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SOVIET CAPABILITIES AND PROBABLE PROGRAMS IN THE GUIDED MISSILE FIELD

CIA HISTORICAL REVIEW PROGRAM
RELEASE IN FULL

Submitted by the

DIRECTOR OF CENTRAL INTELLIGENCE

The following 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, and The Joint Staff.

Concurred in by the

INTELLIGENCE ADVISORY COMMITTEE

on 5 October 1954. Concurring were the Special Assistant, Intelligence, Department of State; the Assistant Chief of Staff, G-2, 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 to the Director, Federal Bureau of Investigation, abstained, the subject being outside of its jurisdiction.

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* See footnote to paragraph 9.

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SOVIET CAPABILITIES AND PROBABLE PROGRAMS IN THE GUIDED MISSILE FIELD

THE PROBLEM

To estimate Soviet capabilities and probable programs in the field of guided missiles.

FOREWORD

In preparing this estimate we have had available conclusive evidence of a great postwar Soviet interest in guided missiles and indications that the USSR has a large and active research and development program. However, we have no firm current intelligence on what particular guided missiles the USSR is presently developing or may now have in operational use. Therefore, in order to estimate specific Soviet missile capabilities we have been forced to reason from: (a) the available evidence of Soviet missile activity, including exploitation of German missile experience; (b) our own guided missile experience; and (c) estimated Soviet capabilities in related fields. In addition, we have analyzed such factors as: (a) Soviet industrial resources and economic capabilities; (b) Soviet nuclear capabilities in relation to guided missiles; (c) the estimated reliability of missile systems; (d) various logistic and training factors; and (e) Soviet capabilities in geodesy and cartography. Finally, in the absence of current evidence on specific Soviet missile projects, we have estimated Soviet intentions on the basis of probable Soviet military requirements, within the context of probable Soviet capabilities in this and other weapons fields. Therefore our estimates of missile characteristics and of dates of missile availability must be considered as only tentative, and as representing our best assessment in the light of inadequate evidence and in a new and largely unexplored field.

CONCLUSIONS

GENERAL CONCLUSIONS

1. We believe that the strategic requirements of the USSR would dictate a major effort in the field of guided missiles, and the evidence which we have concerning large number of personalities and activities believed to be involved in the current Soviet missile program leads us to the conclusion that it is an extensive one. However, our evidence is insufficient to permit a more precise estimate as to the magnitude of this program.

2. On the basis of our extensive knowledge of Soviet exploitation of the wartime German missile experience and our estimate of Soviet capabilities in related fields, we believe that the USSR has the basic scientific and technical capabilities

to support a comprehensive missile research and development program.

3. The USSR also has an adequate economic base for a sizeable missile production program. However, because of the limited capabilities of the Soviet electronics and precision mechanisms industries and other competing demands for their output, the USSR will almost certainly be unable to produce in the desired quantities all of the missiles for which it has an estimated military requirement, except over an extended period of years. Consequently, the USSR will probably concentrate over the next few years on those missiles for which it has the most urgent military requirements.

4. Over the next several years the increasing size of the Soviet nuclear stockpile and the larger yields estimated to be available from nuclear warheads will make missiles an increasingly practicable means of nuclear attack, despite their limitations in reliability and accuracy.[1] Nevertheless, because of these limitations we believe that the Soviets will place primary reliance on aircraft delivery of nuclear weapons so long as the Soviet stockpile remains limited and Allied air defenses can be penetrated without unacceptable losses. We recognize, however, that these considerations would not preclude earlier employment of nuclear missiles when the advantages of surprise or other factors so dictate.

5. Although we have no evidence to confirm or deny current Soviet missile production, we believe that the Allies will face a growing Soviet guided missile threat within the next several years. This threat will probably appear first in increased Soviet air defense capabilities, together with or followed by improved Soviet capabilities against US and Allied coastal areas and sea lines of communication and in tactical operations. Later the threat will probably extend to all Allied base areas in Eurasia, and ultimately to the entire US. The following dates for specific missile capabilities give the earliest probable dates when we estimate the threat could begin, but it should be recognized that an additional varying period of time would be required for these missiles to be available in large quantities.

SPECIFIC MISSILE CAPABILITIES

6. *Surface-to-Air Missiles.* The Soviets will probably devote highest priority to producing surface-to-air missiles to overcome their serious air defense deficiencies. We estimate that they could now have an all-weather improved Wasserfall design and in 1955[2] a further improved version

[1] See Annex C, *Restricted Data*, for estimates of time-phased warhead yields.

[2] The estimated dates given in this estimate are the earliest probable years during which small quantities of missiles could have been produced and placed in the hands of trained personnel of one operational unit, thus constituting a limited capability for operational employment. These dates are based on the assumption that a concerted and continuous effort began in 1948. If no major delays of any sort were encountered and an intensive effort of the highest order of priority were undertaken, the earliest possible dates of availability could be on the order of one to two years earlier, or as much as three years in the case of the "intercontinental ballistic missile." The above dates are those around which the missile could have been operationally tested and be ready for series production. However, an additional period (which would vary according to missile type) would be required before missiles could be produced in quantity and the necessary units trained and deployed. We estimate that at least an additional six months would normally be required for shift or conversion from pilot plant to series production, and an additional period to reach the planned production rate. Some 18 months to two years would probably be required for individual and unit training of each operational unit, although this period could to a considerable extent overlap the production period.

with semiactive homing. In 1957–1958 they should be capable of having a much better missile with terminal homing and 50,000 yards slant range at 60,000 feet altitude. The low yield nuclear warhead probably available for this missile in 1958 would greatly increase the kill probability.

7. *Air-to-Air Missiles.* Because of its air defense weaknesses, the USSR will probably also assign a very high priority to air-to-air missiles. We estimate that it could develop in 1955 a guided rocket with infrared homing and in 1955–1958 an improved version with greater range. However, their guidance system would permit only tail cone attacks under generally fair weather conditions at the engagement altitude. In 1958–1960 the USSR could probably have a new all-weather missile.

8. *Air-to-Surface Missiles.* The USSR also would almost certainly seek to produce in quantity any precision weapon available for effective HE antiship attacks. For this purpose it could now have available and would probably produce a rocket-propelled glide bomb, although limited to good visibility conditions. In view of its extensive bomber capabilities, we do not believe that the USSR would produce a long-range air-to-surface missile for attacks on Allied ports and bases over the next several years. In 1960, on the other hand, when we estimate that an all-weather air-to-surface missile with nuclear warhead could be ready for series production, there will probably be a high priority Soviet requirement for a weapon of this type because of the increased effectiveness of Allied air defense around key target areas.

9. *Submarine-Launched Missiles.* The USSR will almost certainly have a requirement for submarine-launched missiles for nuclear attacks on US and Allied coastal areas. It could already have available improved V–1 types with nuclear warheads. In 1955 the USSR could have ready for series production a turbo-jet pilotless aircraft[3] with improved range, speed, and accuracy, and by 1958 its nuclear warhead yield could approach compatibility with its estimated accuracy and greatly increase its effectiveness.

10. *Ground-Launched Surface-to-Surface Missiles.* The USSR could also use the above pilotless aircraft from ground-launchers. However, we believe that it would favor ballistic missiles because of their relative immunity to presently known countermeasures and their greater capability for achieving surprise. The USSR probably could have available: (a) in 1954 an elongated V–2 type with 350 nautical miles range and a CEP of two nautical miles[4] or an alternative V–2 type or native design with less range but a larger warhead and a smaller CEP; (b) in 1955 an elongated V–2 type with 500 miles range and a CEP of 2.5 miles; in 1957 (or at the earliest possible date in 1955) a single stage ballistic missile with 900 miles range and a CEP of three–four

[3] The Assistant Chief of Staff, G–2, Department of the Army, the Director of Naval Intelligence, and the Deputy Director for Intelligence, The Joint Staff, believe that use of the term "pilotless aircraft" to define the broad category of guided missiles which are not ballistic in principle is misleading in that it gives the impression that all such missiles are conventional aircraft which have been modified to the extent that the human pilot has been replaced by the guidance equipment and which are intended to return to their bases and land. They believe that the term "nonballistic guided missile" would more adequately describe this category of missiles and should be used in lieu of "pilotless aircraft" wherever that term occurs.

[4] CEP (Circular Probable Error) means 50 percent hits within the stated radius. All CEPs and ranges are given in nautical miles.

miles; and (d) in 1959 (or at the earliest possible date in 1957) a two stage missile with 1,300 miles range and a CEP of three–four miles.[5] However, the accuracy of all these missiles would probably be markedly inferior to that obtainable by either visual or radar bombing, and their range is inferior to that of Soviet bombers. Therefore, until Allied air defenses improve greatly, we believe that the USSR will rely primarily on high performance bombers, except for all-weather use in the ground battle.

11. In view of growing Allied tactical nuclear capabilities in Europe, the USSR will probably give high priority to a ballistic missile for support of its field forces. Aside from this missile, Soviet efforts over the next several years will probably be concentrated more on ballistic missile development than upon quantity production. When the USSR estimates that improved Allied air defenses will soon pose a major threat to successful delivery by aircraft, it will probably undertake a heavy investment in these missiles. However, the limited nuclear yields now available from such warheads and the limited accuracy and reliability of these missiles point toward use of aircraft as a better means of delivery at least until 1958. Moreover, by this time estimated increases in the Soviet nuclear stockpile and in nuclear warhead yields should have greatly reduced the significance of the limitations of missile accuracy or reliability.

12. *Intercontinental Ballistic Missile (IBM).* We believe that the USSR, looking forward to a period, possibly in the next few years, when long-range bombers may no longer be a feasible means of attacking heavily defended US targets, will make a concerted effort to produce an IBM. In this event it probably could have ready for series production in about 1963 (or at the earliest possible date in 1960) an IBM with a high yield nuclear warhead and a CEP of roughly five nautical miles.[6] Advent of the IBM would create an entirely new type of threat to the US. Attacks upon the launching sites are the only countermeasures now known or in prospect. If the USSR should develop such a missile and produce it in considerable numbers before the US developed adequate counterweapons or countermeasures, the USSR would acquire such a military advantage as to constitute an extremely grave threat to US security.

DISCUSSION

I. SOVIET SCIENTIFIC AND TECHNICAL RESOURCES

Basic Soviet Scientific and Technical Capabilities

13. *Trained Manpower.* The rising general level of technical ability in the USSR and the increasing number of scientists and engineers available provide the manpower potential necessary to staff a large guided missile program. At the end of World War II, the USSR had an acute shortage of trained manpower and to help alleviate this condition brought about 3,500 German scientists and technicians to the USSR. Beginning at the same time, graduations from Soviet science and engineering institutions were greatly increased,

[5] See footnote to paragraph 6.

[6] See footnote to paragraph 6, but note that in the case of the IBM, operational firing of limited numbers might be conducted by factory technicians at the assembly site, and the full 18 months to two-year training period for missile units would not be required.

and returned Germans report that by the time they left the USSR the quality and quantity of Soviet scientists had markedly improved. At present the USSR has some 1,035,000 science and engineering graduates working in their specialities, nearly as many as the US, and is increasing this pool at a greater rate than the US.

14. *Research Equipment.* In the immediate postwar period lack of adequate research equipment was a handicap to any Soviet guided missiles program, but from 1947 to 1950 there was also reported to be a substantial improvement in this respect. In view of the demonstrated Soviet ability to equip research programs in electronics, aircraft, and nuclear energy, we believe that the USSR could now have equipped laboratory and test facilities for a large scale guided missile research program.

15. *Materials, Including Propellants.* Analyses of materials taken from operational Soviet aircraft, electronic, and other equipment demonstrate Soviet ability to produce unique materials for special application of a quality generally comparable to their US counterparts. Currently published Soviet literature reveals advanced research in such fields as metallurgy and chemistry. We have no knowledge of special materials developed specifically for guided missiles but we believe that the Soviets can develop the materials necessary to carry on a successful program. For example, the Soviets are cognizant of German missile propellants through their exploitation of German scientists, facilities, and specialized equipment. Based on this knowledge, combined with demonstrated native capabilities, the Soviets appear capable of developing those propellants required.

16. *Availability of US Data.* The unclassified information available to the USSR on the US guided missile program discloses in considerable detail the extensive US program in this field, the relative emphasis accorded various types of US missiles, and many of the technical characteristics of the missile systems being developed. Both Tass and the Four Continent Book Corporation have acquired a vast number of US publications for transmittal to the USSR. Soviet officials in this country have overtly obtained information on the US missile program including, for example, motion pictures of the Matador and Nike taken in May 1954. While we cannot assess the degree of success obtained by Soviet covert activities in this field, we do know that considerable material was available in the early postwar years. A Soviet defector, whose information has proven generally reliable, stated that in 1947 he presented a lecture on the latest US missile developments including details of the US Gorgon II missile (which was classified confidential in the US). The Julius Rosenberg spy ring is believed to have transmitted some guided missile information to the USSR.

17. Therefore, proper evaluation of the US guided missile information available to the USSR could indicate the course, nature, and many of the details of our guided missile research and development efforts, provide an indication of our successes and failure, save the USSR considerable time and money, and assist it in establishing its military requirements.

Soviet Exploitation of the German Program

18. The USSR had no known guided missile program at the close of World II. However, the Soviets then initiated a thorough and systematic exploitation of German guided missile personnel, facilities, and equipment. They obtained four general results: (a) the acquisition of operational and prototype missiles, research and production facilities and equipment, and approximately 400 missile specialists; (b) completed studies of German achievements prior to 1946; (c) the familiarization of Soviet personnel with German techniques of research, development, testing, and production of missiles and their components; and (d) further technical studies and limited hardward development performed by German scientists. We believe that the Soviet exploitation program was an effort to acquire equipment and techniques peculiar to the guided missile field in which the Soviets had little or no experience.

19. Indications are that as a result of the foregoing exploitation the Soviets acquired a thorough familiarity with the German program by 1948, and were capable of conducting some independent guided missile development. By 1950 they were phasing out the Germans and apparently felt themselves capable of conducting a native program, with the exception of some advanced guidance and control systems. Of the roughly 400 known German guided missile specialists used by the Soviets, only about 50, mainly guidance and control specialists, still remain in the USSR.

Organizations and Facilities in the Soviet Program

20. In addition to our knowledge of Soviet exploitation of German resources, we have considerable intelligence leading to the conclusion that numerous Soviet facilities and personnel are probably engaged in a missile program. These facilities are spread through seven all-union ministries, and their work is supported by certain personnel and departments of the Academy of Sciences, USSR (see chart).[1] We believe that the USSR would tend to pursue a centrally controlled and supervised program, with emphasis on a small number of missile projects. Such an emphasis would tend to conserve technical and scientific resources, although at the expense of increasing the seriousness of errors in judgment.

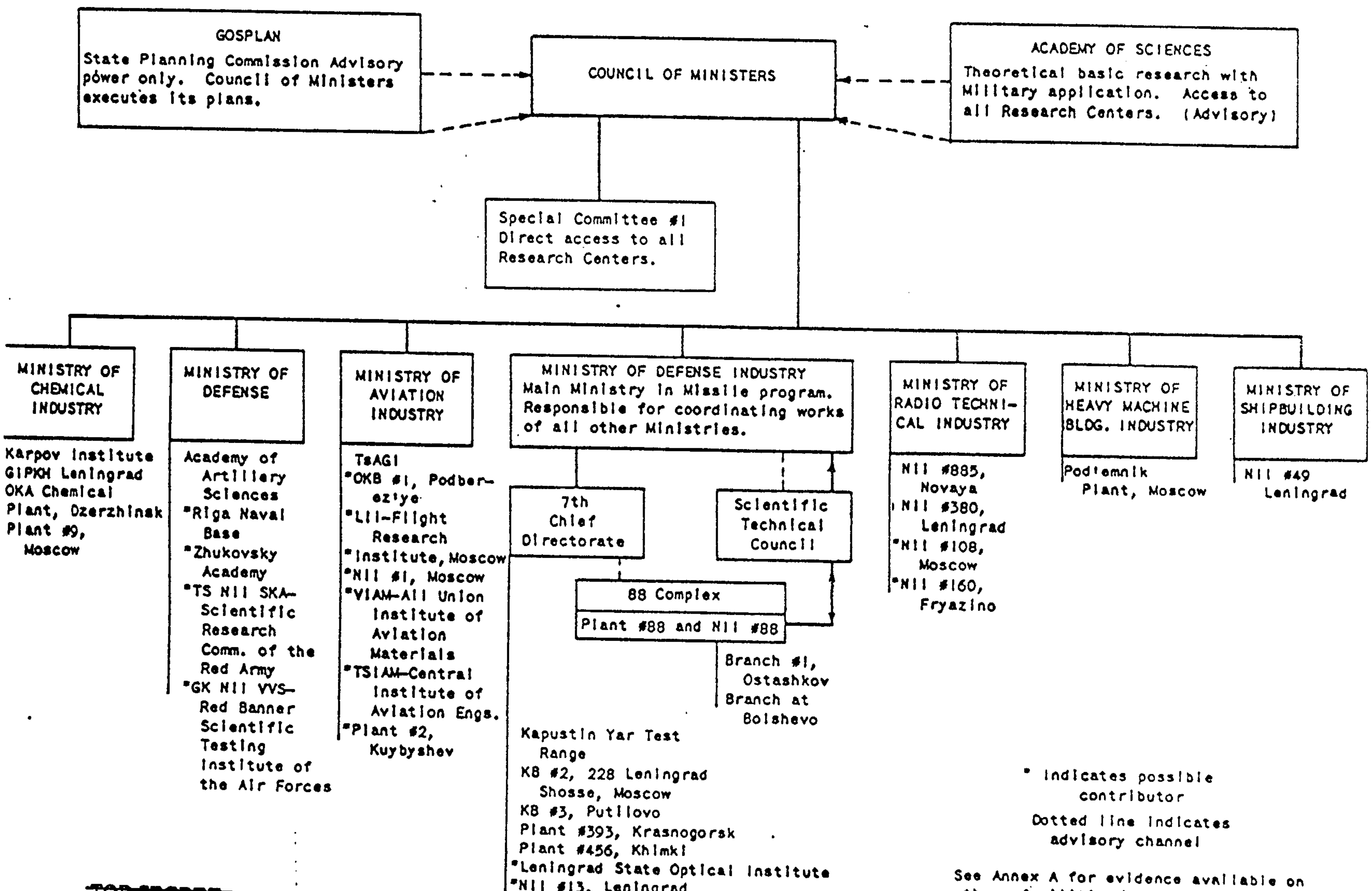
21. The controlling authority of the Soviet missile program was, and probably still is, a Special Committee of the Council of Ministers. This conclusion is based on the known existence of such a committee in 1946 and 1947, and on the fact that the Council of Ministers normally charges committees of this nature with the responsibility for the development of special weapons. Stalin reportedly participated in a meeting of the Special Committee in 1946 which discussed a proposal for an intercontinental rocket bomber as set forth during the war by German scientist Eugen Sänger (US scientists and German engineers in the USSR evaluated this proposal as technically unsound and the USSR probably came to the same conclusion, but it is significant that such a proposal apparently received early high-level consideration).

22. Responsibility for conducting and coordinating at least a part of the program has been delegated to the Ministry of Defense Industry. It has subordinate to it the largest number of the installations known to have been involved in missile activities. In addition, a Scientific Technical Council (NTS) has been described by a returned German scientist as the highest technical authority on guided missiles. Its location in the organizational structure and its continued existence after 1949 are not firmly established. The chairman was the Director of NII 88, the principal known guided missile installation under the Ministry of Defense Industry. Whether the NTS was set up solely to direct the German activity (the US handled its German scientists in such a manner), or whether it also has an active part in the native program is not known. It was composed of about 40 members from the military, various contributing ministries, universities, and various institutes of the Academy of Sciences; its function was to discuss specific projects before extensive development was undertaken, and to allocate funds.

23. *Kapustin Yar Test Range.* We also have considerable intelligence on what we believe to be the principal Soviet guided missile test range, located southeast of Stalingrad. Several Germans, some of whom visited the range in 1947, described equipment either located there or intended for such use. Although the range head was then only in the early stages of construction, the Soviets apparently planned an extensive permanent installation. Firm intelligence on the present status of Kapustin Yar is lacking, but we believe that it is now probably a modern, well-equipped range. While it is believed to have extended only about 200 miles eastward in 1947, it could be extended roughly 2,000 miles eastward or roughly 1,600 miles to the southeast. Operations have been conducted here since 1947 and it is believed to be currently in active missile operation.

[1] Available intelligence on these facilities is listed in Annex A.

ESTIMATED ORGANIZATION OF ACTIVITIES BELIEVED TO BE ASSOCIATED WITH THE SOVIET MISSILE PROGRAM



* Indicates possible contributor

Dotted line indicates advisory channel

See Annex A for evidence available on these facilities and organizations.

24. *Summary.* In the light of the above intelligence as to basic Soviet scientific and technical capabilities, the systematic Soviet exploitation of German missile experience, and the numerous personnel and facilities engaged in missile activities, together with probable Soviet military requirements, we conclude that the USSR has an active and extensive guided missile program, at least in the research and development phase.

II. SOVIET CAPABILITIES TO DEVELOP GUIDED MISSILES

25. In contrast to the amount of available evidence indicating the existence and general scope of a Soviet missile program, current intelligence on the particular missiles under development is almost nonexistent. Therefore, the following descriptions of missiles which may be available to the USSR have had to be based on: (a) the available evidence on German work for the Soviets; (b) our own guided missile experience; (c) Soviet capabilities in related fields; (d) probable Soviet military requirements; and (e) a few scattered bits of specific data. We recognize that the USSR would not necessarily base its missiles on any German or other foreign designs. It is also important to note that the missiles hereafter described are typical of those which we believe the USSR is capable of developing, not necessarily those which it will in fact develop.

26. The estimated dates given for missile availability are the earliest probable years during which small quantities of missiles could have been produced and placed in the hands of trained personnel of one operational unit, thus constituting a limited capability for operational employment. These dates are based on the assumption that a concerted and continuous effort began in 1948. If no major delays of any sort were encountered and an intensive effort of the highest order of priority were undertaken, the earliest possible dates of availability could be on the order of one to two years earlier, or as much as three years in the case of the IBM.[a]

[a] See footnote to paragraph 6.

Soviet Capabilities in Surface-to-Air Missiles

27. During 1945–1946 the Soviets exploited in Germany all the important German surface-to-air missiles under development during World War II. A group of Germans was assigned to reconstruct Wasserfall, Schmetterling, and Rheintochter, and in one instance to undertake a new design, Fluse. Upon transfer to the USSR in October 1946, they were directed to continue work on the first three missiles but to drop Fluse. Work on Schmetterling and Rheintochter appears to have been continued by the Soviets, but the Germans were gradually phased-out except for one group who continued to work on ground guidance system computers until about 1952. The capabilities of Schmetterling and Rheintochter would probably limit their use to a guidance test or as training vehicles, but the computers and, in general, their control and guidance systems could have served as the basis for continuing advances.

28. Returned Germans report continuing development of Wasserfall up to the time of their removal from classified work in 1951. Among the projects undertaken by one German group was a semiactive homing head design, reportedly for Wasserfall. It operated in the 10-centimeter wavelength region, had a reflector diameter of 35 centimeters, and utilized conical scan techniques. It was to have a slant range on the order of 15 nautical miles. Laboratory tracking tests utilizing an aircraft target, a ground based SCR–584 radar for tracking and illumination purposes, and a prototype of the homing head, are reported to have been conducted during 1949–1950, and tracked successfully only to seven to eight nautical miles. Four laboratory models were actually constructed and taken over by the Soviets in late 1950.

29. At that time another group of Germans was set to designing a new missile based on experience gained from Wasserfall. This project (designated R–113 by the Germans) sought to overcome some of Wasserfall's weaknesses and to introduce some new concepts. The R–113 was equipped with two midwings

and three tail control surfaces and was to perform coordinated turns as in piloted aircraft. Its design envisaged a 1,100 pound warhead located in the nose. It utilized the standard Wasserfall engine with a slight increase in thrust. The German work on R–113 did not progress beyond the paper-design stage. However, the Soviet specifications for it were more rigorous and more closely supervised than were those for other German design projects.

30. *Present Soviet Capabilities.* Although we have no evidence of any Soviet operational missiles, assuming that the Soviets would make use of the German work we can estimate the availability of these designs. Where possible the estimated performance characteristics are based on recalculations of the fixed parameters supplied by the Germans. Taking into account Soviet exploitation of the Wasserfall missile guidance, propulsion and hyperbolic fuels, and the general status of Soviet electronics, the USSR could now have an improved all-weather version of Wasserfall. The chief improvements could include a 1,000-pound increase in motor thrust and use of a ground guidance system utilizing two radars and a computer. We doubt that a homing head could be available at this time which would permit utilization of the maximum range capabilities (30,000–35,000 yards) of the missile. Assuming the use of conical scan radars of an improved SCR–584 type and under optimum conditions, an over-all system accuracy of one to two mils could be obtained, resulting in an effective slant range of 20,000 to 25,000 yards at 50,000 feet altitude with a warhead of approximately 600 pounds. A radar command technique or proximity fuse could be employed to detonate the warhead.

31. *Future Capabilities.* The projects undertaken by the Germans while in the USSR also offer the only firm basis for extrapolating into the future. The Soviets will probably strive to increase the effectiveness of Wasserfall and could have an improved missile by 1955. The semiactive homing head under development by the Germans could be employed to provide effective accuracies at its 30,000–35,000 yards maximum range. Warhead weight might be reduced to make room for the homing head, but this would be compensated for by the increase in accuracy.

32. By 1957–1958 we estimate that a new missile, possibly including some features of the R–113 design study, could be ready for series production. It could incorporate terminal homing, have a maximum effective range of 50,000 yards at 60,000 feet altitude, and have a warhead on the order of 500 pounds. By 1958 the USSR could develop low yield, implosion nuclear warheads suitable for this missile.

33. Although the above surface-to-air missiles are the only ones for which we have some base in existing intelligence or on known components, we believe that the Soviets will endeavor to develop improved missiles with ranges in the order of 100 nautical miles. However, due to the many technical difficulties involved, it is highly unlikely that the USSR could develop such missiles until some time after 1960.

Soviet Capabilities in Air-to-Air Missiles

34. The Soviets acquired such German air-to-air missiles as the X–4, Hs117H, and Hs298. A group of German scientists was also employed in the USSR on reconstruction and extension of some of the German World War II solid propelled rocket designs, including a number of the more promising Rheinmetall-Borsig unguided rockets and at least one guided rocket, designated Sokol. This group worked on the guided rocket project only through the paper design stage, at which point the work was turned over to the Soviets in 1948. Its design called for a solid propellant rocket motor of conventional design and an optical track radio command guidance system.

35. Although there is considerable evidence of Soviet interest in infrared devices, we have no firm evidence of its application to missile guidance systems. The Soviets exploited German World War II infrared developments, including a missile homing head called Juno. One source reports that work on this homing head was continued in the USSR at a location known to have been engaged in other infrared activities. However, there is other contradictory information concerning the exact nature

of these activities. Nevertheless, we believe that the USSR has sufficient capability in the infrared field for the development of infrared guidance systems.

36. *Present Soviet Capabilities.* Considering the limited effectiveness of Sokol and the German World War II air-to-air missiles, these probably could have served only as test vehicles. We have no reliable information of further Soviet activities or interest, but if the Soviets had decided by 1948 to put an air-to-air guided missile into operational use, a supersonic, solid propellant missile probably could now be available. It could utilize an infrared homing head and achieve a range of approximately 5,000 yards at 30,000 feet altitude with a 25 to 30 pound warhead and an over-all weight of about 175 pounds. The range would vary somewhat according to the altitude at which fired. Such a missile would be limited to a tail cone attack under generally fair weather conditions at the engagement altitude.

37. *Future Soviet Capabilities.* Despite the lack of any reliable evidence on Soviet intentions, we believe that sometime during 1955–1958 the range of the above missile could be increased to approximately 10,000 yards, and it might not be limited to tail cone attacks. By 1958–1960 a completely new supersonic air-to-air guided missile could be ready for series production. This missile could have an effective range of approximately 10,000 yards, an over-all weight of approximately 300 to 400 pounds and a warhead weight of about 50 pounds. The guidance system would probably incorporate a semiactive radar homing head. If the missile does not appear until the latter part of the 1958–1960 period, the likelihood of incorporation of an active homing head will increase.

Soviet Capabilities in Air-to-Surface Missiles

38. In 1945 the Soviets acquired many completed German air-to-surface missiles and design data on all German air-to-surface types. Among these were the FX–1400 guided glide-bomb and the Hs–293 and Hs–294 series powered glide-bombs. Information was also obtained on German air launching of the V–1. The Soviet Navy and Army Air Forces followed the usual pattern of exploitation of these guided missiles during 1945–1946; German scientists were employed in the reconstruction of missing data and assembly of missiles. Both Soviet services reportedly continued to follow air-to-surface developments after the Germans were taken to the USSR in October 1946. One group of Germans, formerly concerned with the Soviet exploitation of air-to-surface missiles in Germany, arrived in Leningrad by late 1946. However, their known work in Leningrad consisted largely of improvements on surface-to-air computers. Riga was identified by a Soviet defector in 1947 as the probable location for naval testing of air-to-surface missiles. He also reported that both the Navy and Army Air Forces were responsible for this class of missiles.

39. We have evidence that research institute KB–2 in Moscow, predominantly staffed by Soviet personnel, until recently employed a small group of German engineers to do research on guidance components for an antiship missile. Among their tasks was the development of an X-band guidance system which was to use midcourse beam riding and a semiactive homing head. The Germans were once told that a winged missile, which they saw from a considerable distance suspended from the wing of a four-engined plane, was the missile on which they were working, and that it was to have a range of about 90 miles and fly at about 500 miles per hour.

40. We have fragmentary evidence of Soviet work on the German television homing system Tonne, which the Germans originally tested with the Hs–293 missile during World War II. Soviet exploitation of this system took place in Germany in 1945–1946, and about 10 to 15 sets are reported to have been shipped to the USSR in December 1945. Development work is believed to have been continued by the Soviets in NII 380, Leningrad. However, we have no evidence which would connect this work with a specific guided missile system.

41. *Present Soviet Capabilities.* There is no evidence of Soviet operational employment of the German World War II missiles Hs–293 and

FX–1400, whose effective range would be comparatively short. On the basis of a probable Soviet requirement for additional range and greater warhead weight and known Soviet exploitation of the Hs–293, we believe that the USSR could now have ready for series production an improved rocket-propelled glide-bomb. Its estimated characteristics would be: range of 20 nautical miles; speed of Mach 0.9; gross weight of 8,000 pounds; and a nuclear or HE warhead. The guidance system could utilize television target presentation with a radio-command link and be capable of a CEP of roughly 100 yards against a readily identifiable target. Such a system would be limited to good visibility conditions.

42. *Future Soviet Capabilities.* We estimate that a pilotless aircraft could be ready for series production in 1956–1957, with ranges up to 50 nautical miles, a speed of Mach 0.9, a gross weight of approximately 8,000 to 10,000 pounds, and a 3,000 pound warhead. The guidance system could be either: (a) television homing with a radio command link and a CEP of roughly 200 yards; (b) a passive homing head for use with clandestine beacons and a CEP of roughly 100 yards; or (c) a midcourse X-band beam-riding system with semiactive terminal homing and a CEP of roughly 50 yards against a ship target. By 1956–1957 an acoustic homing torpedo suitable for use in this missile might be available.

43. We also estimate that, if the Soviets so desired, they could have ready for series production by 1960 a supersonic missile weighing about 11,000 pounds capable of carrying a nuclear warhead under all weather conditions to land targets within a range of 100 nautical miles. The guidance system probably would be a midcourse radar-track radio-command system capable of CEPs on the order of one to two nautical miles. Clandestine beacons would increase this accuracy.

Surface-to-Surface Pilotless Aircraft

44. Except for Soviet improvement of the wartime German V–1, we have almost no reliable information on Soviet work on pilotless aircraft. The major portion of the known Soviet-controlled German missile research work was devoted to ballistic types. However, the USSR could have been pursuing simultaneously a substantial pilotless aircraft program which escaped German detection. German specialists prepared a preliminary design study, the R–15 project, for a ram-jet supersonic pilotless aircraft to carry a 6,600 pound warhead approximately 1,600 nautical miles. A Soviet air force officer who defected in 1950 reported, as second-hand information, that work on a radio-controlled pilotless aircraft roughly of C–47 size was initiated in 1939, but ceased when the aircraft crashed in 1940. We also have a report of questionable reliability that Soviet experiments were conducted with a remotely controlled TU–4. Advancements in the Soviet aircraft industry since World War II indicate an over-all capability of supporting a comprehensive program for pilotless aircraft research, development, and fabrication.

45. German V–1 production facilities, missiles, components, and scientists and technicians were moved from Germany to the USSR in 1945–1948. One German reported that several hundred V–1's were assembled at Khimki in 1946–1947, but that series production was not attempted. Other Germans reported seeing between 10 and 30 missiles being assembled at one time. In 1948, four or five sets of tools, jigs, and manufacturing machinery for the V–1 were shipped from Khimki to an unknown destination, while at least one complete set was retained at Khimki. The Germans also worked on an improved V–1 control system elsewhere in the USSR. It is reported that six units were built in 1949.

46. Work on improvement of the pulse-jet engine was also conducted. The Germans observed Soviet work on a version of the V–1 using two pulse-jet engines. One German reports that about 30 to 35 missile bodies having twin pulse-jets were assembled at Podberezye during 1948 and early 1949. Another German reported seeing a different twin pulse-jet V–1 at Khimki. Whether any of these developments culminated in operational models is not known. No indications of production of the twin pulse-jet missile

have been detected, and there is no evidence that any V-1 type is in operational use.

47. A low-frequency, ground-based, hyperbolic type navigation system has been developed by the Soviets (designated "Moon" by Allied intelligence). While no connection of "Moon" with missiles has been detected, it could be adapted for use with winged types.

48. *Present Soviet Capabilities.* While we have no intelligence that any pilotless aircraft are in operational use, we estimate that the USSR is presently capable of having:

a. A Pilotless Turbo-jet Aircraft. A MIG-15 could be modified for use as a guided missile and would provide a decided speed, altitude, and range advantage over a pulse-jet missile. A modified MIG-15 type missile could have approximately a range of 500 nautical miles; a speed of Mach 0.8; a flight altitude of 40,000 to 45,000 feet; and a payload of 3,000 pounds. For guidance it could use "Moon" or a similar radio-controlled system. The CEP could vary from less than one to as much as 10 nautical miles. An inertial guidance system could achieve accuracy of approximately 10 nautical miles at a 500 nautical mile range, thus providing sufficient accuracy to bring the missile within range of a clandestine beacon.[9] Within the range of radar tracking, up to about 200-250 nautical miles, a CEP on the order of one nautical mile could be achieved.

b. A V-1 Type Missile. Although the performance of a pulse-jet missile is considerably below that of a turbo-jet missile and it is an essentially obsolete weapon, its simplicity of construction and light weight may have appealed to the Soviets. It is believed well within Soviet capabilities to have had operational V-1 type missiles by 1950. They could have an over-all weight of 5,400 pounds, a warhead of 2,000 pounds, a speed of Mach 0.6, a flight altitude of 5,000 feet, and a range of 200 nautical miles. With an inertial guidance system they could achieve a CEP of roughly three nautical miles. With a radar-tracking radio-command range of 80 nautical miles (limited by flight altitude), they could achieve a CEP of roughly 0.5 nautical miles if ground-launched, and roughly one to two miles if launched from submarines (depending on the navigational aids and techniques used to fix the submarine's position).

c. A Twin Pulse-jet V-1 Type. If the Soviets so desired, they probably could have had such a missile by 1951. It could have approximately a weight of 8,000 pounds; a warhead of 3,000 pounds; a flight altitude of 10,000 feet; a speed of Mach 0.65; a range of 200 nautical miles; and a range of radio command of 100 nautical miles (limited by flight altitude). The guidance system envisioned would be a ground based system that tracked the missile and transmitted radio commands. At 100 nautical miles the estimated CEP of such a system would be on the order of 0.5 nautical miles from land bases and one to two nautical miles from submarines (depending upon the navigational aids and techniques used to fix the submarine's position).

d. A Submarine-Launched V-1 Type. We estimate that the USSR could at present be capable of launching either of the above V-1 types from submarines. The feasibility of launching techniques has been demonstrated by the US. However, no modifications or external changes in the configuration of Soviet submarines which might indicate preparations for launching guided missiles have been observed.

49. *Future Soviet Capabilities.* Despite the absence of intelligence on Soviet development of pilotless aircraft other than the V-1 type, the Soviets nevertheless appear capable of developing advanced aircraft type missiles if they so desire. Their principal problem would be that of guidance, since development of inertial components suitable for the time of flight involved probably has not reached the stage required for inclusion in pilotless aircraft having more than about 30 minutes flight duration. However, use of high yield nuclear warheads would tend to compensate for the inaccuracy of inertial guidance systems on flights of longer duration.

[9] A clandestinely placed low power beacon in the target area, if effectively coordinated with the attack, could materially improve the accuracy of this and other pilotless aircraft.

50. Soviet interest in low frequency developments has been considerable, and the "Moon" navigation system demonstrates their capability in this field. "Moon" or a similar system if designed for missile use could be used for winged missiles for ranges up to 1,500 nautical miles. Accuracy would depend primarily upon azimuthal orientation of the target with respect to the base line, and the CEP could vary from less than one to as much as 10 nautical miles. However, missiles using such navigation systems would be especially vulnerable to countermeasures.

51. There is little information concerning Soviet development efforts on ram-jets. The Germans did some work on the ram-jet principle for the Soviets, but little Soviet interest has been detected. We assume that the Soviets are conducting such research at a moderate rate.

52. *Short-Range Pilotless Aircraft.* The USSR could develop a subsonic, turbo-jet pilotless aircraft suitable for launching from submarines in 1955. It could be in the Mach 0.9 class, weigh in the order of 12,000 pounds, and carry a 3,000 pound warhead approximately 500 nautical miles. A radar-track radio-command guidance system could be used only up to ranges of 200 miles. However, by employing advanced guidance stations within 200 nautical miles of target, this missile could be launched from as far as 500 miles away and still achieve from land bases a CEP of roughly one nautical mile at a range of 200 miles, and 0.5 nautical miles at a range of 100 miles. From submarines these CEPs would be somewhat greater, depending on the accuracy of navigation. An inertial guidance system could also be used, but its accuracy would be much less.

53. *Medium Range.* If the Soviets so desired, we estimate that a subsonic pilotless aircraft could now be in the prototype testing stage. It could have a 1,500 nautical mile range, a speed of about Mach 0.9 at 45,000 to 50,000 feet cruise altitude and carry 8,000 to 10,000 pounds payload. Such a missile could be ready for series production by 1957. Guidance could be provided by a low frequency hyperbolic system; its CEP at 1,500 nautical miles could vary from less than one to as much as 10 nautical miles.

54. *Intercontinental Pilotless Aircraft.* In our view, there is little likelihood that the USSR would devote the required amount of effort to developing such missiles. However, the US programs for Snark and Navaho indicate the types which could be developed. Highly speculative estimates of availability for series production would be approximately 1958–1960 for a Snark type and 1962 for a Navaho type. Soviet capabilities for developing adequate guidance systems by these dates are questionable. An inertial system for mid-course and a terminal system for homing on a clandestine beacon could possibly be used.

Surface-to-Surface Ballistic Missiles

55. While extensive information is available on German work done for the USSR on ballistic missiles, it does not necessarily characterize the actual Soviet program. However, a Soviet defector whose information has proved highly reliable reported that in 1947 the USSR planned a development program aimed at making such improvements in accuracy and range of the V–1 and V–2 as would be possible in a relatively short time, rather than to wait for greatly improved designs which could not be ready for many years. A long-term research program was to be conducted concurrently, but the source believed that it would suffer from the urgency attached to the short-term work.

56. In the fall of 1947, the Soviets test-fired 10–15 V–2 missiles. Reports indicate that possibly six of these used a radio beam method for azimuth control. They used the German-developed Leitstrahl system, which was exploited by the Soviets during 1946–1949. One significant improvement accomplished by the Germans for the Soviets was the modification of the V–2 engine which increased its thrust rating from 25 to 35 tons by 1948.[10] We believe that: (a) approximately 150 to 200 engines of 35 ton thrust were produced at Khimki during 1948–1950; (b) about 200 engines of 25 ton thrust were produced there in

[10] All thrust ratings in this estimate are given in metric tons.

1947–1948; and (c) up to 20 missiles were assembled at Kaliningrad during 1947.

57. Soviet-directed Germans applied considerable effort to improving the V–2 ballistic missile. Projects worked on concerned improved accuracy, increased range, and better performance of components. A three-gyro stabilized platform using air bearing was under development by the Germans during 1947–1950, and an experimental model was submitted to the Soviets by the end of 1950. The Soviets told one of the German specialists that they had built an experimental model of the same type in an attempt to improve the accuracy of the original V–2 guidance system.

58. German reports on their work on a guidance system which used radar tracking and radio command to control azimuth and elevation and doppler radar to control fuel cutoff, reveal that the work was based on sound principles, and that some limited test flights using aircraft were conducted in 1949. However, numerous engineering difficulties were encountered. The Soviets took over the development of this system in late 1950 and are reported to have continued work for at least three years.

59. In December 1948, the Germans submitted to the Soviets a preliminary design study (designated R–10) for a ballistic missile using a 32-ton thrust engine. It represented a consolidation of proposals for improvement of the V–2 missile, including a turbine fuel pump driven by bled exhaust gases and the guidance system described in the above paragraph. Disposition of the study is unknown, but the Soviets are known to have continued work on the guidance and turbine drive systems after the Germans were programmed out. Another project worked on by the Soviets without German participation concerned elongating the V–2. The Germans had started this development during World War II and the Soviets continued it by themselves after 1947 at Kaliningrad, near Moscow. A key German missile specialist believed the missile could have been ready for flight testing in 1949. Elongated railroad cars, believed to be missile carriers, first appeared at Kaliningrad in 1950.

60. *Present Soviet Capabilities.* We have no evidence of any ballistic missiles available for operational use. Nevertheless, based on the above intelligence and our analysis of basic Soviet capabilities, we believe that the USSR could now have operational short-range surface-to-surface missiles of the following maximum performance characteristics:

a. A missile of approximately 40,000 pounds gross weight that could carry a 2,000 pound warhead a distance of 350 nautical miles with a CEP of two nautical miles. These characteristics are based on improvements that could be made to a standard V–2, including use of a 35-ton thrust engine, increasing the length to provide additional fuel capacity, and use of an improved inertial and radio controlled guidance system.

b. A shorter-range missile capable of carrying larger warheads. Such a missile could have a somewhat smaller CEP than the one above, and could use nitric acid or liquid oxygen as the oxidizer. Use of nitric acid would reduce the logistic problems for a tactical vehicle. Some reports indicate Soviet interest in short-range tactical missiles, e.g., one report specified a 60 nautical mile ballistic missile.

61. *Future Soviet Capabilities.* Soviet interest in the development of long-range weapon systems is indicated by: (a) early high-level Soviet interest in the Sänger proposal for intercontinental rocket bombers; (b) development of high-thrust rocket engines and corresponding propellants; (c) studies of heat transfer in boundary layers; (d) research on ballistic missile guidance system components; (e) upper atmosphere research; and (f) research on geodetic mapping.

62. Guidance systems suitable for ballistic missiles were under development by German specialists in the USSR during 1947–1951. These inertial and radar/radio-command fuel cutoff type guidance systems are potentially capable of improving the accuracies of ballistic missiles over the original V–2 guidance system and have been used in the following estimates. Development of control tech-

niques, servomechanisms, airframe structures, aerodynamics configurations, high temperature materials, and other necessary advancements for continuation of a long-range guided missile research and development program are also believed to be within Soviet capabilities.

63. German wartime development of the 25-ton thrust V-2 rocket engine and subsequent modifications and improvements in the USSR which produced by 1947 a 35 ton thrust rating have provided the USSR with an adequate rocket power plant for ballistic missiles of ranges in the order of 300 to 500 nautical miles. For greater range, larger engines or clusters of the 35-ton thrust engines would be required, and the Soviets apparently have chosen to develop larger engines for this purpose. German specialists at two locations within the USSR worked independently on designs for rocket engines with thrusts on the order of 100 tons. We know that the Soviets continued work on at least one of these designs; we believe that in 1952, when a static test stand was to have been available, they could have commenced static testing of a 100-ton thrust engine.

64. Although other lines of development are possible, our estimates are based on the following conception of an orderly, step-by-step program involving optimum utilization of these engines as a likely course of further development: (a) utilization of the 35-ton thrust engine in a single stage missile; (b) utilization of the 100-ton thrust engine in a larger single stage missile; and (c) utilization of combinations of the above engines into two stage missiles of medium and long ranges. The range of any specific missile would vary with the warhead weight chosen.

65. *Medium-Range Missiles.* Continued development of the elongated V-2 design for optimum utilization of the 35-ton thrust engine could result in a ballistic missile with approximately 50,000 pounds over-all weight; a warhead of 3,000 pounds; a range of 500 nautical miles; and a CEP of 2.5 nautical miles using an inertial and radar-tracking radio-command guidance system. We estimate that this missile could be ready for series production in 1955.

66. If guided missile design studies were initiated at the time the 100-ton thrust engine was being designed, it is conceivable that a Soviet single stage missile using this engine could now be in the flight test stage. Such a missile could have a range of approximately 900 nautical miles, a gross weight of approximately 110,000 pounds carrying a 3,000 pound warhead, and a CEP of three to four nautical miles. Dependent upon reasonable success of component developments and on early flight tests, the earliest probable date at which this missile could be ready for series production would be 1957, although it is possible that this missile could appear as early as 1955 (see paragraph 26).

67. The Soviet-directed German research activities disclose some interest in missiles with ranges on the order of 1,500 nautical miles. Two proposals, the R-12 and the R-14, were made by the Germans at the request of the Soviets. The R-12 project was a series of feasibility studies for a two stage ballistic missile of approximately 1,300 mile range, carrying a warhead of about 2,200 pounds. The R-14 project, which was carried to a detailed design stage, was to be a single stage missile carrying a 6,600 pound warhead approximately 1,600 nautical miles. Soviet disposition of these design studies is unknown. At the most, they represented preliminary design studies with practically no experimental work accomplished to support the theoretical data. However, these studies represent a logical step in a ballistic missile program.

68. A two stage missile utilizing the 100-ton engine as the booster and the 35-ton thrust engine could provide a guided missile with a range in the order of 1,300 nautical miles. We estimate that such a missile would weigh approximately 140,000 pounds, could carry a 3,000 pound warhead, and have a CEP of three to four nautical miles Assuming development was initiated in 1948, we estimate that the earliest probable date at which this missile could be ready for series production would be sometime in 1959, although it is possible

that such a missile could be ready as early as 1957 (see paragraph 26). Such a missile could also provide a research vehicle for obtaining stage separation, high-speed and high-temperature, and other data pertinent to an intercontinental ballistic missile.

69. *Intercontinental Missiles.* Soviet interest in a 100-ton thrust engine probably indicates their interest in longer-range missiles. We believe a long-range, intercontinental ballistic missile (IBM) would be within Soviet capabilities. It could utilize a booster incorporating two or more 100-ton thrust engines, and a second stage utilizing either the 100-ton thrust engine or two or more 35-ton engines. Such a missile would have an estimated range on the order of 5,500 nautical miles, a gross weight of 200,000–400,000 pounds, carry a 3,000 pound warhead, and have a CEP of roughly five nautical miles. However, even if the USSR decided by 1948 to devote a concerted effort leading to this type, the first operational model probably could not be ready for series production before 1963, although it is possible that it could be ready as early as 1960 (see paragraph 26).

III. OTHER FACTORS AFFECTING SOVIET MISSILE CAPABILITIES

Soviet Capabilities to Produce Guided Missiles

70. *Lack of Evidence on Current Series Production.* A survey of the available economic indicators reveals no firm evidence to either establish or deny Soviet series production of any guided missile at this time. The few indicators available could apply to production for experimental and test purposes or, alternatively, to production for other weapons systems. We have evidence that in 1948 the Soviets might have been planning series V–1 production (see paragraph 45). Similarly, tooling for the standard V–2 propulsion unit was reported to have been sent from Khimki to Kuybyshev. Soviet technicians being trained at Plant #456 in Khimki intimated that they expected to set up series production at Kuybyshev, but we have no confirmatory evidence. Static testing of propulsion units near Kaliningrad has also been reported. Liquid oxygen units and special transportation equipment were sighted.

71. The Soviet electronics industry is producing specialized items which are essential to guided missiles, but because such items have applications in other electronic systems they cannot be regarded as in themselves indicating missile production. Examples of Soviet products employing these specialized items include: (a) microwave airborne-intercept radar; (b) microwave airborne blind-bombing radar; (c) microwave radar altimeters; (d) microwave ground and shipborne fire-control radar; (e) microwave ground and shipborne early-warning/ground-control-intercept radar; (f) microwave communications systems; (g) long and short range pulse type radio navigational systems; and (h) airborne automatic direction-finding equipment.

72. Most of the above examples have appeared in quantity, although none of these products or the specialized items involved have been specifically connected with missile production. Recent trends in production show increased attention to severe operating conditions as would be particularly important in airborne and guided missile applications, such as increased miniaturization, ruggedization, and tolerance for high temperatures.

73. There are also a few possible indicators in the precision mechanism field. During 1951 and 1953 the Zeiss Plant at Jena produced Schlieren instruments, some of which were reported shipped to the USSR. At least one lot of cinetheodolites was sent to the USSR from the Meopta National Corporation, Prague Nusle, Czechoslovakia. Both the above instruments are used primarily in research but could also be used for production testing.

74. *Industrial Resources Available.* We have surveyed the evidence concerning several hundred plants in the Soviet Bloc because they are of a type which could contribute to a missile program. The results of this survey were: confirmed production — 0; possible contributors — 37; unconfirmed or unlikely — 20; and no evidence — circa 200. However, the num-

[11] The indications at many of these plants are listed in Annex A.

ESTIMATED SOVIET CAPABILITIES TO DEVELOP GUIDED MISSILES[1]

Description	Range	Gross Weight	CEP	Earliest Probable Date of Availability[2]
SURFACE-TO-SURFACE (SSGM)				
Ballistic missile (see para. 32)	350 nm	40,000 lbs.	2 nm	1954
Ballistic missile (see para. 37)	500 nm	50,000 lbs.	2.5 nm	1955
Ballistic missile (see para. 38)	900 nm	110,000 lbs.	3 to 4 nm	1957
Ballistic missile (see para. 40)	1,300 nm	140,000 lbs.	3 to 4 nm	1959
IBM (see para. 41)	5,500 nm	200,000–400,000 lbs.	5 nm	1963
Pilotless aircraft (see para. 46)	500 nm		Less than 1 to as much as 10 nm	1954
V-1 type (see para. 46)	200 nm	5,400 lbs.	.5 to 3 nm	1950
Twin pulse-jet V-1 type (see para. 46)	200 nm	8,000 lbs.	.5 to 3 nm	1951

[1] The missiles described are typical of those which we believe the USSR is capable of developing; however, we have no firm intelligence on what particular missiles the USSR is presently developing or may now have in operational use.

[2] The estimated dates given are the *earliest probable years* during which small quantities of missiles could have been produced and placed in the hands of trained personnel of one operational unit, thus constituting a limited capability for operational employment. These dates are based on the assumption that a concerted and continuous effort began in 1948. If no major delays of any sort were encountered and an intensive effort of the highest order of priority were undertaken, *the earliest possible dates* of availability could be on the order of one to two years earlier, or as much as three years in the case of the IBM.

Description	Range	Gross Weight	CEP	Earliest Probable Date of Availability
SURFACE-TO-SURFACE (SSGM) (Cont.)				
Pilotless aircraft (see para. 50)	500 nm	12,000 lbs.	.5 to 2 nm	1955
Pilotless aircraft (see para. 51)	1,500 nm	8-10,000 lbs.	Less than 1 to as much as 10 nm	1957
SURFACE-TO-AIR (SAGM)				
Wasserfall type (see para. 56)	20-25,000 yds. slant range	175 lbs.	1 to 2 mils accuracy	1954
Improved Wasserfall type (see para. 57)	30-35,000 yds. slant range			1955
R-113 type (see para. 58)	50,000 yds. slant range			1957-1958
AIR-TO-AIR (AAGM)				
Guided rocket (see para. 62)	5,000 yds.	175 lbs.		1954
Supersonic type (see para. 63)	10,000 yds.	300-400 lbs.		1958 to 1960
AIR-TO-SURFACE (ASGM)				
Rocket propelled glide bomb (see para. 67)	20 nm	8,000 lbs.	100 yds.	1954
Pilotless aircraft (see para. 68)	50 nm	8-10,000 lbs.	50 or 200 yds.	1956-1957
Supersonic type (see para. 69)	100 nm	11,000 lbs.	1 to 2 nm	1960

ber of facilities surveyed suggests the general magnitude of the industrial resources which might be used to support a missile program.

75. Of the 37 plants possibly developing and/or producing missile components, there are some in most of the industries which would normally contribute to a missile program[11] These plants indicate the existence of an industrial complex capable of engaging in research and development or missile production. Twenty-one plants are believed to be manufacturing electronic items which might be used for missile guidance. There is some evidence that the other plants might be producing other guidance and control components, liquid oxygen or oxygen generating equipment, launching and transportation equipment, propulsion units, and missile airframes.

76. Some 20 other plants have been reported, usually by repatriated prisoners, to be engaged in missile or component production, but investigation has indicated either that these reports were baseless or that missile activity is no longer being carried out there. In some instances, missile production has been reported only by geographic area; all such areas were studied with negative results. Around 200 additional installations, believed suited to production of missile airframes, propulsion units, equipment, or components were also surveyed, and are apparently not associated with the missile program. In addition, all ammunition loading, underwater ordnance, shipbuilding, battery, iron and steel, chemical, petroleum-refining, explosive, locomotive and car, automotive, tractor, and heavy equipment plants and research, development, or testing facilities were surveyed.

77. *Imports.* There is little evidence that Soviet missile activity currently utilizes any appreciable quantity of imports, either from the Satellites or from the western nations. However, the USSR, which imports about one-third of Satellite electronic output, must rely on these sources for some test equipment and precision instruments. There are also reports that the USSR has been receiving liquid oxygen generators from Satellite countries, but we have no evidence that these imports support missile activities.

78. *Analysis of Soviet Economic Capabilities.* To provide some measure of Soviet capabilities for series missile production and possible production rates we have set up a hypothetical Soviet missile program. Although the program hypothesized took into account the "general state of the art" it was based only on estimated military requirements, without consideration of research, development, or production limitations. We analyzed: (a) the rate at which these missiles could be turned out at capacity production; (b) the labor and materials input required; and (c) the aggregate cost of such a program (see Annex B). The results of this illustrative study, *while not to be taken as providing estimates of actual Soviet production rates or stockpile goals,* do indicate in broad terms what the USSR *could* do.

79. Our analysis leads to the conclusion that in general the USSR is rather well endowed with the skilled labor, raw materials, and plant capacity required for an extensive guided missile program, except possibly in the fields of precision mechanisms and electronic equipment. Indeed our analysis points up the absolute smallness of over-all missile materials requirements, except possibly for liquid oxidizers. However, a decided quality problem would also exist. In aggregative terms as well, a sizeable missile program would be well within Soviet capabilities. For example, in the three year period 1954–1956 our illustrative missile program would represent about 10 percent of estimated Soviet defense outlays.

80. The chief bottlenecks in any extensive Soviet production program would almost certainly lie in the precision mechanisms and electronics industries. Although our estimate does not permit a precise measurement, it suggests that if our illustrative program were pursued as rapidly as possible, it might require a large share of Bloc electronics output over an extended period. This share could be reduced somewhat by greater capital investment. The problem would be most difficult in the early years (1954–1956) when an estimated one-half of the Soviet electronics out-

put might be required for the illustrative program. Although the air defense requirements of the Satellites were not specifically considered in establishing our hypothetical air defense requirements (the surface-to-air missile accounts for three-quarters of the total program in the early years), it is believed that they would in fact contribute appreciably to any missile program, particularly in the electronics field. The illustrative program would require about two-fifths of the estimated combined electronics output of the USSR and the European Satellites during 1954–1956.

81. If this guided missile electronics requirement were to be met, availability for other uses would have to be sharply cut, although all other programs would probably not be equally curtailed. Nevertheless, in view of the importance of many of the competing demands for Soviet electronic output (nonmilitary electronics, aircraft, early warning radar, fire control, airborne navigation, bombing, and intercept equipment) it seems unlikely that the USSR would allocate such a high proportion to actual missile programs.

82. A more serious limitation to satisfying the guided missile requirements may well exist in the precision mechanism sector in view of the tolerances involved and the skilled labor required. For example, the average annual missile requirement for gyroscopes in the early years of our illustrative program may be approximately two-thirds of the gyroscopes allocated by the USSR to new military equipment during 1953 (we have no estimate of total 1953 Soviet production of gyroscopes).

Effect of Soviet Nuclear Capabilities on Missile Use

83. We have indications of a possible association between the Soviet missile program and the Soviet nuclear program. Almost all the missiles which we estimate the USSR is capable of developing could be fitted with nuclear warheads. However, our estimates of the Soviet nuclear stockpile indicate that for the next several years it will be inadequate to meet probable military requirements and that reliability and accuracy of delivery will be primary factors in the Soviet choice of delivery vehicles. The yield of the nuclear warheads which we estimate would be available at present for Soviet missiles would not be sufficient to compensate for the lack of accuracy which we estimate these missiles would have. The yields available from such warheads will progressively increase, but the relationship between estimated warhead yield and estimated missile accuracy is such that the effectiveness of nuclear delivery by guided missiles, in terms of levels of target destruction, will not approach that obtainable by aircraft delivery for the next several years.[12] This factor obviously does not preclude earlier employment of nuclear missiles where other considerations so dictate, but it does suggest primary Soviet reliance on aircraft delivery of nuclear weapons so long as the Soviet stockpile remains limited and Allied air defenses can be penetrated without unacceptable losses.

Probable Missile Reliabilities

84. Another major factor affecting the Soviet choice between guided missiles and other weapons systems, particularly for nuclear delivery, will be missile reliability, i.e., the degree of likelihood that a missile fired will actually reach the target area. We do not believe that missile reliability for unopposed delivery will for the foreseeable future approach that of aircraft. US experience suggests that the "state of the art" of missile development is such that a system reliability factor of the order of 40–60 percent might presently be expected.[13]

Soviet Capabilities in Geodesy and Cartography

85. The USSR has succeeded in establishing a modern effective geodetic organization whose scientific and technical personnel are capable of dependable and adequate support in all aspects of geodesy and cartography re-

[12] See Annex C, *Restricted Data*, for an estimate of Soviet stockpiles and time-phased warhead yields.

[13] USAF reservation.

quired by a guided missile program. The high level of Soviet geodesy has resulted from early recognition of the basic importance of geodesy and cartography to Soviet economic development and military operations, which led to a geodetic and cartographic development program on an unprecedented scale.

86. We estimate that the Soviets can now achieve relative geodetic positioning of targets from fixed predetermined launching sites in the USSR with a circular probable error of 300 to 500 feet for most targets in the US, provided they have connected their triangulation across the Bering Strait with the North American datum. In the absence of such connection, the CEP for US targets would lie closer to 1,000 feet. The error for targets in Western Europe is estimated at 200 to 300 feet. Against coastal targets, a missile-launching Soviet submarine out of sight of land could determine its position by celestial observations, day or night, within one to two miles. By using other navigational aids and techniques, positions accurate to within 0.5 miles could be obtained.

87. The USSR can be expected to improve its geodetic positioning capabilities during the period 1954–1965 through extensive adjustments and connections with the geodetic systems of adjoining areas. By 1965, lunar and electronic methods of connecting the continents will reduce the geodetic CEP of positioning at 5,000 miles to not more than 500 feet. This anticipated improvement in geodetic accuracy may result either from Soviet geodetic, astronomic, or gravimetric programs, or more likely from Western programs, if results of these programs continue to be made available to the Soviets through open publication.

Logistic, Personnel, and Training Requirements

88. *Logistic Requirements.* We estimate that for each missile in the basic allowance of a field unit, an additional two to three missiles would have to be produced for testing, training, replacement of defective units in the stockpile, and pipeline requirements. If US experience is any guide, Soviet vehicular requirements for the support of mobile missile units will also be considerable. For example, a Corporal battalion requires an impressive number of very heavy trucks, trailers, and other vehicles. Missiles in excess of 50,000 pounds gross weight would create major transport problems. Such long-range missiles as the IBM probably would have no mobility but would have to be launched at or near the assembly site. However, in general we believe that transport would not be a serious limiting factor on any Soviet missile program, although this program would naturally compete with other Soviet transport requirements.

89. *Personnel.* The complexity of guided missiles and related test and guidance equipment places a high premium on technically trained personnel in operational units. The illustrative program envisioned in Annex B, for example, might require in the early years a T/O strength of as many as 100,000, and ultimately 170,000 relatively highly trained specialists to test, maintain, and operate the various missile systems. We believe, however, that as with other complex programs the Soviets could train personnel of the required calibre to support a missile program, although meeting such personnel needs would involve a major effort and would naturally compete with other personnel demands.

90. *Training.* On the basis of US experience, we estimate that roughly one year would be required for the individual training of certain key missile personnel. Subsequent unit activation and training would require from six months to a year. In some cases the USSR might find it difficult to train and activate such units as rapidly as it could produce the missiles, in which case training would become a limiting factor on Soviet missile capabilities. On the other hand, once missile personnel were trained, the transition from early to later missile types would be facilitated by the basic similarity of guided missile systems.

IV. PROBABLE SOVIET INTENTIONS IN THE GUIDED MISSILE FIELD

91. Because of the lack of intelligence concerning what specific missiles may be in the current Soviet missile program, our estimate

of probable Soviet intentions is based primarily upon an assessment of probable Soviet military requirements within the context of estimated Soviet capabilities in this field. We have assessed the probable military effectiveness of the various guided missiles which we have estimated the USSR is capable of developing, and compared them with other weapons systems which it could develop in the same period. In our view the USSR will seek to develop these missile systems which provide or promise to provide a better means of meeting Soviet military requirements than other weapons systems available to it, and will produce in quantity at least some of these missiles.[14]

Surface-to-Air Missiles (SAGMs)

92. A vital Soviet strategic objective in event of general war will be the defense of the USSR against strategic attack. The USSR has already given a very high postwar priority to air defense. However, the estimated limited effectiveness of present Soviet air defenses against high performance bombers and under poor visibility conditions constitutes a serious air defense deficiency. Thus, the most urgent Soviet defensive need is for a weapon which will provide an effective defense against high performance bomber attacks under conditions of poor visibility.

93. We have estimated that the USSR is capable of having ready for series production in 1954 an all-weather *improved Wasserfall design* with an effective slant range of 20,000–25,000 yards, and in 1955 an *improved version* with semiactive homing and 30,000–45,000 yards effective slant range. We believe that the USSR will make every effort to develop such missiles because of their early availability and the fact that even the first, if employed in quantity, would radically improve Soviet all-weather air defenses. However, its short range would limit its use to a point defense, and numerous peripheral launching sites would be required for effectively defending major target areas. This weapon would probably also have sharply limited capabilities against multiple or low altitude targets. The improved version would be less limited in range and its homing head would be more effective against multiple targets.

94. In 1958 the USSR should be capable of having a *new surface-to-air missile* with terminal homing, a larger warhead, and still greater range. Its increased range would permit the use of a smaller number of units in point defense. Moreover, the low yield nuclear warhead probably available for this missile in 1958 would greatly increase the kill probability.

95. *Potential Military Threat.* Should the USSR fully exercise its capabilities in this field (and allowing for the lead time required for series production, training, and other factors), we believe that Soviet kill capabilities against Allied bombers even in bad weather would be significantly and progressively increased beginning around 1955. The appearance in 1958 of nuclear warheads might dictate greater separation of attacking aircraft

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[14] The estimated dates given for missile availability are the earliest probable years during which small quantities of missiles could have been produced and placed in the hands of trained personnel of one operational unit, thus constituting a limited capability for operational employment. These dates are based on the assumption that a concerted and continuous effort began by 1948. If no major delays of any sort were encountered and an intensive effort of the highest order of priority were undertaken, the earliest possible dates of availability could be on the order of one to two years earlier, or as much as three years in the case of the IBM. The above dates are those around which the missile could have been operationally tested and be ready for series production. However, an additional period (which would vary according to missile type) would be required before missiles could be produced in quantity and the necessary units trained and deployed. We estimate that at least six months would normally be required for shift or conversion from pilot plant to series production, and an additional period to reach the planned production rate. Some 18 months to two years would probably be required for individual and unit training of each operational unit, although this period could to a considerable extent overlap the production period. Thus, depending on the missile type and the priority given to it, a varying period beyond the dates given in this estimate would be required for the development of a sizeable Soviet threat.

and thus also improve the effectiveness of air defenses generally, including airborne interception.

Air-to-Air Missiles (AAGMs)

96. Because of its air defense weaknesses, the USSR probably also has a high priority requirement for AAGMs. As Soviet interceptor performance improves and as the speed and altitude of attacking bombers also increase, improved weapons will be necessary because of the limitations of conventional aircraft armament.

97. We have estimated that the USSR could have ready for series production in 1954 a *solid propellant rocket* with infrared homing and a 5,000 yard range, and during 1955–1958 an *improved version* with 10,000 yards range. These two designs have the advantage of probably being readily adaptable to existing Soviet interceptors. However, owing to their guidance system they could only be used for tail cone attacks. Nevertheless, use of this missile would considerably enhance Soviet interceptor capabilities against jet bombers. Therefore we believe that the USSR would assign high priority to its production as a valuable interim missile.

98. The *new AAGM* with semiactive radar homing which we estimate the USSR could develop by 1958–1960 would have an all-weather capability and be an essential supplement to the expected Soviet all-weather fighter. Therefore, such a missile would almost certainly be assigned a very high priority. In 1960, the USSR could probably have a missile with an active radar homing head. By this time missiles will probably be the primary Soviet interceptor armament.

99. *Potential Military Threat.* If beginning around 1955 the solid propellant rocket began coming into general use in Soviet interceptors, their kill probability against jet bombers under fair weather conditions would probably be substantially increased. The AAGMs with which most Soviet interceptors could probably be equipped after 1960 would greatly enhance Soviet all-weather defense.

Air-to-Surface Missiles (ASGMs)

100. The formidable and growing Soviet submarine fleet and surface navy indicate Soviet strategic emphasis on interdicting the sea lines of communication on which the Allies depend. As Allied capabilities for defense of ships and ports grow, the USSR will require improved weapons for this purpose. Progressive improvements in the air defenses of naval task forces will probably make aircraft torpedo attacks increasingly hazardous, and Soviet conventional bomb delivery techniques lack the accuracy necessary for use against ships. Therefore, we believe that the USSR would almost certainly produce in quantity any precision weapon available for effectively attacking ships with high explosive (HE).

101. We estimate that the USSR could now have available an 8,000 pound *rocket-propelled glide bomb* with 20 nautical mile range and a 3,000 pound HE or nuclear warhead (see Annex C, *Restricted Data*). Since this weapon would afford a means of delivering accurate HE attacks against point targets such as ships, it would probably be adopted, even though its TV tracking would limit it to good visibility conditions. However, since the range of this missile would still be so short as to afford only limited security to the parent aircraft, the Soviets probably would continue to consider that nuclear weapons might be more effectively delivered directly by aircraft, and would not equip this missile with a nuclear warhead. The probable availability in 1956–1957 of a suitable acoustic homing torpedo could further increase the effectiveness of this weapon.

102. We also believe that for the next several years the USSR will rely primarily on its growing high performance bomber capabilities for attacks on key Allied bases and installations. However, at some time in the future the growing effectiveness of Allied air defenses will create a growing Soviet requirement for an improved weapon to penetrate these defenses without excessive bomber losses. At this time the USSR will probably seek to produce an air-to-surface missile with a nuclear warhead for attacking Allied nuclear bases and facilities and other heavily defended installations.

103. In 1956–1957 the USSR probably could have ready for series production an 8,000–10,000 pound *subsonic pilotless aircraft* with 50 nautical mile range and a nuclear warhead. However, except in case of clandestine placement of a homing beacon in the target area, it would be limited to use in fair weather or against ship targets. While its range might enable parent aircraft to stay beyond the range of Allied defensive missiles, the pilotless aircraft itself would be vulnerable to interception. Its size and weight would also restrict the performance of the parent aircraft, and it could be carried only by heavy and medium bomber types. For these reasons, and because direct bomber delivery will probably still be effective, we do not believe that the USSR would produce this weapon in quantity, if at all.

104. However, in 1960, when we estimate that a *supersonic all-weather ASGM* with 100 nautical mile range and a nuclear warhead could be available, the USSR would probably expect Allied defenses around key targets to be such as gravely to limit effective direct bomber delivery of nuclear weapons. Any limitation on the reliability of this ASGM would probably be more than offset by the improved likelihood of penetrating target defenses. After 1960, moreover, the size of the Soviet nuclear stockpile is likely to be such as to justify allocation of nuclear material for this weapon despite the reliability factor. By this time, progress in Soviet nuclear technology could also be such as to permit a high yield warhead, in which case the weight of the missile and the limitations on its accuracy would be of less significance (see Annex C, *Retricted Data*). Therefore, we believe that the USSR would undertake quantity production of such a missile, if available, for use by heavy and medium bombers against well defended target areas.

105. *Potential Military Threat.* Should the USSR put into use an antiship weapon like the rocket-propelled glide bomb, it would significantly strengthen the Soviet challenge to Allied seapower in Eurasian waters. If an all-weather supersonic ASGM began coming into use around 1960–1961, it would greatly increase the Allied air defense problem and probably dictate primary reliance upon long range interception of the parent aircraft.

Submarine-Launched Surface-to-Surface Missiles (SSGMs)

106. The USSR, with its growing submarine fleet, will almost certainly develop the capability for using submarine-launched SSGMs to attack Allied ports and bases in coastal areas, including those in the US. The USSR might consider such missiles to have particular value against key industrial areas and military bases along the US seaboard.

107. We have estimated that in 1950 the USSR could have had available an *improved V–1 type* with a high explosive warhead, and in 1951 a larger twin pulse-jet V–1 type. By 1954 both missiles could have a nuclear warhead (see Annex C, *Restricted Data*). These weapons would provide a capability for submarine-launched attacks on US coastal targets to supplement Soviet nuclear air attacks. Their accuracy would probably be sufficient for use against large cities and base areas.

108. The improved range, speed, and accuracy of the *subsonic pilotless aircraft SSGM* which could be ready for series production in 1955 would greatly increase the number of good targets for submarine-launched attack. In about 1958 the estimated nuclear warhead yield will approach compatibility with the estimated accuracy of the weapon system and would greatly increase the likelihood of its use against such targets as air bases and coastal ports facilities.

109. *Potential Military Threat.* A Soviet capability for submarine-launched nuclear missile attacks, which the Soviets could now have, would constitute a substantial threat to the US and its global security interests. After 1958, when higher nuclear warhead yields appear likely, all SAC overseas bases and some within the US itself would be within range of effective surprise attack. The chief advantage of submarine-launched missiles is that the likelihood of interception is remote. Primary defensive reliance would have to be placed on antisubmarine measures.

Ground-Launched Surface-to-Surface Missiles

110. In the light of probable Soviet strategic objectives, the USSR probably has a series of requirements for improved weapons to: (a) neutralize Allied nuclear delivery capabilities at their launching sites (air bases, carriers, missile launchers); (b) provide an all-weather tactical nuclear capability in battle areas, particularly in view of growing Allied capabilities in this field; (c) attack Allied ports and vital centers, and neutralize such key Allied base areas as the UK and Japan. These requirements might be met by missile systems, but major deterrents to their use during the next few years would be the factors of reliability, accuracy, and yield, which might lead the USSR to consider aircraft a better means of delivering its limited nuclear stockpile.

111. The USSR could use from ground-launchers, with somewhat improved accuracy, the three pilotless aircraft whose use from submarines was discussed in paragraphs 107 and 108 above. Since they would be of limited accuracy and their vulnerability would approach that of piloted aircraft, however, we believe it unlikely that the USSR would choose to develop any significant operational capability of this type. We believe that the Soviets would favor ballistic missiles because of their relative immunity to presently known countermeasures.

112. We have also estimated that the USSR could have ready for series production the following ballistic SSGMs: (a) in 1954 an *elongated V–2 type* with a 2,000 pound HE warhead and 350 nautical mile range; (b) alternatively, in 1954 an *improved V–2 or native design* with much less range but a 3,000 pound warhead and greater accuracy; (c) in 1955 an *elongated V–2 type* with a 3,000 pound warhead and 500 nautical mile range; (d) in 1957 (or at the earliest possible date in 1955) a *100-ton thrust SSGM* with 900 mile range and a nuclear warhead; and (e) in 1959 (or at the earliest possible date in 1957) an SSGM with 1,300 nautical mile range (see paragraph 26). However, the accuracy of these missiles would be markedly inferior to that which the Soviets could probably obtain by either visual or blind bombing. Moreover, all targets within range of the first three missiles would be within the combat radius of Soviet jet light as well as medium bombers. The last two missiles would be markedly inferior in range in the new jet medium bomber. The chief advantages which these ballistic missiles appear to offer is their relative invulnerability to interception and their capabilities for surprise attack.

113. To counter growing Allied all-weather nuclear capabilities in Europe, the USSR will probably give high priority to a missile system for support of its field forces. The improved V–2 or native design estimated to be now available would satisfy this requirement, if considerably improved accuracy could be attained. In this case, considerable effort might be devoted to its production.

114. However, aside from this missile, we believe that the Soviets would seek to produce ballistic SSGMs in quantity only if they expected the kill probability of Allied air defenses to be so high that such missiles would provide more certain delivery than piloted aircraft. We believe that over the next several years the Soviets will rely primarily on high performance bombers as a more assured means of delivery. Therefore, for the next several years the Soviet surface-to-surface missile effort will probably be concentrated more upon development of improved ballistic missiles than upon quantity production of interim types. When the USSR estimates that improved Allied air defenses will soon pose a major threat to successful aircraft delivery, it will probably undertake a heavy investment in SSGM's. By 1958–1960 the estimated growth of the Soviet nuclear stockpile and the larger warhead yields probably available would have reduced the significance of any limitations which the accuracy or reliability of such missiles systems might have placed upon their earlier use (see Annex C, *Restricted Data*).

115. *Potential Military Threat.* Thus the chief Soviet ballistic missile threat in the next several years is likely to arise from a considerable Soviet effort to produce a short-range

missile to counter Allied tactical all-weather nuclear capabilities in Europe. Later, the USSR might develop a ballistic missile capability for neutralizing Allied bases on the Eurasian periphery. For example, the 1,300 mile ballistic missile which could probably be ready for series production in 1959 could reach all present US air bases in Europe, the Philippines, Alaska, Iceland, Japan, and North Africa, with the exception of those in Morocco.

Intercontinental Ballistic Missile (IBM)

116. A major wartime objective of the USSR would undoubtedly be to effect the maximum practicable disruption of the war effort of the US. The presently estimated scale of the Soviet jet heavy bomber program suggests that the USSR intends to rely on this weapon and considers that it will remain a useful means of delivery for several years to come. However, in view of US emphasis on continental air defense, the Soviets must foresee a period when long-range bombers may no longer be a feasible means of attacking heavily defended US targets. They may also be aware of the possibility of eventual Allied capabilities to attack the USSR with an intercontinental ballistic missile, against which there is no presently known defense. Therefore, we estimate that the USSR will almost certainly undertake, if it has not done so already, a concerted high priority effort to acquire an intercontinental ballistic missile. As with nuclear weapons, the USSR will probably estimate that its security will depend upon having such weapons to counterbalance any capability on the part of the US.

117. We have estimated that in this event, the USSR could have ready for series production in about 1963 (or at the earliest possible date about 1960) an IBM with a high yield nuclear warhead (see Annex C, *Restricted Data*) and a CEP of roughly five nautical miles.[15] Such a Soviet missile could be used against large industrial complexes. However, its effectiveness against such point targets as airfields or US missile launching sites might be marginal. Given the likely growth of the Soviet nuclear stockpile by the 1960's, a considerable degree of unreliability might be acceptable to the USSR.

118. *Potential Threat to the US.* Advent of the IBM would create an entirely new type of threat to the US. Attacks upon the launching sites are the only possible countermeasures now known or in prospect. If the USSR should develop such a missile and produce it in considerable numbers before the US developed adequate counterweapons or countermeasures, the USSR would acquire such a military advantage as to constitute an extremely grave threat to US security.

Allocation of Priorities Within the Soviet Missile Program

119. Our knowledge of current Soviet missile activities is so meager as to provide little basis for any firm estimate of the nature, scale — or even existence — of an actual Soviet production program. However, we believe that from the standpoint of currently urgent military requirements and estimated early operational availability, the USSR will give highest priority in the period roughly 1954–1960 to the development and production of surface-to-air and air-to-air missiles to meet urgent air defense needs. In our view it would give a high priority to producing a submarine-launched SSGM, a short-range tactical ballistic missile, and a short-range air-to-surface antiship missile in that order, although priorities might vary according to when designs became operationally available. Other types probably would not be produced in quantity over the next several years.

120. Meanwhile, further research and development in the above missile categories, as well as of a long-range ASGM and various ballistic missiles (especially the IBM), would probably go forward under high priority. The interdependence of development work on all these missiles is such that it is not feasible to differentiate among the priorities they would receive. At some time around 1960

[15] See footnote to paragraph 91, but note that in the case of the IBM, operational firing in limited numbers might be conducted by factory technicians at the assembly sites and the full 18-month to two-year training period for missile units would not be required.

production of the long-range ASGM, if available, would probably be undertaken under highest priority, followed by the medium-range ballistic SSGM's. Production of the IBM would probably be undertaken at the earliest practicable date.

121. The relative production emphasis and quantities of the above missile produced could vary widely, depending on such factors as Soviet strategic planning concepts, the dates of availability of various missiles, Soviet nuclear technology and stockpiles, Soviet economic capabilities, and the competing demands of other Soviet weapons systems. As noted, the capabilities of the Bloc electronics and precision mechanism industries appear to be a major limiting factor on any extensive missile program. With respect to Soviet strategic concepts, primary emphasis on air defense would suggest an all-out effort on SAGMs and AAGMs at the expense of other categories, while primary emphasis on isolating the US from its allies would point to emphasis on missiles having a high potential against shipping or port areas. A Soviet decision on a definite time-table for war might lead to a cutting down of effort on all missiles whose operational availability in quantity could not be anticipated by the presumed D-Day.

ANNEX A

ORGANIZATIONS AND FACILITIES IN THE SOVIET MISSILE PROGRAM

Ministry of the Aircraft Industry

1. *Central Aero-Hydrodynamic Institute (TsAGI), Moscow.* One of the most important Soviet aeronautical research institutes, TsAGI does research in all basic and applied sciences associated with aeronautics and is probably a major source of aerodynamic data for the missile program. For example, TsAGI supplied wind tunnel data to KB-3, a design bureau in Putilovo known to have been concerned with missile activities (see paragraph 23). NII 88 and its Branch 1 at Ostashkov (see paragraph 14) are known to have sent models to TsAGI for aerodynamic tests. TsAGI also had representatives at NTS meetings at NII 88.

2. *Experimental Factory 1, Podberez'ye.* This factory is known to have been utilized for exploiting German aeronautical scientists, engineers, and technicians. The work involved mainly research and development on new aircraft but during 1948–1949 some work was devoted to aerodynamic test vehicles designated as the M-series. The results of such work could be applicable to design of missiles as well as aircraft. Although the research work here was not principally concerned with propellants, some developmental work was done on PENA (a propellant employing metallic sodium suspended in a hydrocarbon fuel), and on combinations of hydrogen peroxide/hydrazine hydrate and petroleum/white fuming nitric acid. While apparently for rocket powered interceptors, this work could also be applicable to missile power plants.

3. Improvements to the pulse-jet, started in Germany in 1945, were continued at Factory 1, and by 1949 apparently resulted in a pulse-jet engine with an estimated thrust of 770 pounds smaller than the German Argus–014. There are also reports of work on a twin pulse-jet V–1 type missile. During 1950, this factory acted as a subcontractor for NII 88, a known missile installation (see paragraph 14). Equipment delivered consisted of cigar-shaped fuselages, wings (approximately 1.2 meters long with a chord of 0.4 meters) accelerometers, altimeters, dynamic pressure recorders, deflection recorders, and angle of attack indicators.

4. *Factory 2, Kuybyshev.* The principal work of this factory is the fabrication, assembly, and experimental testing of new and modified jet engine designs, but there are indications that a small part has also been engaged in the research and development on certain components used in missiles. The Askania group of Germans assigned here continued developments on the Patin automatic pilot, triaxial gyroscopes, and V–1 control mechanisms which they had worked on in Germany. During 1948 this group reportedly overhauled about 100 standard V–1 control systems and modified six systems for electric instead of pneumatic controls. In the fall of 1950, most of the group joined other German missile specialists at Post Box 908, Moscow (see paragraph 21).

5. *Flight Test Institute (LII), Ramenskoye.* This institute, located at Ramenskoye airfield, probably handles most of the flight research and testing for the Ministry of Aircraft Industry. Beginning in 1949, German prisoners of war reported seeing winged objects attached under the wings of TU–4 bombers. The most recent observation was made during late 1951 to 1953 by German electronic specialists who, as prisoners of war, were forced to work at Post Box 908, Moscow (see paragraph 21). One source was told that the "missiles" attached to the TU–4's were an air-to-surface type for which the Germans at Post Box 908 were developing a guidance system.

6. *Scientific Research Institute (NII) 1, Moscow.* In 1947 two members of this institute wrote an article on determination of the temperature and coefficient of complete com-

bustion in the chamber of a ZhRD (liquid fuel rocket engine). Two other persons affiliated with this institute were reportedly interested in the German Sänger project for a long-range rocket bomber. Other scientists, formerly associated with this institute, have appeared at Factory 456 at Khimki, a known missile installation. One of these men, Glushko, was interested in the development of the 100 ton thrust propulsion system as early as 1947, and became head of this project when work was started in mid-1948.

Ministry of Chemical Industry

7. *Physiochemical Institute imeni Karpov, Moscow.* This institute's main function is to conduct, supervise, and/or serve as a consulting agency on technical chemical research of industrial interest. It is reported to have been engaged in research on hyperbolic fuels. Small scale ignition lag tests by the drop method were conducted. By 1950 two rocket fuels, triethylamine and acetonine, had been developed to the pilot plant stage.

8. *State Institute of Applied Chemistry (GIPKh), Leningrad.* The chief function of this institute is the study of the problems involved in the most efficient utilization of natural resources. Propellant research was carried out, with particular emphasis on amine compounds for use in hyperbolic fuels. This research appears to be related to that carried out at the Karpov Institute.

9. *OKA Chemical Plant, Dzerzhinsk.* In the summer of 1948 a group of six Germans from the Karpov Institute were transferred here and concentrated on developing rocket propellants based on amines with nitric acid as the oxidizing agent. The adjoining Plant 96 is the only known producer of hydrogen peroxide in the USSR. Reports indicate that 70 percent hydrogen peroxide was available at Plant 96.

10. *Plant 94, Moscow.* This factory has two pilot plants, one for acetonine and one for triethylamine. Hyperbolic fuel mixtures were sent here from the Karpov Institute and the OKA chemical plant for extensive combustion testing. Bobyshev, the manager, was formerly supervisor of a German team working on hyperbolic fuels at Leuna, Germany. He has also been identified at both the Karpov Institute and the OKA chemical plant.

Ministry of Defense

11. *Academy of Artillery Sciences, Moscow.* This Academy was established on 11 October 1946 to further the development of artillery weapons. Voronov, Chief Marshal of Artillery Science and honorary president of the academy, was the commander of the Special Purpose Rocket Brigade formed in 1946 from the Berka V–2 training unit in Germany, and reported to have gone to a guided missile test range in the USSR. Although the institute was under the Soviet Army and had a command staff of artillery officers, officers of the Army Air Forces and the Navy were attached to it. A commission on rocket techniques was also established by the academy.

12. The Bolshevo Artillery Institute near Moscow is thought to be subordinate to the academy. In January 1947, 41 loads of unidentified "special machines" were presumably dispatched to this institute from Lehesten, Germany, the site of the V–2 combustion chamber static test facilities. Tikhonravov, said to be associated with this institute, was a member of the Scientific Technical Council (NTS). In early 1949, representatives from this institute obtained 20 sets of the German missile-borne receiver, Strassburg, from NII 885 (see paragraph 26). Early in 1951 a Soviet commission allegedly from the Bolshevo Institute went to Ostashkov to select a group of German engineers in the field of guidance and control devices. This group of Germans was later moved to Post Box 908, Moscow (see paragraph 21).

13. *Zhukovskiy Academy, Moscow.* This academy trains aircraft designers and engineers, and is probably the most important Soviet school of its type. Several high level members of the academy have been reported to be working on guided missile problems, e.g., a design study of wings for supersonic long-range SSGM's in 1947, missile trajectories, guidance, and stabilization.

Ministry of the Defense Industry

14. *Scientific Research Institute (NII) 88 and Factory 88 (the 88 Complex), Kaliningrad.* The 88 Complex is the most important Soviet facility known to have been involved in missile development. Its initial task was assembly of standard German A–4's for test firing at the Kapustin Yar test range in late 1947. The 88 Complex worked on improving the A–4 and was also involved in work on Wasserfall and Schmetterling.

15. Other indications of its importance are as follows: (a) in 1948 it received guidance and control equipment from Gema Haus in Berlin, when this organization was dissolved; (b) 25 and 35 ton thrust propulsion units were shipped here from Factory 456, Khimki; (c) the Director of NII 88 was chairman of the NTS, which held its meetings here; (d) flight simulators were sent here from Ostashkov in 1949 and 1950; (e) existence of a wind tunnel has been reported, and Branch 1 below contributed to the design of several components of this tunnel; (f) elongated boxcars have been observed here beginning in 1950 and as late as 1954; (g) results of 1947 firing trials held at Kapustin Yar were evaluated here in the spring of 1948; (h) representatives of NII 88 have appeared at other installations known to be involved in missile activities; (i) A–4 control actuators were reportedly produced here at the rate of 20 per month by 1951; (j) in 1948 construction of a special building was begun, which the Germans reported was to be used for vertical tests of the V–2 (photos confirm completion of this building during 1949); (k) another new building, approximately 200 feet in length and three stories high, was erected sometime in 1951; and (l) static propulsion tests have taken place at the complex since 1947, with the last reported test in March 1954.

16. *Branch 1 of NII 88, Ostashkov* was the destination of the German scientists who were transferred from the 88 Complex in 1947–1948. Approximately 175 German scientists were assigned here, the largest number known to be located at any Soviet installation involved in missile research. Members of this group have supplied considerable information, as indicated by the following list of principal projects proposed by them to the Soviets: (a) *R–10 project* — a design study for a ballistic missile system with a range of approximately 500 nautical miles and a warhead of 2,150 pounds; (b) *R–12 project* — a series of investigations of two-stage ballistic missile designs with a range of approximately 1,300 nautical miles and a warhead of 2,200 pounds; (c) *R–14 project* — a preliminary design study for a ballistic missile system with a range of approximately 1,600 nautical miles carrying a warhead of 6,600 pounds; (d) *R–15 project* — a preliminary design proposal for an aircraft type, supersonic ram-jet missile system with a range of 1,600 nautical miles carrying a warhead of 6,600 pounds; (e) *R–113 project* — a preliminary design study for a surface-to-air missile system of 65,000 yards slant range and a warhead of possibly 1,100 pounds; (f) an ultrahigh frequency radio command guidance system for ballistic type missiles; (g) a system for bleeding combustion chamber gases from liquid rocket engines to run the fuel pump turbines; (h) investigation of the formation of colloidal suspension of metals in fuels which could be applied to guided missiles; (i) design, construction, and operation of a supersonic wind tunnel; and (j) construction of analogue computers to be used as flight path simulators for determining ballistic and aerodynamic data applicable to guided missile designs.

17. There appears to be another branch of the 88 Complex at Bolshevo, although no connection with the Bolshevo Artillery Institute is known. One German worked at this branch for a month in 1946, and other Germans have stated their belief that NII 88 had such a branch.

18. *Factory 456, Khimki.* This factory, believed to be subordinate (since May 1953) to the Ministry of Defense Industry, includes a developmental plant (OKB), and a production plant. OKB was charged with: (a) indoctrinating Soviet technicians in the manufacture, assembly, testing, and operation of V–2 combustion chamber and propulsion components; (b) increasing the thrust of the V–2 from 25 to 35 ton thrust; (c) design of a 100

ton thrust propulsion unit; and (d) design of a 250 ton static test stand. The production plant was charged with: (a) assembly and production of V–1's (reported total production estimates run as high as several hundred); (b) preparation for pilot production of V–2 combustion chambers; and (c) manufacture of certain consumer goods.

19. Propellant research was also conducted here, and had two basic trends, namely, tests for ethyl alcohol and liquid oxygen, and tests of a nitric acid oxidizer. The latter included small scale experimental engine tests. This factory is known to have a test facility for the 25/35 ton thrust propulsion units (test stand, observation bunker, underground fuel storage dump, and a liquid oxygen plant), storage facilities for hydrogen peroxide, a hydraulic test stand, and equipment for dynamic balancing of turbopumps. It was reported that in mid-1950 all V–2 type propulsion units, jigs, and tools were packed and shipped out, possibly to Kuybyshev.

20. *Kapustin Yar Test Range.* This range is located about 57 miles east-southeast of Stalingrad. Germans, some of whom visited the range in 1947, described equipment either located at the range or intended for use there. The basic telemetering equipment used was the German Messina. The range was also equipped with Askania cinetheodolites, radar (including the American SCR 584 radar), a static test stand, and a rather elaborate horizontal test check out stand. Other test equipment which could now be in use includes a second telemetering system, called Messina IN, developed by the Germans after World War II as part of the Soviet exploitation program. It was a pulse transmission system using 16 channels. It is known that, in 1949, a Stalin Prize was awarded to Soviet engineers for the further development of this equipment. The Soviets were also interested in developing a doppler radar system for range instrumentation. Work was started as early as 1945, and continued by the Germans at NII 885 until 1947. At this time all components were shipped out to an unknown destination, and the Germans were assigned other projects. From brief descriptions, it is believed that the system would consist of rangehead transmitters and both rangehead and down-range receiving stations.

21. *Design Bureau 2 (KB–2), Post Box 908 Moscow.* This organization has also been referred to as an electronics research institute. As early as 1947, German prisoner of war technicians worked here on a guidance system for an ASGM with a range of around 90 nautical miles. It is believed that the main part of the German guidance and control group, the only German group still in the USSR working on missiles, are involved in the work of this installation, while another part is believed to be working on a complete SAGM system at an unidentified installation near Khimki. The main body of the group is known as the Buschbeck/Eitzenberger group and was formerly at NII 885 and its branch at Monino (see paragraph 26). Germans from Branch 1 of NII 88 at Ostashkov, from Factory 2 in Kuybyshev, and from prisoner of war camps were also merged into the group. While a complete picture of the activity at KB–2 is not available, the Soviets were apparently very interested in a radar guidance system, described as a midcourse beam-rider with semiactive homing, being developed there. Inasmuch as this system would be adaptable in whole or in part to various types of missiles, KB–2 could be of considerable importance in the Soviet program.

22. *Factory 393, Krasnogorsk.* Two phases of the activities of this factory appear to be applicable to missile research and development: (a) the repair and limited production of various types of theodolites (including the Askania KT 40 cinetheodolites, the type used at US missile ranges); and (b) experimental work with PbS photoconductive cells applicable to infrared detectors. This latter work is believed to be related to the development of the "Juno" missile-seeker head developed in Germany during the war. Additional infrared research here consisted of: (a) research and production of PbS photoconductive cells; (b) work on KRS-5 [16] crystals, including

[16] A combination of thallium bromide and iodide developed by Zeiss during World War II. It has a low attenuation in the two to approximately 35 micron band.

growth of the crystals and the grinding of lenses and windows (the only known use for these crystals is as a superior infrared transparent material); (c) the use and fabrication of black bodies for research; and (d) work on infrared filters (probably for photographic purposes). The appearance of representatives of NII 88 and the Factory 393 in connection with repairs being made on theodolites also indicates probable missile work.

23. *Design Bureau 3 (KB-3), Putilovo.* This installation is known to have worked on the development of an AAGM referred to as "Sokol." It and the nearby Sofrino Proving Ground appear to function as a unit. A group of Germans worked at KB-3 from 1946 to 1952 on development of powder-propelled unguided rockets for air-to-air, air-to-surface, and surface-to-air use, and on antitank rocket developments. There appears to have been a Soviet institute in Moscow working on projects related to the German work at KB-3. A Soviet surface-to-air guided missile engineer from NII 88 is known to have visited the Sofrino Proving Ground several times during 1949–1951. The instrumentation at Putilovo is known to include an intermittent supersonic wind tunnel (Mach 3), a static test stand (horizontal), launching rails, and a small weather station. Measurements were restricted to range and dispersion patterns. There were no facilities for trajectory data.

Ministry of the Heavy Machine Building Industry

24. *Podemnik Factory, Moscow.* Numerous POW reports indicate that special vehicles were being produced here up to 1949. The descriptions indicate that the vehicles were similar to the Meilerwagens, special trailers used by the Germans to transport V-2's to the launching site. This factory specializes in building mobile cranes and is therefore well equipped to produce missile transporting and handling equipment.

Ministry of the Radio Technical Industry

25. *Scientific Research Institute (NII) 885, Moscow.* This institute's activities included the reconstruction and Sovietizing of the Leitstrahl azimuth guide beam system, the Messina IN telemetering equipment, doppler volocity and position measuring equipment, the V-2 electrical system, and an electrical checkout stand and firing console. In addition, reports indicate some work on a celestial guidance system. A branch of this institute, Special Bureau 1 at Monino, worked on design and development of a semiactive radar homing head for a SAGM.

26. NII 885's relationship with other missile installations is indicated by the fact that requests for library books not available at NII 885 and/or requests for consultation with members of the Academy of Sciences, USSR, had to be submitted through NII 88. It is also known to have furnished about 20 Strassburg receivers to the Bolshevo Artillery Institute. At least one German from NII 885 was present at the 1947 firing trials at Kapustin Yar. In 1950 German personnel, principally those connected with the homing head project, were transferred to Post Box 908, Moscow.

27. *Scientific Research Institute (NII) 380, Leningrad.* An electronics institute engaged in the development of civilian and military television equipment, NII 380 is composed of two branches. Its Secret Department was reportedly concerned with developmental work based on Tonne A, a 70 centimeter wavelength television apparatus designed by the Germans during World War II as a guidance system for the German Hs 293D air-to-ship missile. There is as yet no evidence of a direct connection between the activities of the Secret Department and the activities of other missile installations. There are reports that an unspecified institute at Odessa has done work similar to that of NII 380, and engineers from Odessa are known to have visited NII 380.

Ministry of the Shipbuilding Industry

28. *Scientific Research Institute (NII) 49, Leningrad.* Activities of this institute from mid-1945 to early 1953 included development of ground computers for SAGMs and of a gyrostabilized platform for inertial guidance systems. It reportedly had a department con-

cerned with development of radar equipment. Our information is scant, but radar wavelengths of three and 10 centimeters have been indicated. The reconstruction and Sovietizing of the Wasserfall computer was completed sometime in 1948, and the resulting computer was reportedly sent to a range for testing in 1949. The NII 49 laboratories, whose research apparently paralleled the work of the Germans, also constructed a computer for the Wasserfall reported to have been tested at the same time as the German model.

Academy of Sciences, USSR

29. *Department of Technical Sciences, Moscow.* This department contributes to the Soviet missile program by providing basic theoretical research in aerodynamics, propellants, communications systems, computer design, servomechanisms, mechanical components, and fundamental mathematical investigations of external ballistics. It contributed to the development of components in the field of "modelling computers" (probably flight simulators, although sources state that this development was in its infancy in 1951–1952), electronic regulating mechanisms, and gyroscopic stabilizers. Individuals and groups from this department have been associated with other missile activities.

30. *Institute of Automatics and Telemechanics, Moscow.* This institute develops regulatory devices such as servomechanisms, gyroscopic stabilizers, and electronic control devices. It investigates theoretical phases of mechanics such as nonlinear oscillations, as well as pulse modulation, automatic frequency correction systems, and medium high and ultrahigh frequency generators. One member has published research papers on combustion chambers, propulsion units, and hydrodynamics of liquid flow through pipes. This organization is reported to have designed a servodrive system for the direction finding antennas of the UHF radio guidance system developed at Branch 1 of NII 88. It is also reported to have copied and supplied this Branch with small Markgraf gyroscopes to be used in the missile R–10 (a standard length A–4 with improvements), and in missile trajectory simulators. A Soviet physicist of this institute, A. A. Andranov, who died in November 1952, was declared by the Soviets to have been the leading guided missile expert in the USSR.

ANNEX B

SOVIET ECONOMIC CAPABILITIES FOR MISSILE PRODUCTION

1. In order to estimate the rough order of magnitude of Soviet economic capabilities for series missiles production and the economic impact of a major Soviet missile program we have set up an illustrative Soviet program and analyzed Soviet capabilities to carry it out. *Our illustrative program is wholly hypothetical;* it is based upon a set of theoretical Soviet military requirements which are not necessarily indicative of an actual Soviet program, although we have attempted to make them realistic.

2. Our analyses of Soviet production capabilities are admittedly imprecise. They are based on estimates of production capacity, comparable estimated US costs, ruble conversion ratios, and other factors which are subject to a considerable margin of error. However, even though our estimates do not permit precise measurements, they do permit some broad conclusions as to what the USSR *could do* if it chose.

I. HYPOTHETICAL SOVIET MISSILE REQUIREMENTS

3. Our first step was to construct a set of hypothetical Soviet missile requirements. For each missile type which we estimated the USSR would desire to produce, we have estimated the number which it would need to meet initial wartime stockpile requirements. Although the program hypothesized took into account the "general state of the art," it was based only on estimated military requirements, without consideration of research, development, or production limitations. The program is a generous one, designed to meet the offensive and defensive missile requirements of the Soviet Union, but it does not specifically provide for the air defense of the Satellites or the equipping of Satellite forces.

4. We believe that these illustrative requirements serve as a reasonable basis for analyzing what sort of production program the USSR could undertake. For costing purposes, since we have no Soviet missile costs, we have translated into rubles the estimated costs of roughly counterpart US missiles. For timing, we have taken the earliest probable date at which it has been estimated that each missile of the above type could be operationally tested and ready for series production. In line with US experience we believe that it would take on the average, an additional six months between this time and the time at which tooling up for series production would be completed and production models would begin coming off the line.[17] Therefore, we selected the calendar year *following* as the one in which the USSR could begin series production. The selection, including reference to discussion of the classification of these missiles in Section II of this estimate, was as indicated in Table I.

TABLE I

Missile Type	Closest US Counterpart For Cost Purposes	Assumed Soviet Stockpile Requirement	Assumed Production Starting Date
AAGM par. 63	Falcon	120,000	1959
SAGM " 56	(scaled Nike)	30,000	1954
SAGM " 58	Bomarc	5,000	1961
ASGM " 67	Petrel	5,500	1954
ASGM " 69	Rascal	600	1961
SSGM " 50	Regulus	700	1956
SSGM " 32	(scaled Corporal)	2,000	1954
SSGM " 38	(scaled Corporal)	600	1958
IBM " 41	Atlas	500	1964

II. ECONOMIC REQUIREMENTS FOR HYPOTHETICAL SOVIET MISSILE PROGRAM

5. In estimating the production capacity that the above missile program might require, we have assumed that no series production oc-

[17] See paragraph 26 and its footnote.

TABLE II

ASSUMED PRODUCTION OF MISSILE AND MISSILE SPARES
FOR HYPOTHETICAL PROGRAM
(Number of Missiles)

	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	TOTAL
SSGM 1-1	....	....	190	535	597	288	288	288	288	288	288	288	288	288	3,914
SSGM 1-2	450	1,350	1,076	350	350	350	350	350	350	350	350	350	350	350	6,726
SSGM-2	....	....	.....	.....	225	573	108	108	108	108	108	108	108	108	1,662
SSGM-3	....	....	.....	.....	....	.....	.....	.....	.....	.....	100	400	218	90	808
SAGM-1	3,000	9,000	15,000	15,000	8,047	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	98,647
SAGM-2	....	....	.....	.....	....	.....	.....	290	870	1,450	2,030	2,328	620	620	8,208
AAGM-1	....	....	.....	.....	....	13,370	40,110	60,920	20,000	20,000	20,000	20,000	20,000	20,000	234,400
ASGM-1-2	975	2,925	3,812	990	990	990	990	990	990	990	990	990	990	990	18,602
ASGM-2	....	....	.....	.....	....	.....	.....	171	540	199	120	120	120	120	1,630

NOTE: In addition to stockpile missiles, production schedule includes training missiles and missile spares expressed as equivalent missiles.

curred earlier than in 1954. The fact that we have no intelligence on series production lends some credibility to this assumption. Table II presents an estimated time pattern in which the missiles could be produced to satisfy requirements. These production estimates have been derived from US data by assuming that: (a) the Soviet missiles would be produced in plants roughly equivalent in size to the plants producing the US counterparts; (b) they would be produced at rates compatible with these plant sizes; and (c) the USSR would employ capacity operation, i.e., multiple shifts. If one shift operation were used the time pattern would naturally be substantially changed and extended. No attempt was made to adjust the US data for differences in US and Soviet production techniques because the size of such factors are unknown and because most of the US data are based, not on actual production experience, but on production plans.

III. SOVIET CAPABILITIES TO SUPPORT THE ASSUMED PRODUCTION PROGRAM

6. *Available Industrial Facilities.* A survey of available intelligence of Soviet industrial facilities available to fulfill missile requirements revealed no likely restrictions on the assumed program, except in precision instruments and electronics (see paragraphs 16–19). Some capacity in the airframe industry (now devoted to consumer goods and other items) could be used in the missile program. Moreover, since missile frame production is not restricted to airframe facilities, the underutilized plants of the Ministries of Defense Industry or Automotive, Tractor, and Agriculture Machine Building probably could readily be used; particularly for the smaller missiles. Similarly, it is estimated that during 1953 Soviet jet engine factories operated at only about 30–35 percent capacity producing over 15,000 VK-1 type turbojet engines. No information is available on the production of liquid rocket engines, but liquid rocket facilities are not peculiar to any one type of industry. Launching and handling equipment and packaging are not specialized, and would represent no foreseeable production problem to the USSR.

7. *Labor and Material Input Requirements.* The input requirements necessary to meet the assumed production schedules were determined, where possible, on the basis of input data for the counterpart US missiles. Where such data was not available, as for certain assumed Soviet surface-to-surface missiles, inputs were determined by scaling the Corporal inputs by the ratio of the weight of the estimated Soviet missile component to that of the respective Corporal component. Similarly, Nike was scaled by weight for the Soviet SAGM.

8. If the USSR followed the assumed production schedule, the program at capacity scale of effort would require some 67,000 people by the third year. The peak requirement of 110,000 would be reached in about 12 years. This peak labor requirement would include 18,000 technical workers and 6,300 managerial personnel. In the light of the growth of population, skilled labor, and engineering and technical manpower in the Soviet Union between 1947 and 1953, manpower limitations seem unlikely to place any general constriction on the assumed program. Some qualitative problems, however, might develop.

9. A similar determination of basic materials requirements points up their smallness, except possibly for liquid oxidizer. Materials as a bulk problem clearly would not be a matter of major concern. Our examination of the qualitative aspects of the materials problem indicates that for the most part materials satisfactory for missiles are available to the Soviets.

IV. AGGREGATE ECONOMIC REQUIREMENTS AND CAPABILITIES

10. Up to this point our calculations have been based on assumed Soviet requirements for missiles themselves. However, the associated system requirements must be added to the missile needs or Soviet capabilities would be seriously overestimated. In view of the complexity of an over-all missile system and the great variety of individual elements in the system, this problem was approached in aggregative money terms. (We recognize that money calculations are an imprecise

method of assessing Soviet production costs and capabilities, but it does permit a general order of magnitude.)

11. Our calculation of system costs is incremental. It includes such requirements as: (a) special equipment, construction, and platform modifications; (b) the initial wartime stockpile missiles; and (c) training missiles, missile and special equipment spares, and drone aircraft modifications. We have considered that certain other requirements are not properly chargeable to the missile program, or, more accurately, are part of other programs and can therefore be eliminated from our calculations. These include the initial and handling costs for the warhead, organizational equipment, and "inherited" items such as ships, submarines, and operational support and drone aircraft. Nor have we included such "common use" items as the early warning network and airbases. The intermediate and superior command structure, and the cost of providing and maintaining troop housing, subsistence, etc., are also excluded.

12. The entire program from 1954 through 1966, under our assumption, would require cumulative outlays of about 215 billion 1951 rubles,[18] or somewhat under 17 billion rubles a year and an annual carrying cost thereafter of about 12 billion rubles a year (see Table III). The initial rapid buildup reflects the USSR's estimated present capability to embark upon certain programs, particularly in the shorter range surface-to-air and surface-to-surface missiles.

13. The estimated incremental costs of our hypothetical missile program were constructed from four cost categories. Time patterns for *research and development* costs were developed for each system category and phased in prior to the year it was estimated this activity would have been completed. The *costs of missiles produced* was then calculated on the basis of multiple shift operations. Costs of each category of missiles and missiles spares were calculated, giving consideration to the cost reduction effects of applicable labor progress (learning) curves. It was assumed that trained operating units were the goal of the program. As soon, therefore, as sufficient missiles became available from production, an operating unit was scheduled for activation and provided with its complement of stockpile missiles and initial missile spares and supplied thereafter with training missiles and maintenance spares.

14. This activation schedule became the basis for phasing the *initial system costs* into a time pattern. It was assumed that the initial costs of a given unit would be incurred during the year prior to the unit's receipt of its complement of missiles and spares. To obtain the *system operating costs*, the cumulative activation schedule was used as the basis for a unit operation schedule for each missile category.

15. *Soviet Capabilities to Meet Above Requirements.* In value terms the above program would be a substantial but not impossible burden upon the Soviet economy. It would represent a total burden near two percent of estimated GNP from 1954 to 1966. The annual expenditures necessary prior to 1954 would consist primarily of research and development outlays and, if charged to the defense budget, would equal only about two percent of 1951 and 1952 and four percent of 1953 estimated defense expenditures. As-

[18] In the absence of intelligence, we have been compelled to calculate Soviet missile costs in terms of the dollar costs of US counterparts with appropriate modifications, which were then converted to rubles by applying a ruble-dollar ratio. We recognize that the US dollar costs used are themselves based on US estimates of planned production costs which might themselves be subject to a substantial margin of error. The balance of the system costs were similarly derived on the assumption that the Soviets could not cut any considerable "corners" without relaxing performance characteristics. An examination of the economic sector origin of the bulk of the missile components revealed that: (a) the sectors concerned are those in which the ruble-dollar ratios approximate that which describes the over-all relationship between Soviet and US prices; and (b) the pattern of costs in the combination of these sectors seems to be about the same as in the US. For these reasons it was possible to select the national ruble-dollar ratio (10 rubles to the dollar) and apply it generally without risking a serious misstatement of differential costs.

TABLE III

TOTAL COSTS OF ILLUSTRATIVE PROGRAM

(Million of 1951 Rubles)

Year	Research, Development, and Testing	Missiles and Missile Spares	Initial System Cost	System Operating Cost	Total *	Cumulative System Costs
1945	190	.....	.....	.....	190	190
1946	280	.....	.....	.....	280	470
1947	380	.....	.....	.....	380	850
1948	450	.....	.....	.....	450	1,300
1949	650	.....	.....	.....	650	1,950
1950	1,000	.....	.....	.....	1,000	2,950
1951	1,600	.....	.....	.....	1,600	4,550
1952	2,400	.....	.....	.....	2,400	6,950
1953	2,400	.....	2,800	.....	5,200	12,150
1954	2,300	2,000	8,400	300	13,000	25,150
1955	2,200	3,700	8,800	1,200	15,800	40,950
1956	3,000	4,300	4,700	2,000	13,900	54,850
1957	3,200	3,300	8,800	2,400	17,700	72,550
1958	3,000	2,800	9,100	2,900	17,800	90,350
1959	2,400	3,900	2,300	3,600	12,200	102,550
1960	2,000	5,700	3,500	4,000	15,100	117,650
1961	2,500	9,100	3,900	4,600	20,100	137,750
1962	2,900	10,100	1,600	5,200	19,800	157,550
1963	3,200	5,800	2,600	5,300	16,900	174,450
1964	.....	8,000	4,300	5,600	17,900	192,350
1965	.....	13,000	2,000	5,879	20,900	213,250
1966	.....	8,000	.....	6,000	14,000	227,250
1967	.....	5,800	.....	6,000	11,800	239,050

* Total does not necessarily add, due to rounding.

sumed missile outlays beginning in 1954 would be considerably greater. In the three year period 1954–1956 they would equal about 10 percent of estimated defense outlays. Since 1953 Soviet defense expenditures (in 1951 rubles) are estimated to have included 16 billion rubles for aircraft procurement, 11 billion rubles for armored vehicles, and 6 billion rubles for naval vessels, a missile program of the assumed magnitude would on the basis of total cost by no means be impossible. However, the impact of a program of this magnitude would be considerable; either other military outlays or consumption would have to be reduced, or the rate of investment, and correspondingly the rate of economic growth, would be retarded.

16. *Electronic Equipment and Precision Mechanism Costs.* One important aspect of any missile program cost not revealed in the above over-all analysis is its substantial impact upon the electronic and precision mechanism industries. In all phases of the program the requirements from these industries were heavy, and they accounted for about 50 percent of the total cost of the program. Using a procedure parallel to that used for deriving total costs, we have estimated the value of electronic equipment and precision mechanisms involved in our illustrative Soviet missile program (see Table IV). The requirements against these two interrelated sectors of the program could not readily be separated, and we have no estimate of Soviet production capabilities in the precision mechanism field. However, some notion of the magnitude of such demands on the Soviet electronics industry can be gained by assuming, as a first approximation, that the entire requirement is for electronic equipment. On this basis, the requirement would amount to about 38 percent of USSR electronics output for the entire period of the program (1954–1967) or 27 percent of the combined USSR and European Satellite production for the same period. During the years 1954–1956 about two-thirds of total estimated USSR electronics production would be required, or about half of the combined production of the USSR and the Satellites (surface-to-air missiles account for three-fourths of the total program in these years).

17. To arrive at an approximation of the electronics equipment requirement alone, we estimate very roughly that it constitutes between three-fourths and seven-eighths of the combined electronics and precision mechanisms requirements. On this basis the illustrative Soviet missile program would consume about two-fifths of the electronics output of the USSR and Satellites during 1954–1956.

18. Such heavy demands on the available electronic supply in 1954 to 1956 would have to compete with other military and nonmilitary demands. One possible allocation of available electronics might involve cutting back military requirements other than for guided missiles to the 1950–1954 average and leaving the nonmilitary allocations at planned and projected levels. Under an alternative allocation of available electronics the military requirements other than guided missiles might be cut back to a minimum,[19] leaving the nonmilitary allocations at planned and projected levels. In either case, it is clear that the guided missile electronics and precision mechanism requirements viewed as an electronics requirement could be met, but consumption for other purposes would have to be sharply cut.

19. A more serious limitation to satisfying the guided missile requirements may well exist in the precision mechanism sector in view of the tolerances involved and the skilled labor required. For example the estimated number of gyroscopes required for new equipment in 1953 was between 68,000 and 82,000, of which approximately 80 percent were for aircraft use. Moreover, few of these gyroscopes are of the degree of precision and miniaturization necessary for use in guided missiles. By comparison the assumed missile program requires 16,000 gyros in 1954, 49,000 in 1955, and 74,000 in 1956, rising to a peak of 270,000

[19] This minimum for military electronics other than guided missiles involves substantial cuts in the production of all military radio, early warning, ground control intercept, naval and air bombing radar but also a significant increase in airborne intercept radar.

TABLE IV

ELECTRONIC AND PRECISION MECHANISM COSTS OF THE ILLUSTRATIVE PROGRAM

(Millions of 1951 Rubles)

Year	Research, Development, and Testing	Missiles and Missile Spares	Initial System Cost	System Operating Cost	Total *	Cumulative System Costs
1945	80	.....	.....	.....	80	80
1946	110	.....	.....	.....	110	190
1947	150	.....	.....	.....	150	340
1948	180	.....	.....	.....	180	520
1949	260	.....	.....	.....	260	780
1950	400	.....	.....	.....	400	1,180
1951	660	.....	.....	.....	660	1,840
1952	960	.....	.....	.....	960	2,800
1953	960	.....	1,300	.....	2,300	5,100
1954	920	980	3,900	110	5,900	11,000
1955	860	1,900	3,800	440	7,000	18,000
1956	1,200	2,200	2,000	760	6,200	24,200
1957	1,300	1,600	3,400	930	7,300	31,500
1958	1,200	1,500	3,700	1,200	7,600	39,100
1959	980	2,600	1,000	1,600	6,200	45,300
1960	800	4,300	1,600	1,800	8,500	53,800
1961	1,000	6,500	1,700	2,200	11,400	65,200
1962	1,200	6,900	800	2,500	11,400	76,600
1963	1,300	3,900	1,300	2,600	9,000	85,600
1964	.....	4,900	1,600	2,700	9,200	94,800
1965	.....	7,100	730	2,800	10,600	105,400
1966	.....	5,200	.....	2,900	8,100	113,500
1967	.....	4,500	.....	2,900	7,300	120,800

* Total does not necessarily add, due to rounding.

in 1961 and then falling to 110,000 for the remainder of the period. In addition, the qualitative differences between ordinary electronic equipment and equipment of satisfactory tolerances for a guided missile program might retard the rate at which expansion could occur below the rate applicable to the electronic equipment industry in general. The problem is essentially one of dealing with super tolerances. The relaxation of CEP requirements permitted by use of nuclear warheads will mitigate this problem in some cases, but will not eliminate it.

20. *Possible Associated Costs.* While we have confined our analysis to incremental costs (see paragraph 11), any program like that assumed might involve additional costs. For example, while in general the assumed missile program could be accommodated in existing capacity by displacing lower order utilization of this capacity, it cannot be assumed that all the tooling, jigs, and fixtures would be on hand. It is difficult to estimate how much investment outlay would be required for this purpose, but not all of the assumed 1954 capacity would necessarily be available in 1954. However, in relation to the probable total planned Soviet investment in any given year the investment required seems negligible.

21. We have also excluded maintenance costs for the basic units, vessels, and planes using missiles and their intermediate (tactical) and superior command structure, including facilities, housing, maintenance, pay, subsistence, and allowances. In addition, the program will require a considerable number of relatively highly trained specialists to service, test, maintain, repair, and operate the various systems. We estimate that in broad terms the assumed program might require about 170,000 such specialists. Moreover, the bulk of this requirement would arise early in the program. The requirements for 1954 and 1955 came to over 100,000 men, which could aggravate the possible qualitative manpower problems noted in paragraph 8 above.

22. Drone aircraft costs have been excluded on the assumption that obsolete planes would be used for targets. Only the modification costs to convert aircraft to drones were included. However, the requirements for drone aircraft rise steadily under the assumed program from 80 in 1954 to 700 in 1956, 1,000 in 1959, 2,100 in 1961, and over 2,900 for 1965 and each year thereafter.

23. The fuel cost of primary importance seems to be the oxidizer. We have no estimate of the oxidizer the Soviets are likely to use. Moreover, each oxidizer seems to have unique economic problems associated with it. Thus, we cannot provide an estimate of these costs or their import, but we believe that the oxidizer problem may prove another bottleneck in any Soviet missile program.

24. Considerable motor transport will probably be required as organic equipment to most units. In addition some units will require mobility. Conservative requirements for the assumed program might be on the order of approximately 30,000 standard trucks, and an equal amount of special trucks and trailers. These requirements are roughly equivalent to the organic motor transport of some 30 Soviet ground divisions.

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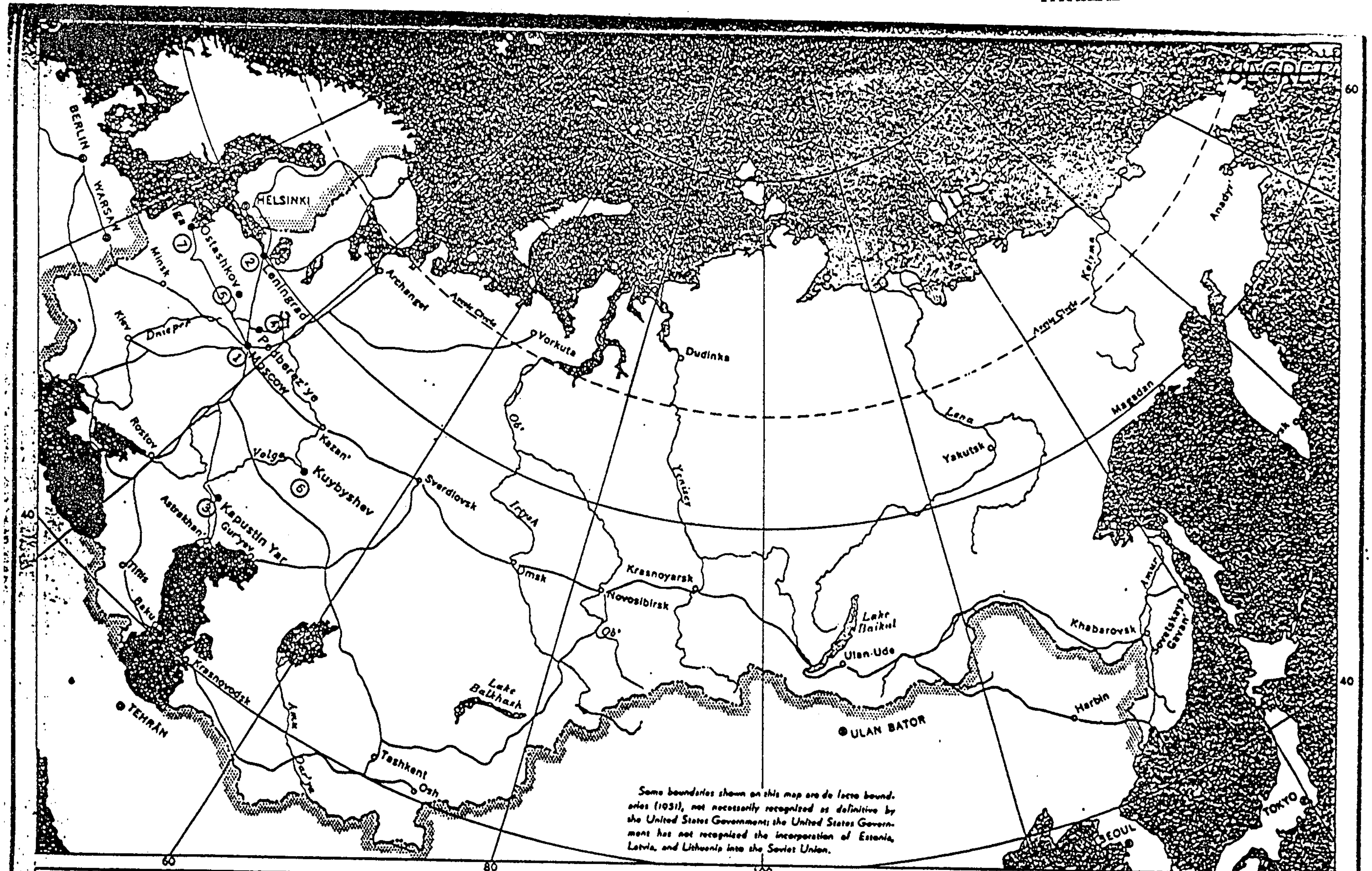

Some boundaries shown on this map are de facto boundaries (1951), not necessarily recognized as definitive by the United States Government; the United States Government has not recognized the incorporation of Estonia, Latvia, and Lithuania into the Soviet Union.

UNION OF SOVIET SOCIALIST REPUBLICS

INSTALLATIONS BELIEVED TO BE CONCERNED WITH GUIDED MISSILE PROGRAM

1. Moscow Area (See separate map)
2. Leningrad Area—The State Institute of Applied Chemistry (GIPKh), NII #380 and NII #49
3. Kapustin Yar—Test Range
4. Podberez'ye— Experimental Aircraft Plant #1
5. Ostashkov—Branch #1 of NII #88
6. Kuybyshev—Plant #2
7. Possible Naval Test Station

Statute Miles: 0 250 500 1000 1500 2000

Kilometers: 0 250 500 1000 1500 2000

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CENTRAL INTELLIGENCE AGENCY

ERRATA

NIE 11-6-54: SOVIET CAPABILITIES AND PROBABLE PROGRAMS IN THE GUIDED MISSILE FIELD

1. In the table on "Estimated Soviet Capabilities to Develop Guided Missiles," pages 17-18, the paragraph references in the first column should all be changed as follows:

a.	for	"(see	para.	32)"	substitute	"(see	para.	60)."
b.	"	"	"	37	"	"	"	65
c.	"	"	"	38	"	"	"	66
d.	"	"	"	40	"	"	"	68
e.	"	"	"	41	"	"	"	69
f.	"	"	"	46	"	"	"	48
g.	"	"	"	46	"	"	"	48
h.	"	"	"	46	"	"	"	48
i.	"	"	"	50	"	"	"	52
j.	"	"	"	51	"	"	"	53
k.	"	"	"	56	"	"	"	30
l.	"	"	"	57	"	"	"	31
m.	"	"	"	58	"	"	"	32
n.	"	"	"	62	"	"	"	36
o.	"	"	"	63	"	"	"	37
p.	"	"	"	67	"	"	"	41
q.	"	"	"	68	"	"	"	42
r.	"	"	"	69	"	"	"	43

2. In the same table on page 18 in the column on "Wasserfall type" delete "175 pounds" which is given as the gross weight.

3. In Table I of Annex B on page 34, the paragraph references in the first column should all be changed as follows:

a.	for	"para.	63"	substitute	"para.	37"
b.	"	"	56	"	"	30
c.	"	"	58	"	"	32
d.	"	"	67	"	"	41
e.	"	"	69	"	"	43
f.	"	"	50	"	"	52
g.	"	"	32	"	"	60
h.	"	"	38	"	"	66
i.	"	"	41	"	"	69