low-yield, small-dimension weapons is well established by their military doctrine and by the large number of low-yield weapons or devices detonated in the test series of 1953, 1954, 1955 and 1956. It is estimated that the USSR now has a small-diameter warhead using an implosion system of low efficiency, with yields in the range of less than one kiloton to ten kilotons. Improved efficiencies, which will permit more widespread use for air defense, are expected by 1959.

14. The Soviets conducted their first underwater atomic test near Novaya Zemlya on 21 September 1955, highlighting a new phase in their continuing development of atomic weapons for a variety of military uses. The underwater test opens new vistas into the development of atomic weapons for a variety of naval uses, resulting in a significant increase in the over-all Soviet atomic warfare capability. The significance of the test can be compared to the Totskoye explosion of 1954 which was an airdrop of a stockpile weapon as part of a tactical military exercise.

15. The estimate of fissionable material available can be converted into a number of estimates of weapon stockpiles, taking into account diversion of fissionable material for non-weapon purposes. The limited availability of fissionable material does not prevent the USSR from having a significant stockpile of high-yield weapons; however, it would limit the Soviet's capability to produce significant quantities of low-yield weapons of the types they have tested which would be suitable for tactical and air defense use.

16. Available evidence indicates that the USSR is presently stockpiling and will continue to stockpile a versatile family of nuclear weapons. We cannot determine with any degree of certainty the probable number of nuclear weapons allocated to each specific use since these will depend on strategic and other factors.

DISCUSSION

PART ONE

STATUS OF THE SOVIET ATOMIC ENERGY PROGRAM AS OF THE END OF 1955

I. INTRODUCTION

17. While the exact extent of Soviet capability in the atomic field remains uncertain, the general nature and some of the details of the Soviet atomic energy program can be assessed with fair reliability. Available evidence establishes the existence in the USSR of: (a) a high priority, extensive atomic energy program, primarily directed toward military application, which is continuing to expand; (b) an ample uranium ore base on which to carry out this program; (c) a substantial stockpile of fissionable materials; (d) a proven capability for the establishment of nuclear-electric power stations; (e) a capability, so far believed to be unrealized, of utilizing nuclear power for propulsive purposes; (f) and a proven capability of producing explosions in yield ranges from a few kilotons up to several megatons and of employing both fission and fusion principles.

18. Reliable evidence indicates that Soviet military planning includes the employment of nuclear weapons for offensive air operations, in support of ground and naval operations, and possibly air defense. At least twice since 1953 there has been military participation in the Soviet nuclear weapons test program indicative of both weapons effects tests and military maneuvers.

19. Our knowledge of the status of the Soviet atomic energy program as of the end of 1955 is derived from a considerable volume of evidence. Sufficient details are available to provide a reasonable foundation for quantitative assessment. Information obtained by technical means on Soviet plutonium production continues to be consistent within the limits of its probable error with information obtained through other sources. Information concerning uranium-235 production does not permit as reliable an estimate as in the case of plutonium production, but important new information has been developed during the past year. Evidence received since our last estimate on the Soviet atomic energy program primarily concerns the mining of uranium ore, its transformation into uranium metal, the production of

plutonium, research on reactors and isotope separation methods, the first Soviet gaseous diffusion uranium-235 separation plant, electric power available to gaseous diffusion plants, further testing of weapons, and military training and indoctrination in atomic warfare. Information received and analysis made since the publication of the last estimate require substantial upward revision of the estimate of uranium-235 available over that given in the 1955 estimate.

II. GENERAL SCOPE OF THE PROGRAM

A. History and Organization

20. The Soviet atomic energy program started in August 1940 with the formation of a Commission on the Uranium Problem attached to the Presidium of the Academy of Sciences, USSR. Members were representatives of various laboratories expected to be major contributors on the problem. In late 1943 the Ninth Directorate of the People's Commissariat of Internal Affairs (NKVD) was organized to make preliminary studies in nuclear physics with special attention to atomic energy. In 1944 it became responsible for uranium mining in the USSR, and, beginning in May 1945, it contracted with more than 200 German and Austrian scientists to work in the USSR on atomic energy problems at several laboratories subsequently built for this purpose.

21. In November 1945 a First Chief Directorate attached to the Council of Ministers was created and given responsibility for the Soviet atomic energy program. As the responsible member of the Council of Ministers, L. P. Beriya exercised over-all direction of policy and drew into the program the best talent and leadership of the nation. These leaders, for the most part, retained their old positions along with their new responsibilities. The appointment to the program of representatives of many diverse organizations, such as the Ministry of Internal Affairs, the Ministry of the Chemical Industry, and many others assured the high priority necessary to implement the program. Between 1945 and 1950 the First Chief Directorate gradually took over the responsibilities of the Ninth Directorate of the NKVD until in early 1950 the Ninth Directorate relinquished the last of its functions, control of the German scientists and was dissolved.

22. Reflecting the steady growth of the Soviet atomic energy effort, a major reorganization took place early in 1950. At this

time the Second Chief Directorate attached to the Council of Ministers was formed and took over the mining, concentration and refining of uranium as well as the development of new uranium deposits. Its responsibilities originally extended to mining operations outside the USSR; however, satellite mines now appear to be subordinate to the Chief Directorate of Soviet Property Abroad, Ministry of Foreign Trade. The First Chief Directorate was thus free to concentrate exclusively on production of fissionable materials and manufacture of weapons. Supply, personnel, and other services common to both chief directorates were placed in a separate body serving both directorates; this body was possibly formed into a Third Chief Directorate.

23. This organizational structure apparently continued until the arrest of Beriya in June 1953. At that time the Ministry of Medium Machine Building was organized, and V. A. Malyshev was designated as minister. Subsequently he was appointed a Deputy Chairman of the Council of Ministers and apparently succeeded Beriya as director of over-all policy for the program. In February 1955 Colonel General A. P. Zavenyagin, a prominent figure in the First Chief Directorate and a leading figure in the program since its beginning, was appointed Minister of Medium Machine Building and elevated to a Deputy Chairman of the Council of Ministers, thereby replacing Malyshev as over-all policy director of the program.

24. In April 1956 TASS announced the formation of a new atomic energy coordinating body, "Main Administration For the Use of Atomic Energy" attached to the Council of Ministers and responsible for insuring the "large-scale use of atomic energy in all branches of the national economy" and developing "cooperation between the Soviet Union and other countries in the peaceful uses of atomic energy". Thus it appears that the Ministry of Medium Machine Building will retain most of its former functions while the coordination and supervision of the application of peaceful uses of atomic energy throughout the Soviet economy will now fall under the control of this new organization.

B. <u>Soviet Technical Capabilities in Nuclear Energy</u>

25. The USSR has demonstrated considerable technical competence in the independent research required for a comprehensive nuclear energy program as evidenced by data obtained through our scientific detection system, the papers presented at the Moscow and Geneva international conferences on the peaceful uses of atomic energy,

information obtained from returned German scientists, and Soviet scientific literature. The Soviet papers presented at international atomic energy and other scientific conferences provide valuable details of some Soviet accomplishments in the general areas of nuclear physics, metallurgy, research reactor design, reactor engineering, instrumentation, and biological and medical aspects of nuclear energy. These conferences also provided opportunities for personal contact between US and Soviet scientists which aided in the evaluation of Soviet professional competence. The USSR has excellent senior scientific leaders and the Soviet educational system graduates competent younger scientists, substantial numbers of whom devote at least part of their time to research in the basic sciences.

26. Computers. High speed computers play an extremely important role in many aspects of an atomic energy program particularly in the design of new weapons. The USSR now possesses a high capability for computer research, and the Soviets have revealed the existence of a number of digital computers. One of these is the BESM, a high speed device comparable to some of the foremost operating computers in the US. This machine was completed in early 1952. Another is the URAL computer, a considerably smaller and slower machine. A very large machine, the STRELA, is known to exist, but this has not yet been announced publicly. Manufacture of both the URAL and the STRELA is scheduled to be initiated shortly, and the USSR has agreed to supply a URAL type machine to India. In addition to these, a small digital computer was seen at a university in Leningrad.

27. Physics. The papers presented at the Geneva Conference by the USSR reflect creditable work in nuclear physics. Many of the fundamental physical constants measured by Soviet scientists agree well with those reported by other countries. There is apparently only a little less emphasis on classical nuclear theory in the USSR than in the United States, and Soviet papers on various aspects of theoretical physics demonstrated considerable competence in this field.

28. Soviet high-energy physics research is quite impressive and represents a logical outgrowth of the long standing Soviet interest in cosmic ray physics. The USSR has an active group working in the field of high-energy physics and high-energy particle accelerator design. The 700 Mev synchro-cyclotron of the Institute of Nuclear Problems of the Academy of Sciences is

the largest machine of its type in the world. A 10 Bev proton synchrotron will also be the largest machine of its type in the world if it reaches design energy when fully operational. Design studies on a 50 Bev strong-focussing synchrotron are now in progress.

29. Chemistry. Papers presented at international conferences, open scientific literature and other collateral information reveal a high degree of technical competence. Research work dealing with isotope separation, tracer techniques and rare earth chemistry is found in widely scattered papers under the guise of seemingly unrelated scientific investigations. Reports on research and development have been notably omitted in certain fields of chemistry. Soviet security is probably responsible for the lack of information directly connected with atomic energy chemical processing and production.

30. Metallurgy. The Soviet Union has a well-developed capability in the special metallurgy required to support a very advanced atomic energy program. All of the metals necessary for use in the most up-to-date designs of US reactors are believed to be available in the USSR and to have received most careful attention by metallurgists known to be associated with the Soviet program. The methods of manufacture, the purity of the metals involved, the types of alloy systems under investigation and the published reports of effects of radiation on mechanical properties suggest that the Soviet Union is well advanced in knowledge of the behavior of metallurgical materials for construction of power reactors. The combination of fundamental scientific research on heat flow and high temperature alloys of certain types appears to present some background for support of an aircraft nuclear power program.

31. Reactors. Soviet papers on nuclear reactors presented at international conferences indicate that their reactors are of creditable designs but have few original features. (See Table II) The First Graphite Reactor, described by V. S. Fursov at the Moscow Conference, is very similar to the first US reactor constructed in 1942.

32. The Heavy Water Research Reactor has a versatile design suggestive of a reactor used to study the properties of heavy water reactors. It was conceived in 1947, designed in 1948 and constructed in 1949.

33. The Laboratory of Measuring Instruments began design of a water-moderated water-cooled reactor in 1950. This design, revised to graphite moderation in September 1950, became the Reactor Physical Technical (RPT). The RPT was used in December 1952 for tests of the fuel elements of the Atomic Power Station reactor and now is testing a fuel element design for the first large Soviet atomic power station reactor. The original light-water moderated and cooled reactor design was used for a reactor built at Moscow University.

34. The Fast Reactor and the Hydrogenous Critical Experiments were operated at very low power to provide data for reactor design. Experiments with these low-power reactors provide evidence of Soviet capability to construct the power reactors of similar design referred to in published statements on the Sixth Five-Year Plan atomic power program.

35. The Atomic Power Station reactor, probably the first Soviet experimental power reactor, was probably designed in 1950 and came into operation in 1954. It is, according to the USSR, producing 5 MW of useful power. The Soviets indicate that there has been little fuel element failure in over one year of operation but refused repeatedly to discuss fuel element construction during the Geneva Conference. It would appear that this reactor, while inefficient and certainly not elaborate, is useful for experimental studies of power reactor design.

TABLE II

USSR RESEARCH AND POWER REACTORS

Arbitrary Name	Heat Power	Fuel	Moderator-Coolant	Location	Remarks
First Graphite Reactor	Less than 10 KW	Natural Uranium About 45 tons	Graphite-None	Laboratory of Measuring Instruments, Moscow	"First Reactor in Europe" Probably critical 1947
Heavy Water Research Reactor	About 600 KW	Natural Uranium 2.5-3.0 tons	Heavy Water (5 tons)	Thermo-Technical Laboratory, Moscow	Critical April 1949 now being rebuilt for 2% enriched uranium
Reactor Physical Technical (RPT)	10,000 KW	Enriched Uranium	Graphite-Light Water	Laboratory of Measuring Instruments, Moscow	Critical April 1952. In use for power reactor fuel element studies
Light Water Reactor, I	About 300 KW	10% Enriched Uranium 3.5 Kg U-235	Light Water	Moscow State University	Design studies complete in Mid-1950
Light Water Reactor, II	2,000 KW	10% Enriched Uranium About 4.5 Kg U-235	Light Water	Unknown	Probably Under Construction
Fast Reactor	Very low	Plutonium	None	Possibly Obninskoye (About 60 mi. SW Moscow)	In operation before mid-1953
Hydrogenous Critical Experiments	1-50 watts	U-235 or Plutonium or U-233	Water or Polyethylene	Unknown	Significant indicator of reactor capabilities
Atomic Power Station Reactor	30,000 KW (5,000 KW Elect.)	5% Enriched Uranium 550 Kg Total	Graphite-Pressurized Light Water	Obninskoye (About 60 mi. SW Moscow)	Critical May 1954 Generated electricity June 27, 1954

36. Controlled Thermonuclear Research. Soviet interest in the application of controlled thermonuclear reactions for the production of power was revealed at the Moscow Conference. Information on Soviet activity in this field indicates that the USSR has the technological competence required to support an effective research program directed toward the achievement of controlled thermonuclear reactions. The Soviets will probably not produce economic power from thermonuclear processes for many years.

37. Instrumentation. The USSR is producing the instruments required to support a nuclear energy program. The instruments used with Soviet reactors appear to be adequate and serve their purposes well. The Soviet nuclear instruments generally lack versatility and appear to be designed for specific jobs. On the other hand, the Soviet mass spectrometer, MS-4, appears to have good versatility and to be a modern, well-engineered instrument. Auxiliary instruments shown at the Geneva Conference exhibited considerable evidence of standardization by the Soviets. The USSR instrument exhibit at Geneva also revealed considerable attention to biological and medical applications for use in therapy, diagnosis and health protection. Some component parts, such as photomultiplier tubes, appear to have serious weaknesses which may have impeded Soviet instrumentation progress. Soviet health physics instrumentation, on the other hand, is judged to be adequate.

38. Biology and Medicine. Considerable Soviet emphasis has been placed on medicine relating to the treatment of casualties which might be caused by nuclear explosions. The work is under the direction of the Medical Research Council, Chief Medical Directorate of the Armed Forces, Ministry of Defense and the Ministry of Health. Preliminary preparations have been made for the treatment of mass casualties caused by nuclear explosions. Experimentation is in progress on the use of novocaine blocks and "sleep therapy," to immobilize the patient to improve the chance for recovery from severe skin burns. A large number of protective drugs found beneficial against exposure to radiation in animal experiments by Western investigators have also been tested by the Soviets, but only one, cystineamine, was found promising by the Soviets as a prophylactic. Other techniques such as blood transfusions, injection of bone marrow emulsion, carotenoid polyenes, and the use of antibiotics have been widely investigated by Soviet medical authorities. Several original Soviet antibiotics have been broadly propagandized but remain untested in the West.

39. Soviet health physics standards discussed at the Geneva Conference and stated in military doctrine are more restrictive than those of the Western world. The conservative health physics standards probably are not adhered to in the USSR and may have been presented to gain a propaganda advantage.

40. Compared to US standards, Soviet radiobiological research is less sophisticated but is directed along parallel lines. An exception is the Soviet emphasis upon the neurophysiological effects of radiation, particularly at low levels of exposure.

C. Raw Materials and Resources

41. Uranium Mining. Much quantitative information is available on Soviet uranium prospecting, mining and ore enrichment in East Germany, and somewhat less on Czechoslovakia, Bulgaria and Rumania. Much less information is available on these activities within the USSR. The estimated cumulative production up to 1956 is more than sufficient to support the fissionable material production estimates. We estimate that a total of approximately 4800 metric tons of natural uranium (in terms of recoverable metal) was mined in 1955 in the USSR and its satellites, including East Germany. This figure is subject to a considerable uncertainty because we lack sufficient evidence on internal Soviet efforts. Approximately 2,000 metric tons of this total are estimated to have come from East Germany. This latter figure is considered to be subject to an uncertainty of not more than plus or minus 25 per cent. Estimated annual uranium production and cumulative uranium stockpiles are given in Table III. Areas of uranium mining in the Sino-Soviet Bloc are shown in Figure 1.

D. Other Raw Materials

42. There is evidence of Soviet atomic energy interest in the exploitation of heavy sand deposits which are known to contain thorium, zirconium, and other elements useful in atomic energy activities. Substantial quantities of the metals mentioned above are available, and it is believed that such quantities as are required for atomic energy purposes would probably represent only a small percentage of the total Soviet capacity for producing them.

TABLE III

ESTIMATED URANIUM ORE PRODUCTION*
(Metric Tons Recoverable Metal)

END YEAR	GERMANY	CZECHOSLOVAKIA	BULGARIA	RUMANIA	POLAND
Stocks					
pre 1946	170-200	60-70	Nominal	- -	- -
1946	30-60	10-30	Nominal	- -	- -
1947	150-200	30-50	10-20	- -	Nominal
1948	300-500	100-150	20-30	- -	10-20
1949	600-1000	150-250	40-60	- -	30-50
1950	800-1200	250-400	60-100	- -	50-90
1951	1000-1500	250-450	70-100	- -	50-100
1952	1200-1700	250-550	100-150	10-50	50-100
1953	1500-2000	300-600	100-200	50-80	30-70
1954	1500-2500	350-650	100-300	50-150	30-70
1955	1500-2500	400-700	150-400	100-500	30-70

END YEAR	USSR	CHINA	KOREA	YEARLY TOTAL
Stocks				
pre 1946	Nominal	- -	- -	230-270
1946	50-100	- -	- -	90-190
1947	150-300	- -	- -	340-570
1948	250-400	- -	- -	680-1100
1949	350-500	- -	Nominal	1200-1850
1950	450-650	- -	Nominal	1600-2450
1951	600-1100	Nominal	Nominal	2000-3250
1952	800-1500	10-40	Nominal	2400-4100
1953	950-1800	10-40	Nominal	2950-4800
1954	950-2200	30-60	Nominal	3000-5900
1955	1000-2200	30-60	Nominal	3200-6400

CUMULATIVE TOTAL END OF 1955 18,000-31,000

* Much quantitative information is available on mining and ore enrichment in East Germany; somewhat less is known on Czechoslovakia, Bulgaria and Rumania; and much less on these activities in the USSR, Poland, China and Korea.

III. NUCLEAR MATERIAL PRODUCTION

43. Uranium Metallurgy Plants. Information obtained during the past year from returned German scientists, used in conjunction with data on calcium production and timetables pertaining to Soviet uranium metal plants permits a fairly reliable estimate of the amount of uranium metal ready for reactor use manufactured each year up through 1952. Analysis of this information indicates that: (a) the first metal suitable for reactor use was made at Elektrostal in early 1947; (b) this plant reached a capacity of 25 metric tons of uranium metal slugs per month by early 1950 and possibly 50 tons per month by the middle of that year; and (c) production lines of 25 tons of slugs per month each went into operation at Glazov, west of the Urals, in September 1949 and mid-1950 and at Novosibirsk, in central Siberia, in mid-1951 and early 1952.

44. Additional expansion could have occurred at any of these sites after 1952 without our knowledge, since the evidence on which to base uranium metal production estimates essentially ceases by mid-1952. The estimate given below is considered a reliable lower limit until 1952.

TABLE IV

METALLIC URANIUM SLUG PRODUCTION
(Metric Tons)

Date	Production During Preceding Year	Cumulative Production
Mid-1947	20	20
Mid-1948	200	220
Mid-1949	250	470
Mid-1950	500	970
Mid-1951	900	1850
Mid-1952	1200	3050
Mid-1953	1500	4550
Mid-1954	1500	6050
Mid-1955	1500	7550

45. Heavy Water (D_2O). Early in 1946 the Soviets began the conversion and installation of equipment at the Chirchik Nitrogen Combine in Central Asia to provide for the production of by-product heavy water for atomic energy purposes. Simultaneously, Germany was

exploited for heavy water, research results, equipment, and research personnel. About mid-1946 construction of production facilities to use the electrolytic-catalytic exchange method was started at five other plants. Construction was also started on a seventh plant at Aleksin which used the hydrogen sulfide-water exchange method. Limited production commenced at Chirchik in 1947 and at Aleksin in late 1948. Most of the other plants began producing by 1949 or 1950. By 1950 work was underway on a plant at Norilsk in far north Siberia using the ammonia-water exchange system. It probably began producing about 1953 and may have had a substantial output by early 1955.

46. The following cumulative estimate of heavy water produced in the USSR is considered to be reasonably accurate up through 1953, but after that time the error may be considerable.

TABLE V

HEAVY WATER PRODUCTION
(Metric Tons)

END	Annual D_2O	D_2O Cumulative
1947	Low	Low
1948	Low	Low
1949	30	40
1950	50	90
1951	55	145
1952	80	225
1953	80	305
1954	90	395
1955	100	495

47. Graphite. The Geneva and Moscow Conferences on Atomic Energy and evidence from returned German scientists have established that at least four Soviet research reactors, including their first one, used graphite as a moderating or reflecting material. Two returned German scientists assert that the first production reactor also was graphite moderated. The details of the manufacture and procurement of reactor graphite are still obscure, but it was apparently available as early as 1947. The exact specifications of Soviet reactor graphite are not known, but Soviet grade TsMTU 2035-47, available since 1949 for mercury arc rectifiers in tonnage lots, has a maximum ash content of 0.1%, a value well within the range used for reactors in the United States.

48. Production Reactors. There is evidence that construction on the first Soviet production reactor started early in 1947 near Kyshtym in the Urals and that it went into operation about mid-1948. Returned German scientists asserted that the first Kyshtym production reactor was graphite moderated and may have been air cooled. The urgency in the Soviet program during this period is perhaps reflected in the fact that construction of this reactor was underway some six months before the USSR's first research reactor (also graphite moderated) went critical in the late summer of 1947.

49. It was also reported that a second production reactor at Kyshtym went into operation sometime toward the end of 1949. It was heavy water moderated and construction must have begun at about the same time construction was initiated on the heavy water research reactor at the Thermo Technical Laboratory in Moscow, which became operational in April 1949.

50. The exact schedule and type of reactors subsequently installed are not known. There may have been insufficient heavy water to permit all subsequent reactors to be heavy water moderated, so that the existence of other types of production reactors appears likely. Evidence indicates that about 1950 construction started on a plutonium production site near Krasnoyarsk in mid-Siberia. The Novosibirsk uranium metal plant was probably built to provide materials to Krasnoyarsk and other Siberian sites.

51. Initially the separation of plutonium from uranium and fission products was done by an oxidation-reduction-co-precipitation process which differed somewhat from that initially adopted by the US. It was designed to recover uranium as well as plutonium, since the uranium metal plant at Glazov was designed to use depleted uranium as partial feed material. Soviet and German research on solvent extraction methods indicates that the Soviets may have later developed a better process.

52. The Soviets have probably been operating enriched or spiked reactors in their production program for some time in order to supply the tritium and U-233 for stockpiling weapons of the higher yield types tested in 1953 and 1955. This could have been done either by modifying existing reactors or by constructing new reactors specifically designed for the task. Research on the Moscow Reactor Physical Technical in 1950-52 and on the Soviet Atomic Power Station Reactor in 1952-54 provided experience and information essential to the design of enriched production reactors.

53. Tritium and U-233. The first known Soviet interest in tritium was revealed by the publication in late 1948 of a comprehensive review of the literature on tritium by M. B. Neyman, a staff member of the First Chief Directorate. Returned Germans report that by 1952 tritium was available for research in their laboratories. This is consistent with the probable use of tritium in the high yield tests of 1953 and 1955.

54. Active Soviet interest in thorium-bearing minerals started about mid-1946 with the formation of a special directorate for their exploitation. Although part of this interest lay in the requirement for lanthanum chemicals for the Soviet plutonium separation chemical plant, German scientists at Elektrostal were also required to design a process for the production of pure thorium oxide. Subsequently, the USSR acquired considerable thorium stocks. [ ] the only certain production of U-233 from thorium was the research quantities mentioned at the Geneva and Moscow Conferences on Atomic Energy.

55. Plutonium. Estimates of Soviet plutonium production are based on a large body of information including the amounts of uranium metal available for plutonium production, [ ] and the timetables of site construction and availability of materials.

TABLE VI

PLUTONIUM PRODUCTION TO MID-1955
(Kilograms)

Date	Cumulative Production
Mid-1949	10
Mid-1950	25
Mid-1951	115
Mid-1952	330
Mid-1953	700
Mid-1954	1200
Mid-1955	1750

56. Much of the information on which the plutonium production estimates are based is of such a nature that it gives only an idea of the total reactor power available to the USSR. No distinction can be

made as to the portions of this power used for the production of plutonium, U-233, tritium, or any other isotopes which the USSR may desire. Therefore production estimates are hereafter given in terms of plutonium equivalent.

57. Uranium-235. During the last year, considerable information on the first Soviet isotope separation plant has been obtained from returning German scientists. This plant, which employed the gaseous diffusion process, was located at Verkhneivinsk in the Urals and was put into partial operation about September 1948. The plant employed flat plate barriers of high permeability and operated at low pressures. Although we believe this plant was designed for the production of 200 grams per day of 95% U-235, it produced initially considerably less than 200 grams per day of 70% material. The failure of the plant to achieve its design performance is ascribable to corrosion problems, in-leakage of air, and rather poor barrier.

58. There is evidence that the Soviets put into operation at Verkhneivinsk in 1951 a more efficient gaseous diffusion process. This process had a greater number of stages and employed the tubular nickel barrier developed by the Germans. Also the operating pressure was appreciably increased. We estimate that this process was in operation in time to produce the U-235 used in the Soviet test of 18 October 1951.

59. Since 1951, there have been substantial increases in electric power capacity near Verkhneivinsk and other Soviet atomic energy sites. The fact that the power capacity increases cannot be accounted for in terms of non-atomic use, the magnitude of the increases, and other evidence lead to the conclusion that the Soviets expanded their isotope separation capacity at Verkhneivinsk and other locations. Although a number of methods for isotope separation were investigated in the Soviet Union concurrently with the development of the gaseous diffusion process, the available evidence indicates that gaseous diffusion was the only process adopted for large-scale production of U-235.

60. [ ]

[

]

61. [

] Thus the uncertainty in the estimate of cumulative Soviet production of U-235 up to 1956 is very large but probably does not exceed $\pm$ 50% of the estimated values.

TABLE VII

ESTIMATED CUMULATIVE SOVIET PRODUCTION OF URANIUM-235 4/

Mid-Year	Production of 90% Material in Kilograms
1950	----
1951*	50
1952	750
1953	2100
1954	4600
1955	9300
1956	16000

* Plant operating only last few months of fiscal year.

62. [ ]

4/ The Deputy Director for Intelligence, The Joint Staff believes that the new intelligence does not adequately support the estimate of U-235 cumulative production through 1955. The estimate of efficiency of Soviet isotope separation operations is composed of scant specific intelligence information and uncertain assumptions as to when certain improvements were made in Soviet plants. Due to the many, varied and complex uncertainties involved, a more practical figure for planning purposes of cumulative U-235 production through 1955 would be in the lower range of uncertainty, approaching the minus 50% lower limit.

IV. NUCLEAR WEAPON TESTS

63. The first Soviet nuclear test was conducted in 1949, and was followed by test series in 1951, 1953, 1954, 1955 and 1956. In the 22 detected tests,[ ] (See Table VIII)

64. The 1949 test[ ] yielded approximately 15 kilotons,[ ]

65. The four explosions of the 1953 test series demonstrated that the USSR was seeking to supplement the medium-yield weapons tested in 1951 by the addition of both high-yield weapons and low-yield,[ ]weapons. A thermonuclear device detonated on 12 August 1953 yielded 400 kilotons (the estimated yield of this device was reduced from the 500-1000 KT previously reported after re-evaluation of the data with the aid of calibrations from more recent tests). The thermonuclear material used in this device was lithium deuteride.]

66. Seven explosions occurred in the 1954 series. The first took place near Totskoye and was an airdrop of a stockpile weapon as part of a military exercise. The remaining six tests occurred at the main Soviet proving ground in the vicinity of Semipalatinsk. All yielded less than 100 kilotons[ ]

67. The 1955 test series consisted of five nuclear detonations. One of these, on 21 September 1955, was the first Soviet nuclear explosion to occur underwater. The 6 November test yielded about 215 kilotons and is considered to have been an airdrop test of a weaponized version of the 12 August 1953 device.[

] A highly significant development was the airburst on 22 November of a thermonuclear weapon which yielded about 1.6 megatons. It is highly probable that this marked the effective beginning of a Soviet multi-megaton nuclear weapon capability. [ ]

68. The Soviets conducted, in 1956, at least three nuclear tests prior to 1 April. All of these were of low yield, [ ]

TABLE VIII

SOVIET NUCLEAR TESTS

NO.	DATE	LOCATION	YIELD (KT)	BURST HEIGHT
JOE I	29 Aug 49	Semipala-tinsk 50°N 78°E	15	Surface
JOE II	24 Sept 51	Semipala-tinsk	45	Surface
JOE III	18 Oct 51	"	50	Air*
JOE IV	12 Aug 53	"	400	Surface
JOE V	23 Aug 53	"	25	Air*
JOE VI	3 Sept 53	"	< 10	Air*
JOE VII	10 Sept 53	"	< 10	Air*
JOE VIII	14 Sept 54	Totskoye 53.1°N 51.8°E	30-60	Air
JOE IX	3 Oct 54	Semipala-tinsk	20	--

TABLE VIII
(Continued)

NO.	DATE	LOCATION	YIELD (KT)	BURST HEIGHT
JOE X	5 Oct 54	Semipala-tinsk	45	Possi-bly over 20,000
JOE XI	8 Oct 54	"	20	--
JOE XII	23 Oct 54	"	70	Air
JOE XIII	26 Oct 54	"	7	Air or Tower
JOE XIV	30 Oct 54	"	25	Air
JOE XV	29 July 55	"	4	--
JOE XVI	2 Aug 55	"	30	Poss. over 20,000
JOE XVII	21 Sept 55	Novaya Zemlya 70.6°N 54.2°E	~20	Under-water

TABLE VIII
(Continued)

NO.	DATE	LOCATION	YIELD (KT)	BURST HEIGHT
JOE XVIII	6 Nov 55	Semipala-tinsk	215	1500-8000
JOE XIX	22 Nov 55	"	1600	3000-10,000
JOE XX	2 Feb 56	Unknown	< 20	--
JOE XXI	16 Mar 56	Semipala-tinsk	40	Tower or surface
JOE XXII	25 Mar 56	"	10	--

* Greater than one fireball radius above the ground
~ Approximately

PART TWO

PROBABLE SOVIET CAPABILITIES AFTER 1955

I. THE FUTURE FISSIONABLE MATERIAL PRODUCTION PROGRAM

69. Soviet capabilities to expand fissionable material production are believed to be primarily dependent upon the over-all effort they are willing to devote to such expansion rather than on the availability of raw materials such as uranium ore. The estimate of future fissionable material production is based upon the assumption that the USSR will continue this program at the present high priority; however the relative emphasis given to each fissionable material is dependent upon Soviet decisions, plans and requirements. Therefore the estimate must be considered to have very wide margins of possible error.

70. Uranium Ore Procurement. The US Geological Survey estimates that the Soviet Bloc has several hundred thousand tons of uranium in medium grade ore deposits and an even greater quantity in low grade deposits. Even if these estimates were twice as high as actual Soviet ore reserves, the Soviet Bloc could double or triple its present ore production without recourse to less economical ore recovery processes than they are now using. If it is assumed that the present estimated rate of expansion of non-German ore production facilities, i.e., 7.5% per year, (see Table III) continues through 1966, a reasonable estimate of Soviet Bloc ore production would be as tabulated below, using median figures rather than a range of possible values. It is unlikely that the actual cumulative production will be less than three-quarters of the values shown and ore production could be considerably higher if more uranium ore is needed. This estimate of Soviet Bloc ore production will adequately support the estimated expenditure of natural uranium through mid-1966.

TABLE IX

ESTIMATED FUTURE SOVIET BLOC ORE PRODUCTION
IN METRIC TONS RECOVERABLE URANIUM

Year	Annual Production	Cumulative Production (Rounded)	Year	Annual Production	Cumulative Production (Rounded)
1946	140	400	1957	5,550	35,000
1947	455	850	1958	5,960	41,000
1948	890	1,750	1959	6,410	47,500
1949	1,515	3,250	1960	6,890	54,500
1950	2,025	5,300	1961	7,410	61,500
1951	2,610	7,900	1962	7,960	70,000
1952	3,255	11,100	1963	8,560	78,500
1953	3,865	15,000	1964	9,200	87,500
1954	4,470	19,500	1965	9,890	97,500
1955	4,820	24,500	1966	10,640	108,000
1956	5,160	29,500			

71. Uranium Isotope Separation. Future Soviet production of uranium-235 has been based upon projected estimates of electric power available for uranium isotope separation and of average operating efficiencies of the Soviet uranium isotope separation plants. It is not believed that the Soviets will continue to increase the efficiency of their gaseous diffusion plants at the rate they are estimated to have achieved during the 1950 through 1955 period. The poor efficiencies of early plants left much room for improvement during that period, and the abundance of ore permitted the more efficient, from the standpoint of kg product per MW electric power consumed, minimal stripping of natural uranium. If the estimate of Soviet Bloc uranium ore production is essentially correct, the Soviets may not need to strip below 0.4% U-235 tails concentration until some years after 1961. However, in view of the Soviet practice of maintaining large uranium ore stockpiles it was assumed that the tails concentration decreased to 0.4 by 1961 and to 0.3 by 1965. Thus, although further improvements in Soviet plant design can be expected, the power expended for the assumed additional stripping of tails will counteract the benefits gained through improved technology. Thus the estimated Uranium-235 production could be considerably greater or smaller than given, if either the derived plant efficiencies or the electric power made available for isotope separation should be significantly different from the estimated values.

TABLE X

ESTIMATED SOVIET PRODUCTION OF URANIUM-235 FOR ALL PURPOSES 5/

Mid-Year	Tails Concentration (%)	Cumulative Production of 90% Material or Equivalent (Kilograms)
1950	0.5	--
1951*	0.5	50
1952	0.5	750
1953	0.5	2,100
1954	0.5	4,600
1955	0.5	9,300
1956	0.5	16,000
1957	0.5	26,000
1958	0.5	38,500
1959	0.5	53,500
1960	0.5	71,000
1961	0.4	92,000
1962	0.4	116,500
1963	0.4	145,500
1964	0.4	176,000
1965	0.3	211,000
1966	0.3	249,000

* Plant operating only last few months of fiscal year.

5/ The Deputy Director for Intelligence, The Joint Staff believes that the new intelligence does not adequately support estimate of U-235 cumulative production through 1955. The estimate of efficiency of Soviet isotope separation operations is composed of scant specific intelligence information and uncertain assumptions as to when certain improvements were made in Soviet plants. Due to the many, varied and complex uncertainties involved, a more practical figure for planning purposes of cumulative U-235 production through 1955 would be one in the lower range of uncertainty, approaching the minus 50% lower limit. (Footnote 5/ continued on page 34)

72. Power Reactor Program. The very large electric power reactor program announced for the Sixth Five-Year Plan and the still greater expansion indicated as planned after 1960, will have a major impact on future fissionable material stockpiles both as a consumer of Uranium-235 and as a producer of plutonium, Uranium-233, and tritium.

a. The Sixth Five-Year Plan includes a reactor generating capacity of 2,000 to 2,500 electrical megawatts in operation by the end of 1960, and further information indicates that a total of 25,000 electrical megawatts is being considered as the goal over the next twenty-five years. Analysis of Soviet public statements on the Soviet Power Reactor Program provides the estimate of the Soviet nuclear electric power program given in Table XI. It is considered that the announced Soviet program for approximately 2,500 electrical megawatts of nuclear power by 1960 is possible of attainment with a very high priority effort, but the specific reactor program in Table XI requires the solution of several difficult engineering problems.

b. Academician Kurchatov outlined the Soviet plan to construct seven different types of experimental power reactors in the period 1956-1960. Three of these reactor types are to be incorporated in four, or possibly five, power stations. All are apparently to be fullscale prototypes. Four small-scale experimental reactors were also described. These would tend to round out the Soviet reactor development program. The Soviet Five-Year Plan nuclear power program is a substantial one, working toward the future when nuclear power would be economically competitive with conventional power costs in the European USSR. During the period 1959 to 1960 the USSR proposes to put into operation

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5/ (Footnote 5/ continued from page 33) The same reasons, plus a lack of intelligence on Soviet plans and programs in the atomic energy field, lead him to conclude that the estimate of U-235 available by mid-1959 and subsequent dates reflects projections and extrapolations under very uncertain conditions, rather than a valid figure for planning purposes.

The above conclusions are applicable throughout the remainder of this estimate whenever estimates of U-235 or weapons fabricated from this metal are discussed.

five large power stations of 400-600 electrical megawatts each in order to accumulate experience in: nuclear engineering, mass production of fuel elements, and fuel processing. These reactor types are outlined in Table XI.

c. The USSR has indicated in some detail the designs of the proposed graphite moderated, water-cooled reactor type and the gas-cooled, heavy-water moderated reactor type. The water moderated and cooled reactor, which could use slightly enriched uranium in a pressurized system has many favorable features. However, there appear to be formidable technical difficulties in the construction of an appropriate pressure vessel for a reactor of this type, which may prevent the USSR from attaining the announced reactor power level. The Soviets have not indicated how they propose to meet such problems.

d. A comprehensive outline of the planned Soviet nuclear electric power program is not available. However, it is estimated that the general objectives of this power program are:

(1) to be "first in the world" in installed nuclear electrical kilowatt capacity.

(2) to produce fissionable materials.

(3) to gain experience directed toward future achievements of economically competitive electric power.

e. These objectives lead to the conclusions that the large power stations (400-600 electrical megawatts) will probably be designed either for dual-purpose power (optimized for plutonium production) or for optimum power production. These large power reactors will be full-scale developmental prototypes for the succeeding Five-Year Plans. The graphite-moderated, water-cooled reactor station and possibly the two water-moderated and cooled reactor stations, utilizing high cost fuel (enriched uranium) will probably be optimized for power production. The dual-purpose reactors would employ low cost fuels such as natural uranium. It is probable that the Soviets would optimize the gas-cooled, heavy water-moderated reactor and the unspecified fifth station type reactor for plutonium production. This distribution would minimize the enriched uranium requirements and maximize the plutonium production from the Soviet power program. The cost of heavy water would tend to keep the utilization of heavy-water type reactors at a minimum. In addition, the Soviets may not, owing to technical difficulties, be able to develop water moderated and cooled reactors of the planned capacity. Therefore, it is possible that they may substitute for this reactor type in order to meet their total announced power output, other types of reactors such as graphite-moderated, gas-cooled reactors, optimized for plutonium production, thereby further increasing estimated over-all plutonium production. The possible range of installed electrical capacity devoted to each major type of reactor is given in Table XII.

TABLE XI

SOVIET POWER REACTORS

No. of Stations	Reactor type	Fuel
	Large Scale Stations	
2	Water moderated & cooled	Enriched Uranium
1	Graphite-moderated, steam & water-cooled (similar to Atomic Power Station of Acad. of Sciences, USSR)	Enriched Uranium
1	Heterogeneous, gas-cooled, heavy water-moderated	Natural Uranium
1	(Unspecified)	
	Pilot Plant Stations	
1	Fast Plutonium Breeder	Plutonium
1	Homogeneous Heavy-Water Thorium Breeder	U-233
1	Sodium-cooled, Graphite-moderated	Enriched Uranium
1	Boiling Water	Enriched Uranium

TABLE XII

USSR ATOMIC POWER PROGRAM

	Nuclear Electric Power (Electrical megawatts)
Large Power Stations	
Developmental Capacity - 400-600 EMW (200 EMW per reactor)	
Dual Purpose Stations	800-1400
Plutonium Production with some power Low cost fuel (natural uranium or U-235 seed core)	
Optimized Power Stations	1400-800
Power production with some plutonium High cost fuel (Enriched uranium)	
Pilot Plant Stations	200-300
Experimental Capacity 50-70 EMW per reactor	
TOTAL EMW	2400-2500

73. U-235 Requirements of Power Program. Lacking precise information we have estimated the U-235 (90% equivalent) sacrifice by assuming that approximately half of the reactors utilize enriched uranium (2.5 - 3.0% U-235) with fuel requirements approximating those of the graphite moderated, pressurized light water cooled reactors similar to the best known current Soviet power reactor type. On this basis it has been calculated that the total U-235 (90% equivalent) inventory, including feed on hand and being recycled, would be roughly 400 kilograms per 100 megawatts of generating capacity. A thermal efficiency of 20% has been assumed on the basis of stated Soviet desire to increase the approximately 16% thermal efficiency of the Obninskoye reactor. The uranium-235 burn-up has been calculated by applying a burn-up factor of 125

kilograms of 90% U-235 equivalent per 100 electrical megawatt years. The use of these assumptions and calculations leads to the following table of uranium-235 expenditure. The cumulative estimate of 90% equivalent presented in Table XIII as expended or tied up in the nuclear power reactor program is subject to considerable variations, depending on Soviet plans for different reactor designs and variation in pipeline inventory requirements. If the Soviets install more than one-half of the announced electrical power capacity in natural uranium reactors, then the quantity of 90% U-235 required would be reduced. The pipeline inventory requirements utilized in this estimate, although based in part on Soviet statements of fuel requirements, are tight. A more flexible or generous pipeline inventory or difficulties being encountered in the separation process could almost double the total inventories outlined. Thus, the actual quantity tied up in the power reactor program could vary anywhere from about one-half to approximately twice the values presented.

TABLE XIII

ESTIMATED USE OF URANIUM-235 IN THE SOVIET POWER REACTOR PROGRAM

Date	Total EMW Installed	EMW in Enriched Reactors	U-235 Inventory in Reactors & Recycling Systems in Kilograms	Cumulative U-235 Burn-up in Kilograms of 90% Equivalent	Cumulative Total 90% U-235 Equivalent Expended or Tied-up in Reactor Program (Kilograms)
End 1958	400	200	800		800
Mid 1959	800	600	2,400	125	2,600
End 1959	1200	1000	4,000	500	4,500
Mid 1960	1600	1200	4,800	1,125	5,900
End 1960	2000	1400	5,600	1,875	7,500
Mid 1961	2500	1600	6,400	2,750	9,200
Mid 1962	3500	2000	8,000	4,750	12,800
Mid 1963	4500	2500	10,000	7,250	17,300
Mid 1964	5500	3000	12,000	10,375	22,400
Mid 1965	6500	3500	14,000	14,125	28,100
Mid 1966	7500	4000	16,000	18,500	34,500

74. The quantity of plutonium which can be produced in the reactor program cannot be accurately calculated since little is known of the specific characteristics of the reactors to be built. Nor do we know the specific timetable under which the USSR will carry out its program. An estimate of plutonium to be produced has been made, assuming that about one-half of the installed capacity will be in dual-purpose reactors and that one-half of the reactors will be optimized for power production. Table XIV gives the estimated total installed electrical megawatts and power reactor plutonium production. The plutonium production has been estimated by assigning to these reactors characteristics and operating conditions consistent with what is known of Soviet reactor technology. The plutonium obtained from the reactors optimized for power production, which amounts to about one-third that provided in Table XIV, will be less suitable for some weapons applications. The values presented in Table XIV could vary by a considerable factor if the Soviets fail to meet their announced goals, depart from the assumed operating conditions, or vary the ratio of dual purpose to optimized power reactor construction.

TABLE XIV

ESTIMATED PLUTONIUM PRODUCTION FROM POWER REACTOR PROGRAM
(Kilograms)

Date	Total EMW Installed	Annual Plutonium Production	Cumulative Plutonium Production (Rounded)
End 58	400	--	--
Mid 59	800	245	245
Mid 60	1600	1230	1,475
Mid 61	2500	2215	3,690
Mid 62	3500	3390	7,100
Mid 63	4500	4640	11,700
Mid 64	5500	5850	17,500
Mid 65	6500	7080	24,500
Mid 66	7500	8300	33,000

75. Plutonium Production. The present Soviet plutonium program is estimated to be capable of producing about 550 kilograms of plutonium (or equivalent in tritium and/or uranium-233) per year. It is estimated that this program has been expanding for the past four years at an average rate of approximately 100 kilograms per year added production capability. It is assumed that this expansion rate will continue on the average through mid-1959 when it is estimated that significant plutonium production from the power reactor program will first appear. It is further assumed that further expansion of plutonium production facilities will be limited to the production capability of the power reactor program after mid-1959. On the basis of these assumptions the following plutonium production may be predicted.

TABLE XV

ESTIMATE OF TOTAL PLUTONIUM PRODUCTION
(Kilograms)

Mid-Year	Cumulative Production
1949	10
1950	25
1951	115
1952	330
1953	700
1954	1200
1955	1750
1956	2400
1957	3150
1958	4000
1959	5200
1960	7400
1961	10,500
1962	15,000
1963	20,500
1964	27,500
1965	35,500
1966	44,500

76. Future Fissionable Material Production. The estimate of future Soviet availability of fissionable materials for weapon purposes is tabulated below. The uranium-235 estimated available for weapons is the estimated total production of uranium-235 minus the estimated use of uranium-235 in the Soviet power reactor program. The "plutonium" estimate represents the estimated total of plutonium equivalent from both production and power reactor programs. Our estimates of future U-235 and plutonium production are subject to many variables which are dependent on Soviet plans and decisions and are therefore less reliable than the estimates of the cumulative production up to 1956.

TABLE XVI

ESTIMATE OF AVAILABILITY OF FISSIONABLE MATERIALS FOR WEAPON USES
(Kilograms)

Mid-Year	Cumulative U-235 Available for Weapons	Cumulative Plutonium Equivalent Available For Weapons
1949	--	10
1950	--	25
1951	50	115
1952	750	330
1953	2,100	700
1954	4,600	1,200
1955	9,300	1,750
1956	16,000	2,400
1957	26,000	3,150
1958	37,700	4,000
1959	50,900	5,200
1960	65,100	7,400
1961	82,800	10,500
1962	103,700	15,000
1963	128,200	20,500
1964	153,600	27,500
1965	182,900	35,500
1966	214,500	44,500

II. NON-MILITARY USES AFTER 1955

A. Nuclear Power Program After 1955.

77. The Soviet nuclear electric power program, which is of considerable magnitude, appears designed to establish a claim for world leadership in this field. The Soviet Union is engaged in design and development of almost a dozen types of reactors ranging in power from 50 to 200 EMW for the production of electric power as part of the 1956-60 Five-Year Plan. This program, which calls for a total capacity of 2000-2500 megawatts of electric power, is within Soviet capability, but will require a high priority effort for its achievement. One small reactor began producing electric power from nuclear energy in June 1954, and has been given wide publicity by the USSR as the "first in the world". This reactor, while inefficient, is useful for experimental studies of power reactor operation. The Soviet nuclear electric power program, assuming continuing expansion, will require an increasingly greater percentage of the total uranium-235 available, but will produce as a by-product plutonium or possibly U-233 and tritium.

B. Soviet International Atomic Energy Activities

78. Beginning in mid-1955, the USSR has taken a more active role in international atomic energy activities and has shown a readiness to use its atomic energy resources for political objectives. Within the Bloc the USSR has entered into agreements to supply Communist China and each of the European satellites, except Albania, with a research reactor, a 25-Mev cyclotron, radioactive isotopes, and technical training. The agreements call for furnishing a research reactor of 6,500 thermo kilowatts to the Chinese and 2,000 thermo kilowatts reactors to the others. Details of the agreements are not known, but it is indicated that raw materials will be sent to the USSR in return. Radio Prague announced in September 1955 that an atomic power station will be built in Czechoslovakia with Soviet help during the second Czech 5-Year Plan (1956-1960). Establishment of a Joint Nuclear Research Institute in Moscow was announced on March 26, 1956. All members of the Sino-Soviet Bloc will participate and it was announced that membership would be open to non-Bloc nations.

79. Outside the satellites, the USSR has agreed to provide assistance to Yugoslavia in constructing a research reactor and in training Yugoslav technicians. Limited offers of training and radioisotope assistance have been made to India, Egypt, Indonesia and Iran. Slightly enriched uranium in research reactor quantities was offered to Norway in early 1956.

80. There has been increased Soviet participation in international meetings during the past year. The USSR participated in the United Nations Conference on Peaceful Uses of Atomic Energy at Geneva. In June 1955 the Soviets invited scientists from the Free World to a conference in Moscow on the peaceful uses of atomic energy.

81. In July 1955 Premier Bulganin announced in Geneva that the USSR was prepared to contribute fissionable material to an acceptable International Atomic Energy Agency when established. In April 1956 the USSR agreed to the draft Statute of the proposed International Atomic Energy Agency along lines proposed by the US.

82. The announced Soviet program of atomic aid to the satellite nations, proposed in January 1955, should be largely fulfilled by 1961. Construction of research reactors will probably be completed in East Germany, Czechoslovakia, Poland, Hungary, Communist China and possibly in Bulgaria and Rumania. It is estimated that the program may be expanded to include reactors capable of producing electric power on an industrial scale after 1960. Further offers of aid to nations outside the Bloc can also be expected in order to gain political advantage.

III. NUCLEAR PROPULSION PROGRAM AFTER 1955

83. Soviet research in application of nuclear reactors to electrical power generation and in the production of fissionable material is applicable, at least in part, to a nuclear propulsion program. Versions of the pressurized-water, the liquid-metal, the gas-cooled and the homogeneous-boiling types of reactors could be adapted to some types of nuclear propulsion.

84. Liquid and Gas-Cooled Reactor Experiments. In December 1952 the first "loop" for testing fuel elements of power reactors with water cooling under high pressure was completed with the test reactor

operating at full power of 10,000 KW. Later, two loops were started to investigate constructional elements of reactors with water cooling under high pressure and with liquid metal cooling. Two additional loops were then placed in operation to test fuel elements of the nuclear power reactors with air and water cooling under working conditions. These last two loops were probably started in late 1953 or early 1954. For these reasons, late 1953 - early 1954 is taken as the date of completion of the feasibility study of this type reactor.

85. Homogeneous Boiling Type Reactor. The paper the Soviets presented at Geneva on this type reactor appears to be a recently completed typical feasibility study for electric power. Research and development of this type applies equally well to reactors for nuclear propulsion as well as for breeding. In view of this fact, it is reasonable to suppose that the date a feasibility study was completed for a reactor used for electric power could very closely coincide with the corresponding completion date for a study on a reactor for nuclear propulsion.

86. Applications of Nuclear Propulsion by the Soviet Navy. The USSR exhibited an interest in nuclear propulsion for naval transports as early as 1948. Publications in 1955 and 1956 have confirmed this interest in nuclear powered transport ships and also mentioned submarines and ice breakers. The 1956-1960 Five-Year Plan calls for "...work on the creation of atomic power installations for transport purposes: To build an ice breaker with an atomic engine....". The ice breaker is stated to be of the 44,000 HP and 16,000 tons displacement class. The pressurized-water, liquid-metal, gas-cooled or homogeneous-boiling type reactors could be adapted for use in naval propuslion units. The time necessary to develop a nuclear propulsion unit for surface vessels is considered to be somewhat shorter than the time required to develop one for submarine propulsion. It is not known if or when any of these types of reactors will become available for use in nuclear propulsion. It is estimated that a nuclear propulsion program began about the time the USSR realized that suitable reactor types were feasible. On the basis of this estimate and interpreting the research that is known to have been taking place in the USSR it is estimated that:

a. A nuclear propulsion reactor for a surface ship could be produced in 1956.

b. A nuclear propulsion reactor for a submarine could be produced in 1956-57.

87. Application of Nuclear Propulsion by the USSR Air Force. There is no evidence of Soviet Air Force activities related to nuclear propulsion for aircraft other than the May 1956 statement by E. P. Slavsky, Director of the Main Administration For the Use of Atomic Energy, that the Soviets "have every possibility of building, in the not too distant future, an aircraft with an atomic motor". Some of the research known to have been conducted by the USSR could apply appropriately to nuclear propulsion for aircraft. It is assumed that a nuclear propulsion program for aircraft began when it was realized by the USSR that certain reactors could be utilized for this purpose. No information is available on Soviet development of nuclear proulsion systems for long range ballistic missiles. It is estimated that a aircraft nuclear reactor propulsion program, to date, probably has not progressed far into the research phase and probably will not progress beyond this phase prior to 1958.

88. Other Applications of Nuclear Propulsion. There have been a few press discussions concerning the application of nuclear propulsion for automobiles and trains; evidence indicates that these applications are not considered seriously by the USSR at this time.

IV. FUTURE WEAPON DEVELOPMENT AND TEST ACTIVITIES

89. Future Soviet weapons development and test activities must be estimated by extrapolating present Soviet capabilities, as revealed by the USSR's test program.

90. We believe that the Soviets will only stockpile significant numbers of weapons which are similar but not necessarily identical with those tested. Major improvements in weapon design or anticipated yields will probably be tested before stockpiling.

91. Possibility of Multi-Megaton Experiments. With the detonation of JOE XIX, a thermonuclear weapon yielding 1.6 megatons, the Soviet nuclear weapons development program has reached the point where fabrication of multi-megaton weapons may be accomplished

by the extension of techniques which led to the development of this weapon. A test of a multi-megaton weapon may occur in any of the future Soviet test series for the purpose of optimizing weapon design and of diversifying weapon types. However, unless radical design changes are involved, the absence of such a test will not preclude the Soviet stockpiling of multi-megaton weapons on an emergency or provisional basis. In general, future Soviet nuclear weapons tests will probably be directed primarily toward the development of smaller-dimension and higher-yield weapons to increase the flexibility of weapons delivery systems.

92. Requirements for Continued Testing In the Soviet Nuclear Weapons Program. The Soviet test program has already provided sufficient data for the rapid and successful development of a variety of nuclear weapons types. We believe that the majority of the 22 Soviet nuclear detonations detected by the US have been primarily weapons development tests, although military interest in weapons effects tests is evident in the Totskoye test of 1954 and the underwater test near Novaya Zemlya in 1955.

93. Possible Effect of a Test Moratorium on the Weapons Program. In our view, further development type tests would be considered desirable by Soviet scientists for the purpose of optimizing existing weapon designs and would be necessary to establish the feasibility of new principles of design. However, we believe that if a test moratorium were imposed the Soviets could satisfy, with acceptable but not optimized nuclear assemblies, their major military requirements for weapons, including warheads for all types of missiles, without further nuclear weapons tests.