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SOVIET CAPABILITIES IN GUIDED MISSILES AND SPACE VEHICLES

CIA HISTORICAL REVIEW PROGRAM
RELEASE AS SANITIZED

Submitted by the

DIRECTOR OF CENTRAL INTELLIGENCE

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

Concurred in by the

INTELLIGENCE ADVISORY COMMITTEE

on 19 August 1958. Concurring were The Director of Intelligence and Research, Department of State; the Assistant Chief of Staff for Intelligence, Department of the Army; the Director of Naval Intelligence; the Assistant Chief of Staff, Intelligence, USAF; the Deputy Director for Intelligence, The Joint Staff; and the Atomic Energy Commission Representative to the IAC. The Assistant Director, Federal Bureau of Investigation, abstained, the subject being outside of his jurisdiction.

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SOVIET CAPABILITIES IN GUIDED MISSILES AND SPACE VEHICLES[1]

THE PROBLEM

To estimate Soviet capabilities and probable programs for the development of guided missiles and space vehicles, including earth satellites, through 1966,[2] and to analyze factors affecting Soviet operational capabilities in these fields.

FOREWORD

This estimate supersedes NIE 11-5-57, SOVIET CAPABILITIES AND PROBABLE PROGRAMS IN THE GUIDED MISSILE FIELD, 12 March 1957, and SNIE 11-10-57, THE SOVIET ICBM PROGRAM, 10 December 1957, as well as those paragraphs dealing with guided missiles (paras. 108 through 114) in NIE 11-4-57, MAIN TRENDS IN SOVIET CAPABILITIES AND POLICIES, 1957-1962, 12 November 1957. The new estimate, like its predecessors, is made in the light of our previous judgments that the USSR does not now intend to initiate general war deliberately and is not now preparing for general war as of any particular future date. It also assumes that through 1966 there will be no international agreements on the control of armaments or of outer space.

The estimate is intended primarily to reassess and update our estimates of probable Soviet missile development programs, missile characteristics, and first operational capability dates. Some discussion is provided on factors likely to affect Soviet acquisition of substantial operational capabilities with missile systems, and Soviet capabilities to place various arbitrarily-selected quantities of ICBMs in operational use are estimated. The reader is cautioned that Annex A of NIE 11-5-57 is no longer applicable.

For the most part, changes in estimated missile characteristics and first operational capability dates result from the accumulation over the past year of a considerable body of new evidence. Of the 13 missile systems estimated as probably available for operational use in 1958 or earlier, we now have direct evidence on the existence of nine; we also have direct evidence on Soviet development of an ICBM.

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[2] For comparability with earlier estimates on this subject, the terminal date chosen for this estimate is the same as that of its predecessor, NIE 11-5-57, SOVIET CAPABILITIES AND PROBABLE PROGRAMS IN THE GUIDED MISSILE FIELD, 12 March 1957.

For some of these systems the evidence is extensive, while for others we have only limited information relative to characteristics and components. Serious intelligence gaps remain, particularly with respect to the operational status of various systems. Furthermore, we do not have sufficient evidence available on which to base an estimate of the vulnerability of Soviet systems to specific electronic countermeasures.

In making this estimate in a field where positive intelligence remains limited, we have considered the available evidence in the light of estimated Soviet military requirements, known and estimated Soviet capabilities in related fields, and US guided missile experience. The entire study rests upon our belief, now well-supported by evidence, that a concerted and continuous Soviet research and development effort in guided missiles was underway by 1948.

For guided missiles, except where noted otherwise, the operational capability dates given are the earliest years during which we believe missiles could probably have been placed in the hands of trained personnel in one operational unit, thus constituting a limited capability for operational employment. We estimate that when they first become operational, the missile systems discussed herein will have a system reliability of 40–60 percent, and that improvement will occur thereafter.[3] For space flight activities, the dates given are the earliest *possible* time periods by which we believe each specific accomplishment could be achieved.

SUMMARY AND CONCLUSIONS

1. The USSR has continued to press ahead with its extensive guided missile research and development, generally along the lines indicated in our previous estimates. As a result of this effort, the USSR now has available for operational use a variety of missile systems. Soviet achievements in ballistic missiles have been especially impressive and have contributed to early successes in the USSR's space flight program. Substantial success in developing surface-to-air missile systems has also been achieved. Available evidence is not sufficient to indicate equal emphasis and similar success in other Soviet missile programs.

[3] The term "system reliability" is here defined as the percentage of missiles which function according to specifications from missile launching to detonation in the target area, excluding malfunctions prior to launching.

2. By itself, each of the guided missile or space programs estimated as a future development appears feasible both as to technical achievability and date attainable. However, some programs may be slowed or even halted by the competition of other missile or non-missile delivery systems, unforeseen development or production difficulties, rapidity of obsolescence, changing military requirements, and/or broad considerations of Soviet national policy. On the other hand, a significant advance in one or more of the programs might be possible if a scientific breakthrough is achieved.

3. *Surface-to-surface missiles*. We believe that the Soviet ballistic missile development program has emphasized reliability and simplicity, rather than minia-

turization or extreme refinement of design. System mobility appears to have been a basic consideration since the early developmental stages. In developing longer-range systems, maximum use has been made of proven components.

4. Since 1954 the USSR has probably had available for operational use ballistic missiles with maximum ranges of about 100 nautical miles (n.m.), 200 n.m. and 350 n.m. We believe that, depending upon various operational factors, nuclear, high explosive (HE) or chemical (CW) warheads would be used with these missiles.[4] In addition, the USSR probably now has operational a very short range anti-tank missile equipped with shaped-charge HE warhead.

5. An extensive Soviet program to develop a 700 n.m. ballistic missile is indicated by a long series of test firings, averaging about two per month since 1955. We estimate that this missile probably became operational in 1956. On the basis of about a dozen test firings over the past year, we estimate that the USSR will also probably have operational in 1958 a modification of the 700 n.m. missile, capable of an 1,100 n.m. range. Nuclear warheads would almost certainly be used in both these missiles, although we do not exclude the possibility of CW use in the 700 n.m. missile.

6. *Intercontinental ballistic missile (ICBM).* Since August 1957, the USSR has test fired at least four and possibly six missiles to a distance of approximately 3,500 nautical miles. We believe this represents the development of an ICBM system which, when first operational, will probably be capable of delivering a nuclear payload to a maximum range of about 5,500 n.m., with an accuracy (CEP) of 5 n.m. and a system reliability of about 50 percent. By the early 1960's reliability will probably be considerably improved. At the beginning of the period 1962–1966, the CEP could be about 3 n.m., and could be reduced to about 2 n.m. later in the period.

7. Available evidence is inconclusive as to the designed payload-carrying capacity of the Soviet ICBM, which we have previously estimated as about 2,000 pounds. Recent evidence and re-analysis may indicate that the USSR is developing an ICBM with a 5,000 pound payload. Serious logistical and operational problems are associated with missiles of the sizes necessary to deliver 2,000 or 5,000 pounds to a range of 5,500 n.m.; these problems would be greater in the case of the heavier payload. In the light of this consideration, we estimate that the Soviet ICBM is designed to carry a nuclear payload of about 2,000 pounds, although there is a possibility that it is designed to carry about 5,000 pounds.

8. The USSR will probably have a first operational capability with ten prototype ICBMs at some time during calendar 1959; the possibility should not be disregarded, however, that in the latter part of 1958 the USSR may establish an ICBM capability with missiles comparatively unproven as to accuracy and reliability.

9. We believe that Soviet planners intend to achieve a sizeable ICBM operational capability at the earliest practicable date, although we have no direct evidence on

[4] Estimated nuclear warhead capabilities for these and other missiles discussed in this estimate are given in Annex C (limited distribution under separate cover).

Soviet preparations for ICBM production and deployment. We estimate that the USSR has the technical and industrial capability to produce ICBMs, complete launching facilities, establish logistic lines and train troops at a rate sufficient to have an operational capability with 100 ICBMs[5] about one year after its first operational capability date (i.e. some time in 1960), and with 500 ICBMs[5] two or at most three years after first operational capability date (i.e. some time in 1961, or at the latest in 1962). This implies that the USSR could achieve an operational capability with ten or more, but less than 100 ICBMs by the end of 1959, depending upon when during the calendar year the first operational capability is achieved.

10. *Surface-to-air-missiles.* For several years the USSR has had in operational use a fixed surface-to-air system which we believe is now capable of employment against aircraft at ranges up to 20–30 n.m., with greatest effectiveness at altitudes of 30,000 to 60,000 feet. This system is known to be employed in a dense and costly complex of 56 sites around Moscow; targets of lesser importance will probably be provided with considerably less elaborate surface-to-air missile defenses. We believe the Soviets also have available for operational use a surface-to-air missile with similar characteristics, except for improved capability to intercept small, supersonic targets. It is probably suitable for employment either with the Moscow system or with a semi-mobile system.

[5] These numbers are selected arbitrarily in order to provide some measure of the Soviet capacity to produce and deploy ICBMs; they do *not* represent an estimate of probable Soviet requirements or stockpiles.

11. Neither of the above systems is likely to be effective against very low altitude attack. We therefore estimate that the USSR is developing and will probably have in operation in 1959–1960 a surface-to-air system with a maximum range of about 15 n.m., effective at altitudes from 50 feet to at least 40,000 feet. We estimate that for improved defense of critical areas, the USSR will probably have available in 1960–1961 a surface-to-air system with effectiveness at altitudes up to 90,000 feet and a maximum range of 75–100 n.m.

12. We estimate that in 1963–1966 the Soviets will probably achieve a first operational capability with a surface-to-air system of limited effectiveness against ICBMs. Such a system could possibly have some effectiveness against IRBMs. A surface-to-air system with limited capability to counter reconnaissance satellites could and possibly will be developed for use in 1960–1964; a more sophisticated system could be integrated with an anti-ballistic missile system at a later date.

13. *Air-to-air missiles.* Three short-range systems which employ HE warheads are now estimated as operational. Two are believed to have radar guidance with ranges of 5–6 n.m.; the other, with a range of up to 2½ n.m., is believed to use infrared guidance. Most currently operational Soviet fighter aircraft types could be modified to employ these missiles. In 1960 the USSR will probably have available a 15–20 n.m. air-to-air missile.

14. *Air-to-surface missiles.* The present operational system is capable of carrying a nuclear or HE warhead at subsonic speed to a range of about 55 n.m. against well-defined targets, such as ships. With dif-

ferent guidance, the system could be employed against land targets. We estimate that the USSR is probably developing and may now have operational an air-launched decoy to simulate medium or heavy bombers. We believe that the USSR will probably develop and have operational in 1960–1961 a supersonic missile with improved guidance and a range of at least 100 n.m., suitable for employment against a wide variety of targets.

15. *Naval-launched missiles.* The Soviet navy probably now has the capability to launch subsonic cruise-type missiles from a few converted submarines of conventional design, although there is little direct evidence of submarine-launched missile development in the USSR. We estimate that the current system could deliver nuclear warheads against land targets within about 200 n.m. of the launching submarine. These cruise-type missiles could be launched by a submarine only after surfacing. We believe, however, that in 1961–1963 the USSR will probably have a submarine-launched ballistic missile system available for first operational use in a prototype submarine of new design. This system will probably be capable of delivering a nuclear warhead from a submerged submarine to a range of about 1,000 n.m.

16. We estimate that during 1959–1960 the USSR will begin equipping its surface fleet with surface-to-air missiles having a maximum range of 20 n.m., with effectiveness at altitudes from 50 feet to at least 40,000 feet. A Soviet shipborne surface-to-air system for use against targets at higher altitudes and longer ranges will probably become available in 1960–1961. These systems, while primarily for air defense, could be modified for employment against surface targets. Late in the period of this estimate, the USSR will probably also have available a missile system for use in anti-submarine warfare.

17. *Soviet space programs.* We believe that the ultimate foreseeable objective of the Soviet space program is the attainment of manned interplanetary travel. The program is supported by extensive Soviet research efforts in a number of related fields, including rocket propulsion, electronics, space medicine, astrobiology, astrophysics and geophysics. Present activities appear to be directed toward the collection of scientific data and experience applicable to future space accomplishments, the ICBM program, and basic scientific research. Soviet requirements for space vehicles have probably been established for fairly specific scientific and/or military purposes in accordance with a planned step-by-step progression.

18. Soviet success in ballistic missile development and earth satellite launchings to date leads us to estimate a considerable Soviet capability for early accomplishments in space including: surveillance satellites, recoverable aeromedical satellites, lunar probes and impacts, lunar satellites and planetary probes to Mars and Venus (1958–1959); "soft landings" by lunar rockets and recoverable manned earth satellites (1959–1960); a manned glide-type high altitude research vehicle (1960–1961); heavy earth satellites and manned circumlunar flights (1961–1962); and manned lunar landings (after 1965). While each individual achievement appears feasible as to technical capability and earliest date attainable, we doubt that the USSR can accomplish all of these space flight activities within the time periods specified.

SIMPLIFIED TABULAR SUMMARY[1]

Probable Soviet Guided Missile Development Program

Arbitrary Designation	Operational Date	Maximum Range	Payload Weight and Type	Design Altitude
Ground-Launched Ballistic Missiles				
SS-1 *	1954	100 n.m.	1,500 lbs. Nuclear, HE, CW	———
SS-2 *	1954	200 n.m.	2,000 lbs. Nuclear, HE, CW	———
SS-3 *	1954	350 n.m.	Up to 5,000-6,000 lbs. Nuclear, HE, CW	———
SS-4 *	1956	700 n.m.	Up to 5,000-6,000 lbs. Nuclear, poss. CW	———
SS-5 *	1958	1,100 n.m.	Up to 3,000 lbs. Nuclear	———
SS-6 ICBM *	1959	5,500 n.m.	2,000 lbs., poss. 5,000 lbs. Nuclear	———
Ground-Launched Anti-Tank Missile				
SS-a. t.	prior to 1958	6,000 yards	20-40 lbs. HE	———
Submarine-Launched Missiles				
SS-7 cruise-type	1955-56	200 n.m.	2,000 lbs. Nuclear	———
SS-8 ballistic	1961-63	1,000 n.m.	1,000 lbs. Nuclear	———
Ground-Launched Surface-to-Air Missiles				
SA-1 *	1954	20-30 n.m.	500-800 lbs.[2]	30,000-60,000 ft.
SA-2 *	1957	15-30 n.m.	500-700 lbs.[2]	20,000-60,000 ft.
SA-3	1959-60	15 n.m.	150-250 lbs.[2]	50 ft.-40,000 ft.
SA-4	1960-61	75-100 n.m.	500 lbs.[2]	Up to 90,000 ft.
SA-5	1963-66	limited effectiveness against ICBMs		
Shipborne Surface-to-Air Missiles				
SA-6	1959-60	20 n.m.	150-250 lbs.[2]	50 ft.-40,000 ft.
SA-7	1960-61	75-100 n.m.	500 lbs.[2]	Up to 90,000 ft.
Air-to-Air Missiles				
AA-1 *	1955-56	5 n.m.	70 lbs. HE	———
AA-2	1955-56	2½ n.m.	25 lbs. HE	———
AA-3	1958	6 n.m.	50 lbs. HE	———
AA-4	1960	15-20 n.m.	150 lbs.[2]	———
Air-to-Surface Missiles				
AS-1 *	1956-57	55 n.m.	3,000 lbs. Nuclear, HE	———
AS-2	1960-61	100 n.m.	3,000 lbs. Nuclear	———

[1] Detailed summaries of each missile category, including all estimated characteristics and other pertinent data, are presented in Tables 1-5 in Annex A. A summary of estimated Soviet capabilities in space flight is presented in Table 6.

[2] Nuclear warheads would increase the kill probabilities achievable with these missiles and will be required for effective use of the missiles under some conditions. However, HE warheads will be effective in most applications.

[3] Those missile types for which our estimates are supported by significant current intelligence are indicated by an asterisk following the missile designation.

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DISCUSSION

I. AIR DEFENSE MISSILE SYSTEMS

THE THREAT AND SOVIET REQUIREMENTS

19. One of the most immediate and greatest of Soviet military concerns is the safeguarding of key industrial and military installations and centers of control. During the period of this estimate, the USSR will be faced with increasing diversity in the weapons systems that can be employed against its forces and territory. There may not be large numbers of some of the newer Western delivery vehicles, but with nuclear weapons even small numbers will increase considerably the Soviet defensive requirements and problems. Soviet planners almost certainly recognize that anti-aircraft guns and aircraft armed with guns have only limited capability against certain types or tactics of high performance aircraft and will have no capability against US ballistic missile systems. Thus, as their air defense requirements became more exacting, they probably planned to arm increasing numbers of interceptor aircraft with air-to-air missile systems, largely replace anti-aircraft guns with surface-to-air missile systems and develop anti-ballistic missile systems.

20. During the period of this estimate the USSR will require surface-to-air missile systems capable of engaging Western aircraft and missiles at altitudes from 50 feet to several hundred miles. Soviet planners probably now consider their requirements to include:

— Static and mobile all-weather systems with altitude capabilities up to 70,000 feet and horizontal ranges of at least 25 n.m. with either nuclear or HE warhead.

— Static all-weather system with altitude capabilities of up to 90,000 feet and a horizontal range of 75–100 n.m. with nuclear or HE warheads.

— Static and mobile all-weather systems with low altitude capabilities down to about 50 feet and ranges of at least 10 n.m.

— Anti-missile systems capable of engaging shorter-range (75–200 n.m.) ballistic missiles.

21. From 1959 there will be further requirements for a mobile anti-ballistic missile system capable of engaging missiles with ranges of from 200 to 500 n.m. and a static anti-missile system capable of engaging longer-range (500–6,000 n.m.) ballistic missiles. There will also be a requirement for an anti-satellite defense system to counter reconnaissance satellites orbiting at a few hundred miles altitude and, in the latter years of the estimate, a system may be needed to counter hypersonic glide vehicles. All surface-to-air systems will need to be capable of resisting Western saturation and confusion tactics and electronic countermeasures.

22. To increase the kill capability of its fighter aircraft during the period of this estimate, we believe that the USSR will require air-to-air guided missiles for defense against Western aircraft and cruise-type missiles, operating at altitudes ranging from 50 feet to 85,000 feet. As speeds of aircraft and rates of closure increase, the USSR will require longer range and improved air-to-air missiles which are compatible with Soviet aircraft interceptor systems. Air-to-air systems will need to be capable of all-weather operation and all-angle attack, and of resisting electronic countermeasures. Soviet planners probably will also consider it desirable to employ nuclear warheads in air-to-air missiles under certain circumstances.

23. At present, surface units of the Soviet navy depend primarily upon land based air cover for air defense. The limited radius of action of Soviet fighter aircraft imposes what the USSR probably considers to be a severe restriction on the surface forces of the Soviet navy. Soviet planners probably view ship-borne surface-to-air missile systems as a continuing requirement, not only to extend the radius of action of their ships, but also to provide improved air defense, even when under land based cover.

— There are current requirements for all-weather systems providing (1) low altitude coverage and a horizontal range of at least 10 n.m. with HE warhead and, (2) altitude capabilities up to 70,000 feet and a horizontal range of at least 20 n.m. with either nuclear or HE warhead.

—From 1959 on, the USSR will probably also require a system with altitude capabilities up to about 90,000 feet and a horizontal range of about 100 n.m. with either nuclear or HE warhead.

Soviet planners probably consider it desirable that these naval air defense systems be capable of modification for alternative use as shipborne surface-to-surface weapons in appropriate naval roles.

DEVELOPMENT CAPABILITIES AND PROGRAMS

Surface-to-Air Systems

24. Since shortly after World War II, the USSR has been engaged in an intensive program for the development of surface-to-air missile systems. The Soviets appropriated German surface-to-air missiles, missile designs and associated guidance systems. These, together with lend-lease electronic equipment and available information on Western radar design, development, and techniques were of enormous value to the Soviet surface-to-air development program. Of additional value was the knowledge and skill contributed by German scientists and engineers in the USSR. By 1950 and 1951, however, Soviet scientists displayed an originality in basic concepts, although they continued to utilize the capabilities of German electronic technicians, as well as native Soviet resources, to develop some of these basic concepts into operational equipment.

25. A significant amount of information has become available on guided missile installations around Moscow. Herringbone or chevron-type installations were first observed under construction in about mid-1953. These installations have been associated with a static surface-to-air missile system reportedly designated "B-200" by the Soviets and designated SA-1 in this estimate. Possible surface-to-air missile sites have been observed or reported at other locations, but to date the SA-1 surface-to-air missile system equipment has been identified only at Moscow. In that area, forty-five missile sites have been located with accuracy sufficient to indicate their arrangement in two concentric rings with radii approximately 25 and 45 n.m. from the center of the city. There are probably 56 sites in the system, of which 22 are on the inner ring and 34 on the outer. A typical site has 60 launch positions joined by a network of roads. Associated with the system are buildings which could be for housing, maintenance shops and limited missile storage. We believe that some Moscow sites became operational in 1954 and that all sites were operational by the end of 1956.

26. Each site in the Moscow system incorporates a track-while-scan radar (US intelligence designation "Yo-Yo"), having about 54° vertical and horizontal coverage. Recent information indicates that the guidance system at each site has a traffic-handling capability of 20 targets and 20 missiles simultaneously. The missile employed with the system has radio-command guidance and is probably a single-stage, liquid propellant vehicle. It can probably deliver a 500–800 pound payload at a speed of about Mach 3 to a maximum range of 20–30 n.m. Nuclear warheads would increase the kill probabilities achievable with these missiles and will be a requirement for effective use of the missiles under some conditions. However, HE warheads will be effective in most applications. Recent information from German returnees indicates that the missile may use an adjustable proximity fuze armed by a signal from the ground. We believe it was designed for optimum effect against aircraft at altitudes between 30,000 and 60,000 feet; it can probably achieve CEPs of 65–120 feet at these altitudes. Limited effectiveness could probably be obtained at about 80,000 feet altitude. However, the SA-1 system has certain limitations such as limited capability against small, supersonic targets, immobility and limited azimuthal coverage at each site.

27. The appearance of a boosted surface-to-air missile at the Moscow Parade on 7 November 1957 suggests that the USSR has now over-

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Figure 1

Surface-to-Air Guided Missile Sites in the Moscow Area

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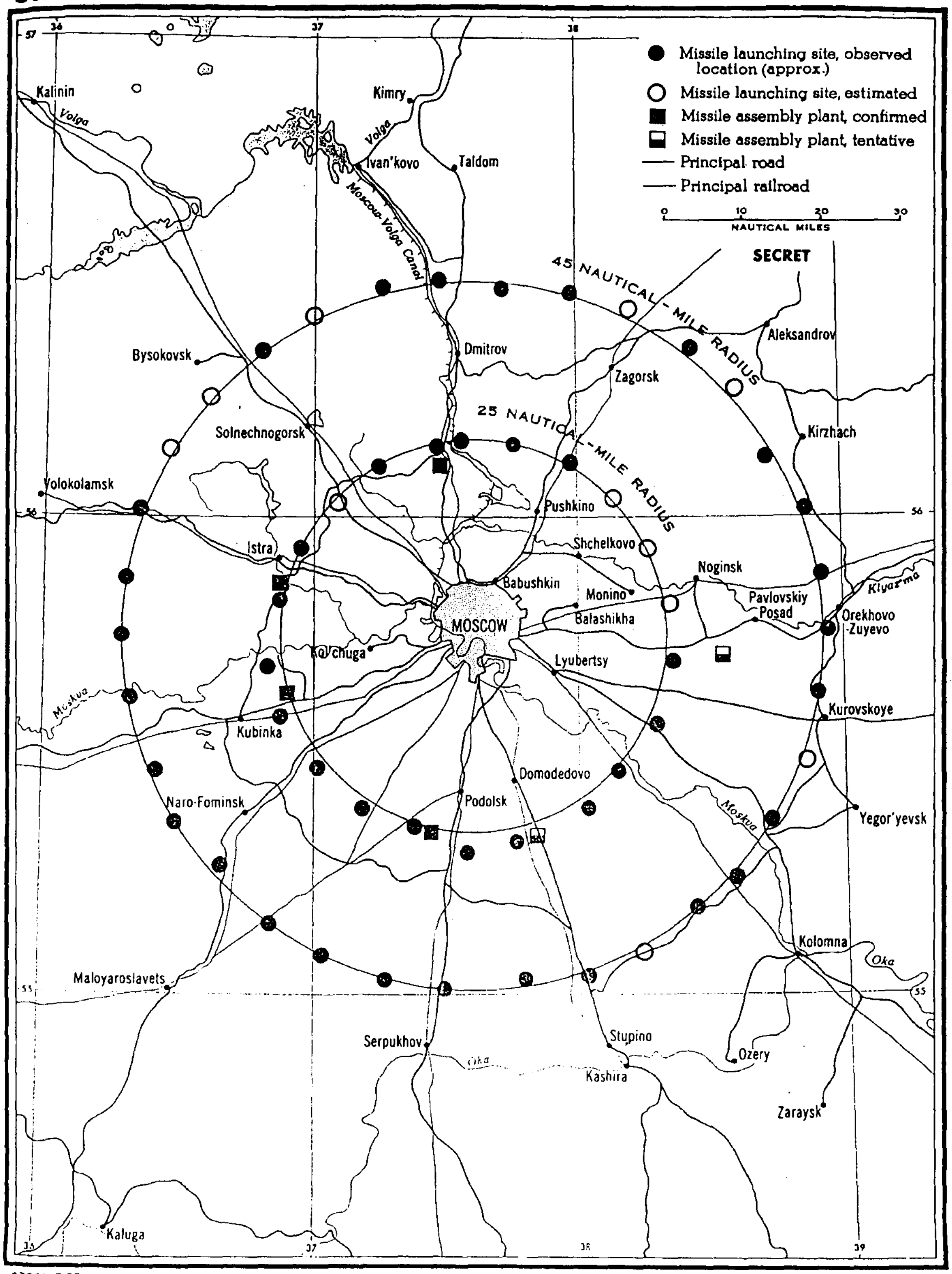

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Typical Surface-to-Air Guided Missile Site, Moscow Area

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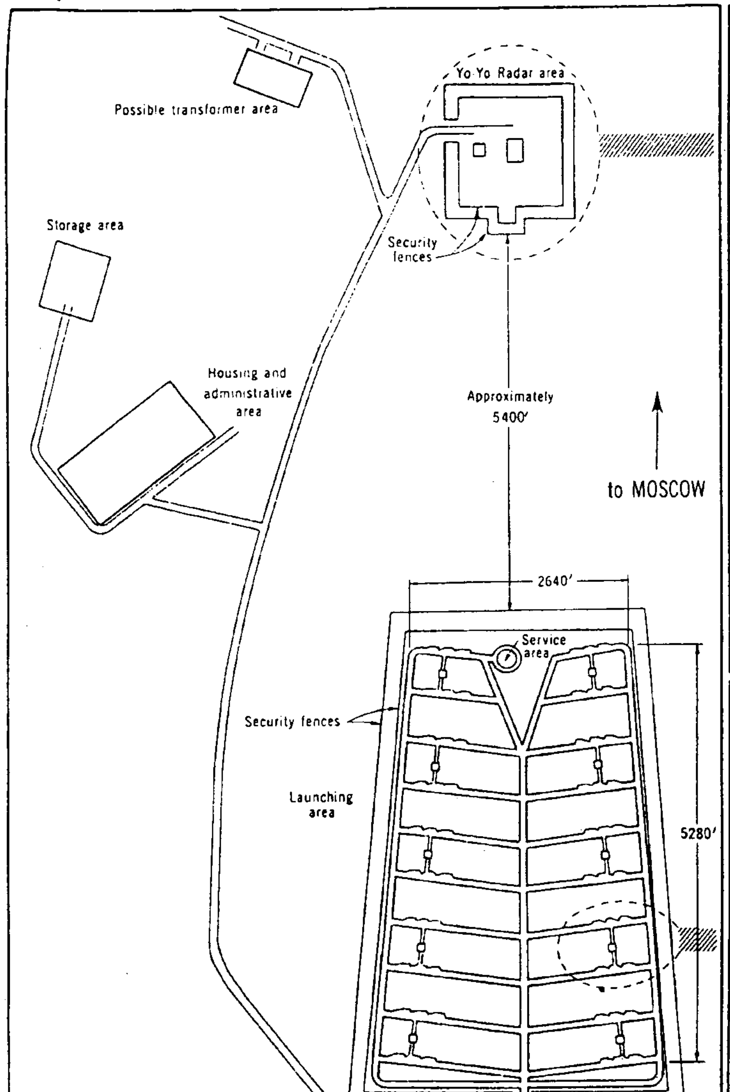
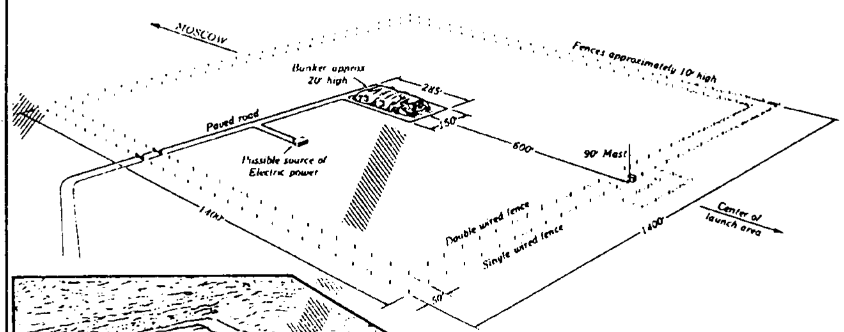


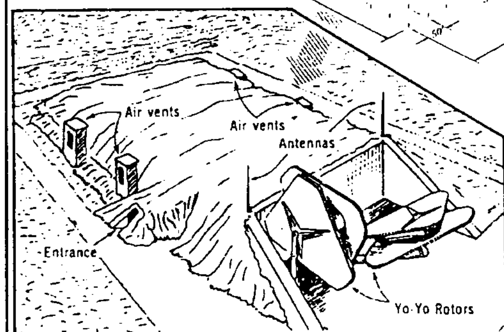
Site Layout

(Schematic)

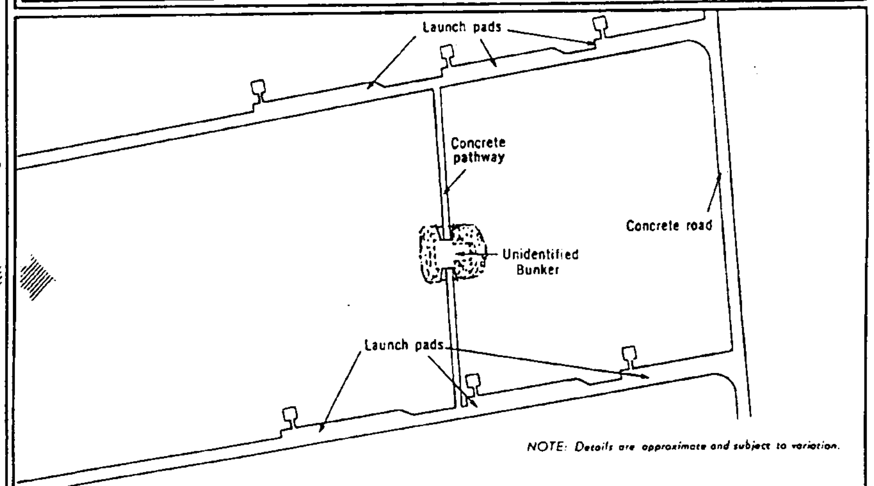


NOTE: Details and dimensions are approximate and subject to variation.

Artist's Conception of a Typical Layout of a Yo-Yo Radar Area



Artist's Conception of Yo-Yo Bunker *Not to scale*



NOTE: Details are approximate and subject to variation.

Launch Pad and Bunker Arrangement

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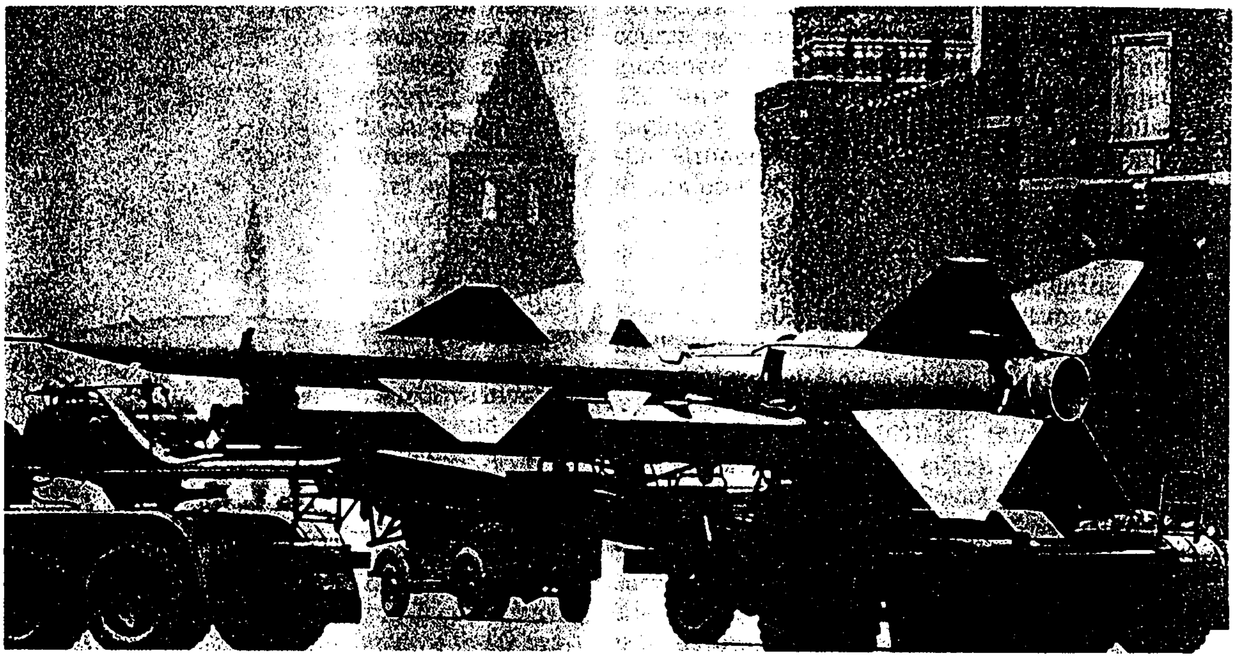
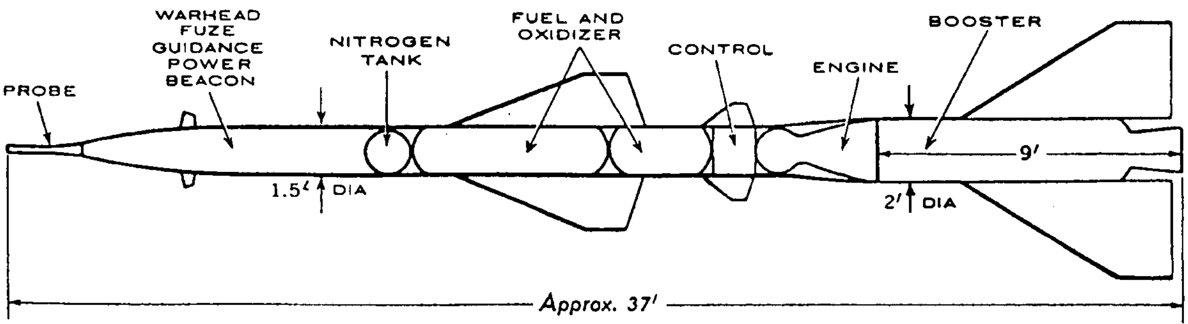
Figure 3





7 November 1957 Moscow Parade Surface-to-Air Missile

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come at least some of these limitations. This missile (SA-2) can probably reach engagement altitudes in less time than can the SA-1 missile, and hence is probably more effective against small, supersonic targets. We believe that this missile could be employed with a semi-mobile ground guidance system having 360° coverage capability and could be adapted with little difficulty to the Moscow system. This missile could have a horizontal range of from 15-30 n.m. and an optimum design altitude of from 20.000 to 60,000 feet, with some capability up to 80,000 feet. Its speed would be about Mach 3 and it could have a CEP of from 65-120 feet with a 500-700 pound payload. Nuclear warheads would increase the kill probabilities achievable with these missiles and will be a requirement for effective use of the missiles under some conditions. However, HE warheads will be effective in most applications. This missile system could probably have been operational in 1957.

28. The above systems probably have no effectiveness at very low altitudes (below 1,500 feet). To overcome this deficiency, it is probable, although there is no direct information, that the USSR has developed and could have in operation in 1959-1960 a surface-to-air system for low altitude coverage (SA-3), with optimum design altitude of from 50 feet to 40,000 feet and limited effectiveness to 60,000 feet. Maximum horizontal range would be about 15 n.m. This system could have a payload of from 150-250 pounds with a CEP of 20-50 feet and a maximum speed of Mach 2-3. Nuclear warheads would increase the kill probabilities achievable with these missiles and will be a requirement for effective use of the missiles under some conditions. However, HE warheads will be effective in most applications. Guidance would be semi-active continuous wave radar homing. Future developments would be toward increases in range and altitude capabilities.

29. Although there is as yet no evidence, we estimate that for improved capabilities in defense of critical areas, the USSR will probably develop and have in operation in 1960-1961 a static surface-to-air system (SA-4) with effectiveness at altitudes up to 90,000 feet, and capable of carrying a 500-pound payload. Nuclear warheads would increase the kill probabilities achievable with these missiles and will be a requirement for effective use of the missiles under some conditions. However, HE warheads will be effective in most applications. Such a system will probably have a horizontal range of 75-100 n.m. with mid-course command, terminal radar homing guidance, attaining a CEP of about 100 feet. The Soviets have displayed interest in ramjet engines which could be utilized in such a missile, although from an operational viewpoint a solid propellant is preferable.

30. We have little evidence indicating either Soviet priority or technical approach to an anti-ballistic missile system. Considering the technical problems involved, we estimate that in the period 1963-1966 the USSR will probably achieve a first operational capability with a missile system (SA-5) capable of limited effectiveness against ICBMs. Such a system could possibly have some effectiveness against IRBMs. A considerable Soviet electronic development program, extending well beyond the period of this estimate, would be necessary to achieve an effective anti-ballistic missile system. Using a different but simpler missile, the above anti-ballistic missile system could alternatively be employed against high altitude aircraft and cruise-type missiles.

31. We believe that a ground-based missile system with limited capability to counter reconnaissance satellites could be and possibly will be developed in the USSR in the period 1960-1964. Due to the guidance problem inherent in a system employing a high velocity intercept vehicle, we believe that an anti-satellite system available as early as this could probably engage only those satellites whose orbits had been established. It is possible that a more sophisticated system could be integrated with an anti-ballistic missile system at a later date. It is also possible that in 1966-1970 at the earliest the USSR could develop a surface-to-air system with limited capability to engage hypersonic glide vehicles.

32. *Shipborne systems.* Although we have very little evidence of Soviet programs for shipborne surface-to-air missiles, we believe that the USSR will probably develop and have

in operation in the fleet in 1959–1960 a low altitude defense system (SA–6) with characteristics somewhat similar to those estimated for the SA–3 land-based low altitude defense system. Over water, its maximum range would probably be increased to about 20 n.m. Ship storage and handling requirements would favor the use of solid propellants. Such a missile could probably be modified to permit dual purpose use as a surface-to-surface missile as appropriate to naval requirements. We estimate that a Soviet shipborne missile defense system against high altitude, longer range targets (SA–7) will probably be available in 1960–1961. The SA–4 system could probably accomplish this mission with certain modifications for shipboard handling and storage, and modifications could also permit dual purpose employment against surface targets.

Air-to-Air Systems

33. In late 1945 and 1946 the USSR acquired the results of German efforts on air-to-air missile designs. German scientists in the USSR advanced certain of these designs and assisted the Soviet development until about 1948, although even before that time the Soviets had a native capability for advanced design. During the subsequent years, with German assistance, they continued development of air-to-air missile systems.

34. We know from German returnees that in 1952 the USSR had in active development a radar beam-riding air-to-air missile, designated "ShM" by the Soviets and AA–1 in this estimate. Unsuccessful flight tests of this missile in 1952 necessitated re-design of several of the missile control features, and probably delayed an operational capability until 1955–1956. The AA–1 missile is very similar to the US Sparrow I, developed in approximately the same time period. It is designed to operate with a relatively high-powered radar compatible with a version of the Soviet all-weather interceptor, FLASHLIGHT. This system is estimated to have a maximum head-on range[a] of 5 n.m., tail approach range of 2½ miles, a CEP of 20 feet, and a 70 pound HE payload. The beam-rider concept is a logical first step in the development of an all-weather attack capability, but inherent missile maneuvering limitations would probably have led the Soviet planners to consider such a system as only an interim solution, to be supplanted during the period of this estimate by more versatile systems.

35. Since World War II, emphasis on research and development on infrared within the USSR and Satellites has indicated that the Soviets could have a significant infrared capability. Although the Germans worked on an infrared homing head for the Soviets, we have no further knowledge of the utilization of infrared as a missile guidance technique. However, assuming a normal development program, we believe the Soviets probably had operational an air-to-air missile system with infrared homing guidance (AA–2) in 1955–1956. This system could have a maximum range of 2½ n.m. with a CEP of 10 feet and a 25 pound HE payload, but would be limited to a tailcone attack angle of about sixty degrees. This missile could be utilized with most Soviet interceptor types which are now operational. An infrared missile system is less susceptible to countermeasures and has somewhat greater growth potential than a beam-rider system. Because of this it will be a highly flexible system capable of continuing utility through the period of this estimate. Clouds, rain and fog reduce the effectiveness of infrared homing, although such conditions seldom occur above 30,000 feet in the USSR.

36. Soviet missile guidance development work indicates interest in semi-active radar homing, but there is no firm data that such development was pursued with respect to air-to-air missiles. Considering the general level of Soviet electronic capabilities, and assuming a normal development program, we estimate that an air-to-air system with semi-active homing guidance (AA–3) probably will be introduced into service use in 1958. Employment of such a missile with a version of the FLASHLIGHT would provide a maximum range of 6 n.m. in head-on attack and about 3 n.m. in tail attack, with a CEP of 15 feet. A 50-pound HE payload could be employed.

[a] Distance between launching aircraft and target at time of launch.

This missile system could be improved and modified for employment with advanced Soviet fighters.

37. The USSR will probably develop for operational use in 1960 a longer range air-to-air missile (AA-4) with a 150-pound payload. Nuclear warheads would increase the kill probabilities achievable with these missiles and will be a requirement for effective use of the missiles under some conditions. However, HE warheads will be effective in some applications. The requirement to safeguard the pilot of the launching aircraft from nuclear effects would dictate a range capability of 15–20 nautical miles in a head-on attack at high altitudes. A rocket propulsion system meeting this requirement could achieve a range of 5 n.m. under conditions of tail attack; this would likewise be sufficient to safeguard the launching aircraft at high altitude. At low altitudes, closer approaches could be tolerated for both head-on and tail attack with nuclear warheads. When first operational, this missile system could employ semi-active radar homing or passive infrared homing guidance, achieving a CEP of about 50 feet. The basic guidance system probably could be refined to include composite semi-active radar guidance with passive homing (ECM and/or infrared). These estimated refinements could be in service use by 1963.[7]

FACTORS AFFECTING OPERATIONAL CAPABILITIES

38. We believe that the USSR is working toward the extensive integration of air-to-air and surface-to-air missiles into its air defense system. As suitable missile systems and associated equipment become available in quantity, a large portion of the medium and some light anti-aircraft guns will probably be phased out of the defenses of static targets in the USSR. Concurrent surface-to-air and air-to-air programs will be justified during much of the period of this estimate because of their complementary relationships. Throughout the period the proportion of surface-to-air missiles in the overall Soviet air defense effort will probably increase, particularly as offensive missile systems become an increasing proportion of the Western threat.

39. Within the next several years, the rapidity of technological change and the possibility of rapid obsolescence will increase the economic risks involved in committing large quantities of resources to defensive missile systems. Our assessment of expanding Soviet industrial capabilities, however, leads us to conclude that the USSR will be able to produce and deploy in quantity the defensive missile systems which it can develop for operational use in the 1958–1966 period. The numbers produced and deployed will be governed by the Soviet view of the benefits to be gained and the alternative use of the same resources for other purposes. We believe that, because of its special importance, the Moscow area will continue to be the initial recipient of advanced defense systems as they are placed in production.

Surface-to-Air Systems

40. Information from recent German returnees indicates that the USSR was engaged in at least limited series production of surface-to-air missiles and systems equipment of the SA-1 type as early as 1952. At the same time, in a parallel development program, the Soviets also produced a number of prototypes of a surface-to-air missile which was somewhat similar in configuration to the surface-to-air missile which appeared in the Moscow Parade in November 1957 (SA-2). We have evidence of the deployment of only the SA-1 missile.

41. In addition to the Moscow launching sites and associated equipment, the USSR has made a substantial investment in at least four and possibly more than six large support facilities which are spaced along the inner Moscow ring. The function of these facilities is probably depot assembly, storage, maintenance and recycling of the Moscow defense missiles. On one occasion in late 1955 more than 450 missiles and/or trailers were observed at one

[7] Pending the operational availability of this long range missile, the USSR could have operational an unguided air-to-air rocket with a nuclear warhead which would be limited to attacks at lower altitudes or to tail attacks at high altitudes. See NIE 11-57, SINO-SOVIET BLOC AIR DEFENSE CAPABILITIES THROUGH MID-1962, 16 July 1957.

of these facilities. This indicates that a total of several thousand missiles could be at these facilities at one time. The availability of this number of missiles at support facilities, together with the fact that repeated observations have consistently revealed only a small number of missiles on site at any one time, leads us to conclude that these support facilities play an important and integral role in the Moscow missile defense system.

42. Moscow-type surface-to-air systems have not been observed elsewhere in the USSR in completed form, even though more than two years have elapsed since the last site construction in the vicinity of Moscow. There is evidence that preliminary construction of a less extensive but similar system was initiated in the Leningrad area in 1955. Subsequent observations of the area by Western attaches have failed to reveal evidence of the existence of completed sites in this area. However, the opportunities for observation have been very limited. If site construction at Leningrad had progressed at a priority and pace approximating that observed at Moscow, the ground installations should have been completed by early 1957. We believe, therefore, that the USSR may have altered an earlier intent regarding Leningrad, and that the surface-to-air missile defenses of this area probably will employ a system with greater flexibility and less cost than that at Moscow.

43. Considering the above, we believe that the dense and costly Moscow missile defense system was a special case, dictated by the importance and priority of that area to the USSR. The 7,000–8,000 square mile area defended by the Moscow surface-to-air missile system contains not only the center of Soviet administrative and political control and a large scientific research and design bureau complex, but also an industrial concentration which accounts for almost one-fifth of Soviet gross industrial production. While these factors justified the unique expenditure of resources and effort applied to the Moscow area defense system, we believe that this is unlikely to be the case in other areas.

Air-to-Air Systems

44. We have no direct evidence of series production of Soviet air-to-air missiles. We estimate, however, that the difficult manufacturing problems related to the small size of these missiles and the specialized components required would not prevent the USSR from achieving quantity production. The USSR has and continues to produce substantial numbers of fighter aircraft, airborne intercept radars, and associated early warning and ground control intercept systems which, when taken together, represent the major portion of the industrial effort required for the operational employment of air-to-air systems. We estimate that the USSR, having made this investment, is concurrently improving the effectiveness of its fighter force with air-to-air missiles.

45. Generally, there are no significant factors which would limit or materially delay this program. Relatively few modifications are necessary to equip presently operational Soviet aircraft with air-to-air missiles. Existing facilities at Soviet airfields should be adequate for missile handling and checkout, except for a possible need for humidity-controlled missile storage areas to protect guidance components. Special training required for air and ground crews could be accomplished as part of normal training programs.

II. AIR-TO-SURFACE MISSILE SYSTEMS

SOVIET REQUIREMENTS

46. During the period of this estimate, the USSR will have requirements for air-to-surface missile systems to reduce bomber attrition and increase the probability of successful air attack against targets with heavy local defenses. In establishing requirements for air-to-surface missile systems during the period of this estimate, Soviet military planners would need to consider foreseeable improvements in Western land and shipborne air defense systems. They would probably assess Western air defenses about as follows:

— From 1958 on, capabilities of Western surface-to-air guided missiles will be gradually improved from present ranges of 25–85 n.m. and altitudes of up to about 80,000 feet. Land and shipborne interceptor aircraft will be armed with air-to-air guided missiles and unguided rockets (including some armed with nuclear warheads) which will be continuously modified and improved.

— In addition, by 1961 and throughout the remainder of the period of the estimate, Western land-based surface-to-air guided missiles will have ranges up to 200 n.m. and possibly greater. The range of Western shipborne surface-to-air guided missiles will increase to about 100 n.m.

— From 1958 throughout the period of the estimate, Soviet planners would consider that they would face increasingly effective early warning radar and semi-automatic GCI equipments.

47. Faced with these defensive capabilities, Soviet planners would probably have anticipated the following requirements during the period of this estimate:

— A current requirement, probably continuing through 1966, for an air-to-surface missile system of about 50 nautical miles range for use against shipping, naval task forces, and land targets.

— From 1959 through 1966 a requirement for an air-to-surface missile system for use against both naval and land targets with a range of at least 100 n.m.

— A requirement for some missiles of both the above types to be modified as anti-radar missiles.

— Improvements to both basic missile systems, in the nature of improved operational characteristics rather than increased ranges.

— An air-launched decoy to simulate medium or heavy bombers.

DEVELOPMENT CAPABILITIES AND PROGRAMS [8]

48. In 1947, the USSR began development of an air-to-surface guided missile (AS–1) which we now believe was operational in Soviet medium bomber units in 1956–1957. The guidance system, which was developed with the assistance of German designers and designated as "Komet," employs beam-riding for the first part of the trajectory and semi-active radar homing for terminal guidance. The speed of the missile is about .8 Mach and it has a maximum range from the launching aircraft of about 55 n.m. Employment of this missile system requires that the launching aircraft be at altitudes of 10,000 to 20,000 feet. The missile then flies at a flat angle approach. It is estimated to carry a 3,000 pound nuclear or possibly HE payload and to attain a CEP of about 150 feet against ships at sea or other similarly well-defined radar targets.

49. We have estimated that the USSR also has a requirement for a general purpose 55 n.m. air-to-surface missile that would not require such well-defined targets and could be employed against a wider variety of targets, including those on land. Although there is no evidence to so indicate, we believe it well within Soviet capabilities to have modified the above missile system by substitution of a

[8] For detailed information on Soviet air-to-surface missile test programs, see Annex B (limited distribution under separate cover).

radar-track/radio command guidance system attaining a CEP of 1,500 feet.

50. We estimate that the USSR will develop a supersonic air-to-surface missile system (AS-2), with a range of at least 100 n.m. and with improved propulsion and guidance systems. Such a system could become available to Soviet bomber units during the 1960–1961 period. For use against general land targets, this missile could employ any one of several guidance systems, including radar or inertial types, and could probably achieve CEPs of one-half to two n.m. depending upon the system chosen and the type of target attacked. Modification of this missile by the addition of terminal homing guidance would make it more effective against well-defined targets such as ships, and would result in greater accuracies.

51. Equipping of the two preceding air-to-surface missiles with guidance systems capable of homing on radiating radar transmitters is believed to be within Soviet capabilities. Development of a special type of passive seeker will be the only major development necessary to fulfill this requirement. We estimate that guidance systems of this nature could be available in 1958, although there is no evidence to support this development.

52. Although we have no evidence, we estimate, on the basis of operational desirability and technical feasibility, that the USSR is probably developing and may now have operational an air-launched decoy to simulate medium or heavy bombers. Such a decoy could confuse, saturate, or otherwise degrade Western air defense capabilities. This system could use passive radar corner reflectors and/or active echo simulators (beacon) with a minimum guidance system pre-set to a programmed flight pattern. Internal stowage of decoys is required in order to preserve the performance capabilities of the carrier aircraft. It is therefore desirable that the size of the decoys be minimized to permit stowage of as many as possible. The decoy would probably be propelled by a turbojet engine which would permit the decoy to simulate aircraft performance. Improvements to this system will be required to maintain its compatibility with advanced bomber developments.

FACTORS AFFECTING OPERATIONAL CAPABILITIES

53. We believe that the 55 n.m. subsonic air-to-surface missile is now in series production. However, we have no direct evidence regarding the Soviet facilities engaged in this production. The problems of producing this missile are similar to those encountered in the production of aircraft. Because of the limited number of missiles carried per aircraft, and the somewhat limited operational requirement for its employment, production of the overall quantity required by the USSR should not impose serious economic problems.

54. The USSR has produced and is continuing to produce considerable numbers of BADGER jet medium bombers, which we estimate are the primary carriers for the AS-1, although larger aircraft could also be modified as missile carriers. We believe the missile is small enough so that two can be carried externally on one BADGER. Production of the aircraft and associated navigation and electronic equipment represent the major portion of the investment required in establishing this missile system. This investment has been made. We do not believe that the necessary modifications would seriously hinder the establishment of a significant operational capability with missile equipped aircraft.

III. SURFACE-TO-SURFACE MISSILE SYSTEMS

SOVIET REQUIREMENTS

55. During the period of this estimate the USSR will have requirements for surface-to-surface missiles to provide nuclear and non-nuclear fire support for ground forces, for defense of naval surface forces, for fulfilling naval offensive missions, and for long range nuclear bombardment of targets of a strategic nature. Specific requirements for surface-to-surface missiles will vary from very short range missile systems capable of attacking pinpoint targets to missile systems capable of attacking all major land targets located in North America. Soviet planners probably consider that these missile systems should be programmed initially to supplement and eventually to replace to a varying degree other delivery systems. Decisions to develop particular missile systems to the point of introduction into operational units would be taken in the light of a variety of factors, including the relative priority of the development effort within the missile program, the cost and effectiveness of the system in relation to other available weapon systems, the availability of appropriate warhead materials, etc.

56. *Ground-launched systems.* We believe that in preparing their requirements for operational missile systems, Soviet planners would have considered systems in the following general categories:

—Close support systems with high mobility and simple but extremely accurate guidance, capable of attacking hard targets and enemy strong points on the battlefield at ranges from a few thousand yards to about 15 n.m.

—Systems with ranges from 25 to 700 n.m., capable of supporting major ground force elements (up to and including the Soviet "front") at distances corresponding to the depth of operations envisaged in Soviet ground operational doctrine, and of attacking deep targets such as air bases and industrial centers.

—A system with maximum range of 1,000 to 1,600 n.m., capable of delivering nuclear payloads on distant targets in Eurasia and its periphery from launching sites within the Sino-Soviet Bloc.

—A system with a maximum range of 5,000 to 6,000 n.m., capable of delivering nuclear payloads on all targets in the continental US from launching sites well within the USSR.

57. Soviet planners would desire that to the maximum extent practicable, such systems have warhead effects and accuracies compatible with the missions to be accomplished, have high resistance to electronic countermeasures, that once launched they be independent of guidance and control from the ground, and that they be highly mobile. The Soviets may also have a requirement for cruise-type, ground-launched decoys for use in conjunction with long-range attack by manned bombers.

58. *Naval-launched systems.* The USSR will probably require a submarine-launched missile system of about 1,000 n.m. range to attack land targets within Western-controlled areas. Soviet requirements for surface-to-surface missiles to be employed by surface vessels can be met to a large extent by the dual-purpose surface-to-air/surface-to-surface systems described earlier. However, Soviet planners probably also have requirements for anti-submarine missiles capable of employing nuclear warheads.

FACTORS AFFECTING DEVELOPMENT CAPABILITIES

59. The exploitation of German personnel and equipment in the early post-war period, together with parallel and subsequent native efforts, enabled the USSR to make significant progress in the development of ballistic missiles of short and medium ranges. In addition to the 25- and 35-ton thrust rocket motors which were available before 1949, we estimate that a motor with a nominal 100-ton thrust

was successfully developed and available in 1953. We also believe the USSR has high capabilities for development of guidance systems, warheads and airframes for ballistic missiles.

60. There is evidence that the Soviet ballistic missile effort has been well conceived and that programs have progressed step-by-step, making maximum use of proven and reliable components. Miniaturization or extreme refinement of components probably has not been emphasized in Soviet missile development, but, rather, reliability and simplicity have been the objectives. The mobility evidenced by missiles displayed in the Moscow Parade of November 1957 is apparently a basic consideration in Soviet surface-to-surface missile systems under development. Even ICBMs may to a certain extent be rail mobile; although previously prepared sites would be required, some of these would have only a minimum of fixed equipment.

61. The surface-to-surface program has probably developed around a limited number of basic missiles and has, in logical progression, extended Soviet missile capabilities from those of the V-2 toward an ICBM operational capability. Throughout the 1958–1966 period, advances in nuclear, guidance and propellant technology will be incorporated in subsequent generations of missiles. In some cases, improvements will be scheduled into subsequent production without a basic model change. We believe that toward the end of the period, solid or storable liquid propellants will probably be used in most, if not all, Soviet surface-to-surface missiles. These propellants improve reaction time, lend simplicity, and reduce operational problems normally associated with non-storable liquid propellants.

62. Although the USSR will continue to develop components to improve accuracy, and to decrease missile size and weight, such developments probably will not be incorporated until they result in significant improvements in missile performance. In all surface-to-surface missile systems, especially mobile systems, accuracy is dependent to a considerable extent on the degree to which launching site and target locations are determinable. Inherent missile accuracies are somewhat better than the accuracies specified in the text and tables, which take into consideration average degradation factors.

63. Reduction in size and weight of warheads with increased yields will follow from improved nuclear technology. It is reasonable to believe that at least the earlier, shorter range missiles were developed for HE warheads and that as nuclear weapon stockpiles grew, the emphasis probably shifted to nuclear compatibility. For missiles with ranges of about 350 n.m. or less, we believe HE, nuclear or CW warheads will be employed in accordance with Soviet military policy and dependent upon nuclear stockpiles, missile accuracy, character of the target and results desired. We estimate that for missiles with ranges of 700 n.m. and over, nuclear warheads will be employed, although we do not exclude the possibility of CW use with 700 mile missiles.

GROUND-LAUNCHED SYSTEMS

Development Capabilities and Programs[9]

64. *Very short range missiles.* Considering general Soviet progress in the missile field, we believe that for several years the USSR has had the capability of making close support missiles available to ground force units. Such missiles could include: (a) a single stage missile with a range of about 5,000 to 6,000 yards, capable of delivering a 20–40 pound shaped HE charge against tanks or other hard targets with a CEP of about two feet, employing wire link command guidance; (b) a missile capable of delivering a 500 pound payload to ranges on the order of 10,000 to 30,000 yards which could with a forward observer/controller obtain an accuracy of 15–30 feet, employing radio command guidance. Despite the lack of evidence, we estimate that the first of these missiles probably has been

[9] For detailed information on Soviet ground-launched ballistic missile test programs, principally at the Kapustin Yar test range north of the Caspian Sea, see Annex B (limited distribution under separate cover).

developed and is now operational; Soviet development of the second missile remains a possibility.

65. *100 n.m. ballistic missile.* Until the Soviet display on 7 November 1957 in Moscow, direct intelligence on a short range ballistic missile was very limited. However, analysis of the photography of that display confirms the existence of a missile (SS–1) of about 100 n.m. maximum range. The high degree of mobility, as evidenced by the tracked vehicle, indicates a weapon system which is self-sustaining and ready for almost immediate operational use. As such, it would be necessary that the weapon be transported in a fueled, operationally ready condition.

66. We estimate that the SS–1 was first operational in 1954. A solid propellant system, although operationally preferable, probably would not have been available for the first generation missile. The present version, however, may be either liquid or solid propelled. We believe that in 1954 the missile could have employed a radar track-radio command guidance system, possibly with some inertial components, and that an accuracy of about 1,200 feet under average operational conditions could have been achieved if a terminal correction system were used. Considering normal development in guidance technology, we believe that this missile probably now employs, or soon will employ, an all-inertial guidance system. Although not materially improving the accuracy of a missile of this relatively short range, an inertial guidance system would require less ground support environment, improve the operational flexibility of the system, and overcome its vulnerability to electronic countermeasures. We estimate this missile to be capable of carrying a 1,500 pound payload to ranges of about 100 n.m. with a CEP of about 1,200 feet.

67. *200 n.m. ballistic missile.* A missile in the 200 n.m. maximum range class (SS–2) was developed, probably as a logical outgrowth of the German V–2, and became operational not later than 1954. There is some evidence that it may have been operational as early as 1951. This missile could employ a 25 ton thrust liquid propellant motor and be capable of delivering a 2,000 pound payload. We estimate this missile to have been initially developed with a radar track-radio command/inertial guidance system having an initial CEP of about one to two n.m., with subsequent system improvements resulting in a CEP of about ⅓ to ⅔ n.m. by 1958. In 1958–1960, we estimate that this missile could employ an all-inertial guidance system with approximately ⅓ to ⅔ n.m. CEP.

68. *350 n.m. ballistic missile.* [ ] information have established the existence of a missile of about 350 n.m. maximum range. We believe the missile system (SS–3) became operational in 1954. It could employ a 35 ton thrust liquid propellant motor and be capable of delivering a payload up to 5,000–6,000 pounds. While we believe that this missile was initially developed with an HE warhead, we estimate that it could also currently be equipped with nuclear or CW warheads. We believe that in 1954 this missile probably employed a radar track-radio command/inertial guidance system and had a CEP of about one to two n.m. with a subsequent improvement in CEP to about ½ to one n.m. in 1958. Between 1958 and 1960, the USSR will probably be able to utilize an all-inertial guidance system with comparable accuracy.

69. *700 n.m. ballistic missile.* The existence of a 700 n.m. maximum range missile (SS–4) is also clearly established [ ] The Soviets are engaged in an extensive program on such a missile; firings have averaged about two per month since mid-1955. [ ] testing has been conducted for a variety of purposes and may, in several firings, indicate ICBM component testing. [ ] We estimate that the SS–4 was initially operational in 1956, and that it is now capable of delivering payloads weighing up to 5,000–6,000 pounds with a CEP of one to two n.m. at maximum range. Although

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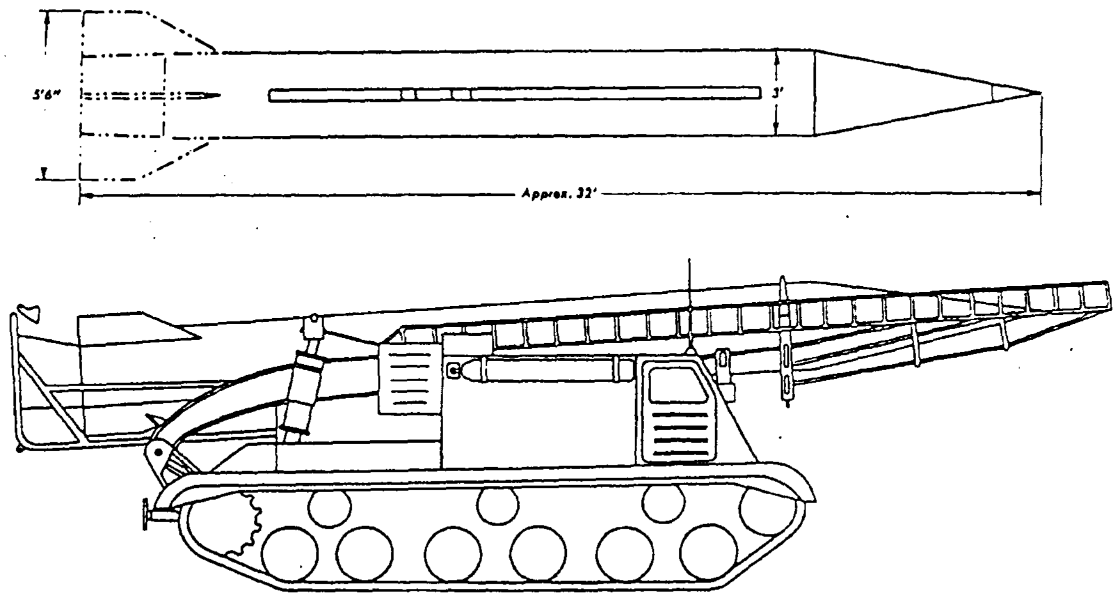
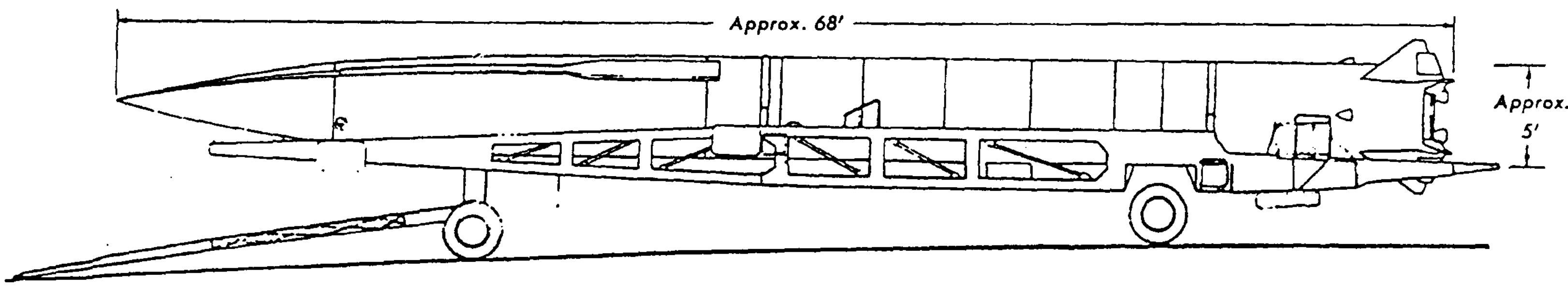
Figure 4



Soviet Short Range Ballistic Missile (100 N.M. Range), and Mobile Carrier*



Soviet Medium Range Ballistic Missile (350 or 700 N.M.) on Trailer*

~~27064 7-58~~

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*Drawing based on 7 November 1957 observation.

we believe the missile was initially developed with a radar track-radio command/inertial guidance system, it is probable that between 1958 and 1960 an all-inertial system could be developed and employed in subsequent modifications, giving approximately the same CEP but with improved operational flexibility and increased mobility.

70. On 7 November 1957, several large missiles, about 68 feet long and about five feet in diameter, were displayed in the Moscow parade. Intensive engineering analysis of photographs of these missiles indicates a possible range of either 350 or 700 n.m., depending upon the payload weight. Although there is other evidence of missiles of both ranges, it is not possible to associate definitely either the SS-3 or the SS-4 with the large missile displayed in Moscow.

71. *1,100 n.m. ballistic missile.* Analysis [ ] indicates about a dozen firings to a range of approximately 1,000 n.m. over the past year. A surface-to-surface missile of about 1,100 n.m. range would bring within range of missiles launched from within the Sino-Soviet Bloc all but a few critical peripheral targets. The USSR probably will have a missile (SS-5) of this range operational in 1958. This date is predicated on the belief that this missile is a relatively simple modification of the 700 n.m. missile, including, for example, reduction in payload weight or possibly changes in propellant or tankage. Payload weight could be up to 3,000 pounds. Reduction in payload would be compatible with improving Soviet nuclear warhead technology. Essentially the same guidance system as the SS-4 would be used, probably achieving a CEP of about two n.m. at maximum range. Between 1958 and 1960 an all-inertial guidance system could become available for use. While we have estimated a missile system that is essentially a modified SS-4, we cannot discount the possibility that the vehicles fired to about 1,000 n.m. range represent the initial testing of a new missile system or that they were dual purpose tests which included component testing for ICBM or earth satellite vehicles.

72. It is possible that the USSR will develop during the period of this estimate an intermediate range ballistic missile system with a maximum range of at least 1,600 n.m., capable of being launched from Soviet territory against virtually all peripheral targets. Tentative Soviet interest in such a system was indicated as early as 1949, but there has been no further evidence of developmental work or test firing activities to this range. Considering the target coverage achievable with 700 and 1,100 n.m. missiles, and the availability of other delivery systems for coverage of more distant peripheral targets, we believe that a nominal 1,600 mile missile is probably viewed by Soviet planners as having a fairly low priority at the present time. They might therefore have deferred development effort until later in the period of this estimate, when they would expect sophisticated guidance, solid or storable liquid propellants, and improved mobility to be available. In any case, the initiation of test firings would probably precede first operational capability by about two years.

73. *Intercontinental ballistic missile (ICBM).* There is firm evidence [ ] that test ICBMs were launched to approximately 3,500 n.m. on 30 January, 29 March, 4 April and 24 May 1958; there is less conclusive evidence that a test ICBM/ESV was also launched sometime in August 1957 and on 7 September 1957. In addition, three Soviet earth satellite vehicles have been placed in orbit (4 October 1957, 3 November 1957 and 15 May 1958) with what we estimate to have been basic ICBM hardware. Calculations based on the earth satellite orbits indicate that they were launched somewhere in the vicinity of the Aral Sea. Analysis of the transportation facilities in this area, including sightings of unique railroad cars, tends to pinpoint the Tyura Tam area as the rangehead for the launchings. [ ] indicates that the range terminal is in the vicinity of the Kamchatka Peninsula. Thus, the Soviets appear to have developed, in addition to Kapustin Yar, an entirely new test range of about 3,500 n.m. length for launching larger missiles, IGY satellites, and other space vehicles. Although 3,500 n.m. is a shorter range than that ulti-

mately desired for ICBM testing, a study of Soviet population densities in relation to possible launch sites and booster impact areas indicates this range to be about as long as feasible for land instrumentation. The range could be almost doubled by using shipborne instrumentation.

74. There is no direct information on the configuration of the Soviet ICBM. There has been no conclusive intelligence regarding ICBM component testing, but numerous Soviet statements indicate a positive relationship between ICBM and satellite launching vehicles and proven military hardware. The large size of the last stage of Soviet satellite rockets, as determined by photography,[10] indicates that the ICBM and the Soviet satellite launching vehicles are probably two stage vehicles, although we cannot yet eliminate the possibility that the launching vehicles may be one and one-half stages or employ parallel staging.

75. The Soviet ICBM test firing program, as indicated by the number of ICBM test vehicles launched to date, has not proceeded as rapidly as implied in our estimate of December 1957.[11] Based on knowledge of the Soviet state-of-the-art and their already demonstrated capability in test launchings, we now estimate that the USSR will probably have a first operational capability with ten prototype ICBMs some time during the calendar year 1959. When it first becomes operational, the system will probably have a reliability of about 50 percent, a maximum range of approximately 5,500 n.m. and a CEP of about 5 n.m. The possibility should not be disregarded that the Soviets may establish in the latter part of 1958 an ICBM capability with missiles of comparatively unproven accuracy and reliability.

76. Available evidence is inconclusive as to the designed payload-carrying capacity of the Soviet ICBM, which we have previously estimated as about 2,000 pounds. Recent evidence and re-analysis may indicate that the USSR is developing an ICBM with a 5,000 pound payload. Serious logistical and operational problems are associated with missiles of the sizes necessary to deliver 2,000 or 5,000 pounds to a range of 5,500 n.m.; these problems would be greater in the case of the heavier payload. In the light of this consideration, we estimate that the Soviet ICBM is designed to carry a nuclear payload of about 2,000 pounds, although there is a possibility that it is designed to carry about 5,000 pounds.

77. A radar track-radio command/inertial guidance system will probably be employed in the first generation ICBM system. We believe that by the early 1960's reliability will be considerably improved. Refinements introduced into the original guidance system could result in CEP improvement to about three n.m. at the beginning of the 1962–1966 time period, and further improvement to about two n.m. later in the period. Between 1960 and 1963, Soviet guidance technology will probably have advanced to the point where an all-inertial system will be available for use in the ICBM. Reliability, operational simplicity, and the requirement for less complex ground support will probably override the slightly degraded accuracy, which we estimate at 3–5 n.m. CEP.

78. *Cruise-type missiles.* Considering the meager evidence on the development of cruise-type missiles and the success of the Soviet ballistic missile program, we estimate that at present the USSR has no active surface-to-surface cruise-type missile development for ground-launching. We do, however, believe that it has such a program for naval purposes (see Naval Launched Systems, below).

79. The Soviets are capable of developing a cruise-type decoy of about 5,000 n.m. range should they so desire. Such a decoy would

[10] These measurements (Sputnik I — roughly 50 feet excluding the instrumented satellite; Sputnik II — roughly 75 feet including the 10 foot satellite; and Sputnik III — tentatively determined as about 85 feet excluding the satellite), definitely indicate that these are not third stages. The variations in length, if correct, indicate that the last stage is not the same in all these cases. Available measurements suggest that the carrier rocket approximates the size of a 700 n.m. missile, although measurement inaccuracies are too great to permit positive identification.

[11] SNIE 11-10-57, The Soviet ICBM Program, 10 December 1957.

probably have only very minimal guidance and no appreciable payload capability, and therefore would have little or no effectiveness as a weapons delivery system. We believe that the USSR will not consider such a decoy sufficiently important to warrant its development.

Factors Affecting Operational Capabilities

80. We believe that the USSR has the capability to produce in quantity a wide variety of ballistic missiles, including the ICBM. The USSR possesses the skills, facilities and economic resources required to carry out a sizeable program of ballistic missile production and deployment throughout the period of this estimate. Newly acquired evidence indicates that the USSR may possess considerably more experience in the actual production of ballistic missiles than we have estimated previously. We now believe that the USSR may have initiated series production of a short range surface-to-surface ballistic missile system as early as 1951.

81. In view of our estimate of Soviet over-all production capabilities, the principal factor affecting the scope and character of the Soviet ballistic missile production and deployment program through 1966 will be the nature and timing of decisions made by Soviet planners. The USSR must make basic decisions concerning the size of the operational capability which it considers necessary to have in being at given times and the investment which it is prepared to make in initial production and deployment of missile systems and equipment replacement with more advanced types. These decisions will have to be modified in the future as a result of progress in the development of newer missile systems, as well as changing international and internal conditions. We believe the USSR has already decided to achieve a sizeable ICBM operational capability at the earliest date practicable. Other ballistic missile systems, some of which the USSR may judge to be of less critical importance, may not be produced in large quantities because of the costs involved and the rapidity of obsolescence. We lack information on the concepts which govern Soviet decisions on the production and deployment of ballistic missile systems, and on the timing of these decisions. Therefore, we are able to estimate Soviet intentions only in general terms, and must select from among several feasible programs those which appear to be most favorable from the Soviet point of view, particularly in the case of the ICBM.

82. *100 to 350 n.m. systems.* We have no direct intelligence on any Soviet facilities producing the 100 n.m. ballistic missiles displayed at the Moscow Parade on 7 November 1957, although the USSR is capable of producing such missiles in quantity. Observations of these missiles at the parade itself reveal a probable Soviet philosophy to adapt to guided missile use, wherever possible, equipment which is already available. The tracked missile carriers were adaptations of existing equipment also used with more conventional armaments. This adaptation minimizes the number of new design, production, and maintenance problems which must be solved, thereby facilitating production and deployment of the missile system.

83. As a result of recently acquired information which sheds new light on older evidence, we now believe that in 1951 the USSR converted the former Dnepropetrovsk Automotive Plant to the production of modified V–2 type (200 n.m.) ballistic missiles, with subsequent partial conversion to tractor production starting in 1953. Such missile production in 1951 would be several years earlier than previously estimated. Although we have no direct evidence, we believe that the Dnepropetrovsk facility is currently producing the 200 n.m. SS–2 missile, or perhaps longer range missiles. These missiles, or their components, could probably be produced without drastic changes in the production processes formerly employed on modified V–2 type missiles. While a large portion of the facility has been allocated to tractor production, we believe that missile production is continuing and that an expansion in production rates may now be planned. There is evidence that the plant has been undergoing an expansion and is currently operating on a multi-shift basis.

84. We estimate that the USSR now possesses an extensive short range ballistic missile production capacity and trained labor force in reserve, possibly at a number of facilities, and that the USSR is capable of mass producing the 200 n.m. and 350 n.m. ballistic missile systems if it chooses. Furthermore, we believe that the USSR has military manpower with experience and training in the use of short range ballistic missiles, and has had sufficient time to train operational units to a high degree of proficiency in the employment of the newer systems which could now be operational.

85. We have no information on the disposition of the short range ballistic missiles we believe have been produced. Some of these missiles almost certainly have been expended in training troops, and to some extent, others may have been modified to incorporate more advanced components. Numerous reports have been received from various sources regarding deployment of ballistic missiles in the Satellite countries. However, reliable observers who has investigated these areas report that no guided missiles or supporting facilities have been identified. Short range missile systems are designed for mobile operations, and could be deployed rapidly into Satellite or other forward areas.

86. *700 and 1,100 n.m. missiles.* We estimate that the USSR probably now possesses operational 700 n.m. SS-4 ballistic missiles, although on the basis of available intelligence, we cannot judge the present scale of production or the number of operational units so equipped. Production, operational troop training, logistics and deployment associated with these missile systems would be facilitated by proven methods previously developed for the shorter range ballistic missiles. We have no evidence on which to base a judgment of the scale of Soviet production or deployment of the 1,100 n.m. SS-5 ballistic missile system. If, as we have estimated, this missile system is a modification of the 700 n.m. system, the USSR probably would face no serious problems in its production and deployment.

87. *ICBM.* We do not know what production facilities are now devoted to the Soviet ICBM program, nor have we any direct evidence regarding Soviet preparations to produce ICBMs and systems equipment in quantity. We do know, however, that the USSR possesses a highly developed industrial base which includes all the skills and facilities necessary for quantity production of successfully developed missile systems. Furthermore, as indicated above, we estimate that the USSR has a background of valuable experience in the production, logistic and training aspects of ballistic missile systems acquired as early as 1951–1953. The centralized planning of the Soviet economy will permit the USSR to marshal economic resources very rapidly for the quantity production of ICBMs and systems equipment.

88. The USSR will determine the peak production rate for ICBMs on the basis of Soviet planners' judgments, primarily with respect to Soviet requirements for various numbers of missiles at selected points in time. These requirements will include not only the production of ICBMs but also construction of launching facilities, production and installation of equipment, training of troops, and establishment of logistic lines.

89. There are indications that mobility is a consideration in the Soviet ICBM systems. Mobility as applied to ICBM systems would comprise rail transport to previously prepared sites, some of which would have only a minimum of fixed equipment. We believe that planning for deployment was carried out concurrently with the preliminary and detailed design of the ICBM and associated ground equipment; hardware concepts could have been sufficiently firm in 1956 to permit the USSR to make basic decisions regarding projected ICBM deployment. Such decisions include the location of operational launch points, general operational concepts, and logistics. At that time many elements of such a launch system could have been determined, and the implementation of such a program could have been initiated. We conclude that the USSR will have had ample time to complete the preparation of launching facilities needed for deployment.

90. The economic resources required for a rail system would come principally from the heavy machinery sector of the Soviet economy. We believe that this sector is capable of sustaining a program of this magnitude and character with only minor delays in the over-all heavy machinery investment program.

91. A Soviet ICBM production and deployment program of the scope necessary to achieve an operational capability rapidly would require the highest order of planning and accomplishment. Considering the various factors discussed above, we estimate that the USSR has the technical and industrial capability to produce ICBMs, complete launching facilities, and train operational units at a rate sufficient to have an operational capability with 100 ICBMs [12] about one year after its first operational capability date (i.e. sometime in 1960), and with 500 ICBMs [12] two or at most three years after first operational capability date (i.e. sometime in 1961, or at the latest 1962). This implies that the USSR could achieve an operational capability with ten or more, but less than 100 ICBMs at the end of 1959, depending upon when during the calendar year a first operational capability is achieved.

NAVAL-LAUNCHED SYSTEMS

92. We believe that the Soviet navy is moving toward achieving a missile-equipped striking force with emphasis on the submarine. Although existing information is meager as to the types of missile systems involved and the extent of their development, it does suggest that naval-launched missile programs were initiated in about 1954. We do not, however, believe that the Soviets have a major capability with submarine-launched missiles at the present time.

Special Problems Affecting Naval-Launched Missile Capabilities

93. Launching and handling problems are prime considerations in shipboard missile systems. Depending on the desired missile performance, it may be possible to design systems compatible with existing ships or it may be necessary to embark on a building program to provide a ship which will accommodate the missile. A short range cruise-type missile is readily adapted to launching from existing Soviet ships. Such a missile could be accommodated in a surface ship of destroyer size or larger, as well as in tank-type external stowage on a conventional submarine. Required alterations to the launching vessel would include provision for stowage of the missile, missile fuel, warhead and associated checkout equipment, and installation of guidance equipment and launcher. This would necessitate removal of some original equipment or weapons for weight and stability compensation. In order to provide storage and launching facilities for cruise-type missiles with ranges of about 1,000 n.m., the alterations required to existing submarines would be extensive if not impracticable in large submarines and prohibitive in smaller ones. Adaptability of destroyer types for employment of a missile with such a range is marginal. For cruisers, the problem of installing 1,000 n.m. cruise-type missiles would be little more difficult than the installation of shorter-range cruise-type missiles.

94. To accommodate ballistic missiles in the 1,000 n.m. range category, alteration of existing submarines is impracticable. The missile configuration would be a determining factor in the size of the boat. A considerably larger submarine is indicated, regardless of the numbers of weapons to be carried. We believe that submarines specially designed to employ ballistic missiles will be nuclear-powered for increased radius of operation, endurance and concealment. Because of the inherent compactness of a submarine, it is considered almost impracticable to use liquid rocket fuels which require on-board manufacture or transfer.

95. Ship-launched surface-to-surface missiles have a more severe accuracy problem than do those launched from the ground. The princi-

[12] These numbers of ICBMs are selected arbitrarily in order to provide some measure of the Soviet capacity to produce and deploy ICBMs; they do *not* represent an estimate of probable Soviet requirements or stockpile.

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pal difficulty is in determining the position of the ship or submarine in relation to the target. At present, with varying degrees of precision, the Soviets could determine launch position by celestial navigational methods or fixes on known landmarks (including radio transmitters). Future solutions to the guidance problem which would provide better concealment for submarines would involve inertial navigation systems and the development of an accurate knowledge of sea bottom configurations as well as gravimetric and magnetic anomalies. The increased Soviet interest in oceanographic survey, including equipping of a submarine for this purpose, indicates a Soviet intention to acquire these data.

96. For cruise-type missiles, which must be guided all the way to the target, practical guidance range is limited to about 200 n.m. when either a radar track-radio command or a hyperbolic system is used. In the latter case, either transmitting buoys or other ships must be accurately positioned for guidance. In both situations, a missile can be launched at considerably greater distances and then passed to the control of down-range guidance stations, provided such stations are no more than 200 n.m. from the target. Considering both Soviet technical development capabilities and the nature of operational conditions, the guidance problem is one of the important factors in our estimate of the range of the first Soviet operational ship-launched missile.

97. A more difficult guidance development, suitable for cruise-type missiles of any range, is the combination use of rather unsophisticated inertial guidance up to the coast line and radar map-matching over land to give the required accuracy at the target. Only the launch ship is involved regardless of the range to the target. The development of radar map-matching guidance for cruise-type missiles would require a lengthy and difficult effort of little, if any, applicability to any other type of Soviet missile system. Naval-launched ballistic missiles, on the other hand, could employ guidance systems developed for the Soviet ground-launched ballistic missile program, including an all-inertial system.

Capabilities and Programs

98. One of the major Soviet post-war national projects was to restore and greatly expand the shipbuilding industry. The entire industry was devoted for the first several years to naval construction. Beginning in 1955, this high construction rate began to decrease and at the present time appears to be in a state of transition. Cruiser construction was suspended in 1955, leaving several uncompleted hulls in the shipyards. Submarine construction has virtually stopped, but there are indications of more advanced boats in the development stage.

99. *Submarine-launched missile development.* Soviet submarines with missile associations (including missile-like, tank-like, and launcher-like objects on deck) were first sighted in 1955, suggesting that a program to develop a submarine guided missile system was initiated sometime in 1954. Available information indicates that these initial efforts were probably undertaken with a relatively unsophisticated cruise-type missile. Whether or not this development program was successful cannot be ascertained. We believe that by 1955–1956 the USSR could have developed for operational use a cruise-type missile capable of a range of up to 500 n.m. at high altitude and a speed of Mach .8 to .9. However, the technical and operational considerations of achieving an acceptable CEP at this range would have presented various difficulties. We believe that the Soviets would have been able to achieve an acceptable missile accuracy, about 2 n.m., only with a radar-track/radio command guidance system. The guidance range of this system would be limited by line of sight and the submarine antenna size to about 200 n.m. This could have led the Soviets to develop a missile of only about 200 n.m. range capability. On the other hand, this same guidance system could be utilized with the same degree of accuracy at missile ranges of up to 500 n.m. but only by use of an additional forward guidance submarine stationed within 200 n.m. of the target. Such operational employment would, by approximately doubling the number of submarines required, greatly increase the risk of dis-

closing any intended attack but would afford the launching submarine greater physical security through increased stand-off distance. Considering these factors, we estimate that the USSR probably developed and now has operational a subsonic cruise-type missile (SS-7), capable of about 200 n.m. maximum range, to be guided by the launching ship. A relatively simple system of this type, which can be employed with converted submarines, is a logical first step in the development of an operational submarine-launched missile capability. However, it does not satisfy estimated Soviet requirements.

100. In order to provide for increased range capabilities up to about 1,000 n.m., the USSR could pursue the development of one or possibly both of two advanced missile systems for submarine use, although there is no evidence of the development of either system.

(a) A 1,000 n.m. range supersonic (about Mach 1.5) cruise-type system could probably be developed and become operational in 1960. Conversion of existing Soviet submarines to accommodate such a missile is impractical; such a system would probably find application only in a new construction submarine. Because of the problems inherent in other guidance systems, we estimate that a 1,000 n.m. cruise-type missile system, if developed, would probably employ a combination inertial and radar map-matching guidance system and be capable of delivering about a 2,000 pound payload with about one n.m. CEP.

(b) Alternatively, the USSR has the capability to develop in a four-year development program a submarine-launched ballistic missile and a compatible submarine. To achieve maximum operational concealment of the submarine, such a ballistic missile would probably be designed for submerged launching. Extremely accurate underwater navigation would be required. We estimate that the first operational capability for such a system (SS-8) will probably be in the 1961–1963 time period. The missile system would probably employ solid or storable liquid propellants and inertial guidance, attaining a CEP of about 4 n.m. Warhead weight is a critical factor in determining the size and, hence, the number of missiles that can be carried on a submarine; the system would probably be designed for a low-weight payload, about 1,000 pounds. Until the launching subs are observed, we cannot estimate with any confidence the number of missiles that would be carried, although we believe it might be about 4–8.

101. In view of the very extensive Soviet experience with ballistic missiles and the guidance problems inherent in long-range cruise-type systems, we believe that of the alternatives described above, the USSR would elect to develop the ballistic missile system. We do not, however, exclude the possibility that the USSR may develop a 1,000 n.m. cruise-type system.

102. *Operational capabilities.* We believe that two separate guided missile submarine programs of different magnitudes must be considered when assessing the potential Soviet capability with this type of weapon. The first is associated with initial Soviet efforts with a relatively short-range and unsophisticated cruise-type missile, capable of external stowage on converted submarines of existing classes. There is some evidence that a few conversions may have already taken place. In view of the existence of approximately 300 Soviet long-range submarines, it is clear that the USSR is potentially capable of converting large numbers to cruise-type missile employment. However, external tank stowage is not the most desirable solution to the stowage problem, since it imposes rather severe limitations on speed, stability, and maneuverability of the launching submarine. Such a conversion may be impracticable or impossible for large missiles. Internal stowage would require such extensive conversion to present submarines that a large conversion program would not be practicable. We therefore believe that to date the USSR has probably converted only a few conventional submarines to guided missile employment, and that it is unlikely to convert large numbers in the future.

103. Termination of construction of existing Soviet submarine types probably marked the initiation of new submarine programs. These programs will probably include the construction of submarines specifically designed as bal-

listic missile submarines, and possibly some as cruise type missile submarines with internal stowage.

104. *Surface ships.* Several cruisers were launched by the Soviets in 1954–1955 but were not completed. Removal of the forward turrets and fire control tower from one of these ships has been noted, but in general they have lain idle. It is possible that these vessels will be completed as missile ships sometime in the future. It is also possible that other Soviet light and heavy cruisers could be converted for launching surface-to-surface and/or dual purpose surface-to-surface/surface-to-air missiles. There is no evidence of the modification of merchant ships for launching missiles, although the possibility of such modification cannot be excluded.

105. *Anti-submarine warfare (ASW).* While we believe that the Soviet navy has a requirement for advanced ASW missile systems, there is no evidence that such systems are being developed in the USSR at the present time. Since the primary advantage of ASW missile systems is the extended range at which an attack can be launched, effective usage is heavily dependent on capabilities for long-range detection, tracking, and identification of submerged submarines. The USSR has the basic scientific and technical capabilities to develop ASW missile systems as well as the required detection and tracking equipment. We believe that the USSR will probably develop such a missile for operational use. The alternate lines of development available plus a complete lack of evidence on Soviet development of such a missile system precludes an estimate of specific missile characteristics. We believe that an ASW guided missile system will probably not be in operation until the latter part of the period of this estimate.

IV. SPACE PROGRAM

GENERAL SCOPE OF PROGRAM

Objectives

106. Soviet objectives relating to space vehicles cannot be regarded as requirements in the usual sense of weapons systems needed to oppose or counterbalance an enemy's military capabilities. In fact, immediate or known military considerations may have no bearing on the decision to develop certain types of space vehicles, although the successful development of these vehicles could result in military applications.

107. We believe that the ultimate foreseeable objective of the Soviet space program is the attainment of manned space travel on an interplanetary scale. At present the program appears to be directed toward the collection of scientific data which would be applicable to Soviet space activities, ICBM program and basic scientific research. While the Soviet space program was undoubtedly initiated to serve scientific purposes, an immediate aim was to achieve political and propaganda gain. Soviet earth satellite launchings to date have ostensibly been in support of the IGY, although the USSR has revealed almost no significant data to the West. Future Soviet programs probably will be established for fairly specific scientific and/or military purposes in accordance with a planned, step-by-step progression from one achievement to the next. We believe that the Soviet space program aims to acquire greater knowledge of the earth and the universe, together with the national advantages to be derived from this knowledge.

108. We estimate that the Soviet space program will be directed toward the following specific objectives:

— *Unmanned satellites.* There will be a continuing requirement during this period for unmanned instrumented satellites to accumulate scientific data on space, as well as surveillance satellites to obtain weather data, geodetic information, and other information of intelligence value.

— *Lunar rockets.* An important Soviet objective is to acquire scientific data on the moon. This data can be collected by unmanned rockets launched to the vicinity of the moon (lunar probes), by unmanned lunar satellites, and by soft or hard impacts on the moon.

— *Recoverable satellites.* Successful experiments with recoverable satellites, including those containing animals, are essential to the attainment of subsequent objectives.

— *Manned earth orbital flights.* Test flights with manned high altitude research vehicles (rockets or boost glide) probably will be required to obtain necessary data on the environment of outer space. Manned flights will probably increase in altitude and duration, prior to the orbiting of a recoverable manned satellite. In recent months, several Soviet sources have stated that a manned space vehicle is feasible and is one of the USSR's prime objectives.

— *Planetary probes.* Rocket probes probably will be launched toward Mars and Venus in order to obtain scientific data not otherwise available from earth satellites and lunar rockets.

— *Manned lunar flights.* Circumlunar flights by manned space vehicles and eventually lunar landings.

— *Manned interplanetary flight.* This is the announced ultimate goal of the Soviet space flight program.

Organization and Priority

109. After about 50 years of general scientific interest in astronautics and space flight, and governmental interest beginning in 1934, the first consolidated attack on the problem by the USSR was announced in April 1955 with the establishment of the Interagency Commission for Interplanetary Communications. There are some indications that this organization may have been in existence and active

as early as the fall of 1954. Its charter provided that one of the Commission's first tasks would be to organize work on the creation of an automatic laboratory for scientific research in cosmic space (an artificial earth satellite). This was to be the first step in solving the problems of interplanetary travel and to allow Soviet scientists to probe more deeply into the secrets of the universe.

110. There is no direct evidence on the priority assigned to the Soviet space program. From the launchings of the Sputniks, from statements by Soviet scientists and high government officials and from the fact that hardware was diverted from the high priority missile program, we believe the inference can be drawn that the Soviet space exploration program has been assigned a very high priority. In many respects Soviet space programs and military missile programs are complementary; we believe, for example, that the Soviet space program has thus far primarily utilized propulsion units developed for the ICBM. There is no evidence to indicate that this has adversely affected the ICBM program, and we believe that the space flight program will not be permitted to interfere with the early achievement of an ICBM capability.

FACTORS AFFECTING ACCOMPLISHMENT OF PROGRAM

111. Prerequisites to the initiation of an extensive space program are the development of large, reliable propulsion units and an advanced electronics program necessary for providing communications, guidance, tracking and data handling. We have estimated that to a large extent, the USSR has already developed these capabilities in the field of ballistic missiles. By utilizing military missile development in the launchings of the first three Sputniks, the USSR has attained an initial success in its program of space exploration. Further successes in the Soviet space program depend upon capabilities in the following fields of scientific and technical endeavor.

112. *Rocket propulsion.* The weights of the three Soviet satellites as announced by the USSR (successively about 184, 1120, and 2900 lbs.) clearly demonstrate Soviet capabilities for development of high thrust rocket engines. Soviet interest in development of higher thrust rocket engines, higher energy fuel combinations, solid propellants and advanced type propulsion systems has been indicated. These are desirable for future launchings of larger satellites and necessary for manned interplanetary space travel.

113. *Guidance, tracking, and communications.* We believe that the USSR is currently capable of placing unmanned vehicles into orbital flights around the earth with certain elements of the orbit approximately predetermined. Achievement of more complex trajectories (e.g., lunar shots) can be expected to evolve from current capabilities. The USSR has an extensive detection, tracking and data handling network for use in its earth satellite program.

114. All three Soviet earth satellites transmitted signals on publicly-announced frequencies. [

] The Soviets have announced that Sputnik III was equipped with memory devices to store collected data; [

]

115. We also have good evidence that the Soviets are making impressive progress in the field of radio astronomy. Although firm connections have not been noted, such Soviet effort can be applied to problems of communications and of tracking and navigation of space vehicles.

116. *Space medicine.* The Soviets are conducting an advanced research program in space medicine. They have made particular progress in studying rocket flight physiology and in developing space flight equipment. Advanced investigations are reported from the Institute of Biological Physics and the Central Scientific Research Institute of Aviation

Medicine in Moscow and at least 25 other major institutes with an unknown number of subordinate laboratories. At least 100 Soviet scientists have been identified as the authors of significant papers in the field.

117. The depth and scope of the Soviet research effort in space medicine indicates an intention to master the fundamentals that underlie human performance and behavior in space. We believe that high altitude rocket experiments with animals have been conducted for several years as announced by the USSR, and additional medical and biological data reportedly have been obtained from the dog in Sputnik II. Research is also being pursued on the effects of acceleration and weightlessness, super saturation of the blood with oxygen, "sealed cabin" experiments, and other problems relating to manned space flight.

118. *Astrobiology*. This field, dealing with the study of possible living organisms on other planets and of the adaptability of earth forms of life to conditions on other planets, is a significant research area in any space program directed toward manned interplanetary flight. Soviet interest in astrobiology is indicated by the assignment in 1956 of research responsibilities in this area to the Interagency Commission for Interplanetary Communications, which appointed a scientific council of outstanding medical scientists to deal with this subject.

119. *Celestial mechanics*. This highly complex subject, which deals with studies of the motions of bodies in outer space under the influence of their mutual gravitational attractions, has an essential role in space flight research. The Soviet Institute of Theoretical Astronomy, the largest of its kind in the world, devotes much of its effort to research in celestial mechanics. There is evidence to indicate that Soviet scientists have made extensive calculations of moon flight trajectories.

120. *Astrophysics and geophysics*. The Soviets are highly competent in the field of astrophysics, and in those aspects of geophysics relating to space travel. In general, the scientific data obtained from satellites or other space vehicles will have significant value to the USSR, not only in the furtherance of its space research activities, but in the enhancement of its scientific and technological knowledge.

CAPABILITIES TO ACCOMPLISH SPECIFIC OBJECTIVES

121. We believe the Soviets intend to pursue an active space flight program designed to put men into space for scientific and/or military purposes. We also believe they intend to undertake further scientific research utilizing unmanned earth satellites, lunar rockets, and probes of Mars and Venus. The dates given for Soviet space activities estimated in this section represent the earliest possible time periods at which we believe each specific event could be accomplished. We recognize that the space flight program is in competition with many other programs, particularly the missile program, and that the USSR probably cannot successfully accomplish all of the space flight activities described below within the time periods specified. We cannot at this time determine which specific space flight activities enjoy the higher priority and will be pursued first.

122. *Unmanned earth satellites.*[13] We believe that the USSR could orbit scientific satellites weighing on the order of 5,000 pounds within the next several months. The USSR could probably continue to place into orbit more and perhaps even larger satellites throughout the period of this estimate. As additional scientific data is obtained, the USSR could

[13] Reported characteristics of Soviet satellites successfully launched to date:

	Sputnik I	Sputnik II	Sputnik III
Weight	184 pounds	1120 pounds	2925 pounds
Length	23 inches	about 9½ feet	11' 8½"
Diameter	23 inches	5 plus feet	5' 8" at base
Orbit	170–580 miles	150–1035 miles	126–1168 miles
Orbit Time	96.2 minutes	103.52 minutes	106 minutes
Shape	sphere	cone	conelike
Lifetime	3 months	5½ months	estimated 6 months

refine or develop new scientific instrumentation to be placed into satellites. Early in the period of this estimate the USSR could place into orbit and recover aeromedical specimens from satellites, to provide essential Soviet knowledge of recovery techniques and of adverse effects of a space environment for man.

123. The USSR could probably orbit surveillance satellites capable of low optical resolution (approximately 100–200 feet) at any time within the next year, to obtain weather data and perhaps some additional data of military intelligence value, such as information on fleet movements. Within another year or two, the USSR could develop more sophisticated surveillance satellites, involving improved photographic or TV reconnaissance, infrared photography and/or ELINT. Such satellites could provide more diverse scientific and military information. The USSR could also develop a communications relay satellite within the period of this estimate, should they elect to do so.

124. *Lunar rockets.* As far as propulsion and guidance requirements are concerned, the USSR has had the capability of launching a probe to the vicinity of the moon since the fall of 1957. A Soviet program of lunar probes could commence with experimental rockets followed by rocket landings on the moon. Placing a satellite into orbit around the moon requires the use of a retro-rocket and more accurate guidance. We believe the USSR could achieve an unmanned lunar satellite in late 1958–1959 and an unmanned lunar soft landing using retro-rockets about six months thereafter.

125. *Manned earth satellites.* Sufficient scientific data could probably have been attained and recovery techniques perfected to permit the USSR to launch a manned satellite into orbital flight and recovery by about 1959–1960. Recovery techniques from a manned satellite, by both capsule and glide vehicle, appear to be feasible and within Soviet capabilities. In view of the wealth of Soviet experience with ballistic missiles and earth satellite vehicles, we believe that the capsule will be used in the first Soviet attempt to recover a man from orbit.

126. *Planetary probes.* Planetary probe vehicles could utilize existing Soviet ICBM propulsion units for the first stage and presently available guidance components. We believe the USSR could launch probes toward Mars and Venus with a good chance of success. The first launchings toward Mars could occur in August 1958, when Mars will be in the most favorable position relative to the earth. More sophisticated probes could be launched in October 1960, when Mars will again be in a favorable position relative to the earth. Similarly, the first launchings toward Venus could probably occur in June 1959, and more sophisticated probes could be launched in January 1961.

127. *Manned circumlunar flights.* Contingent upon successes with manned earth satellites, the development of a new, large booster engine, and concurrent advances in scientific experimentations with lunar rockets, the USSR could achieve a capability for manned circumlunar flight with reasonable chance for success in about 1961–1962.

128. *Manned lunar landings.* We believe that the USSR will not have a capability for manned lunar landings until sometime after 1965.

129. *Space platforms.* There is insufficient information on the problems involved in constructing platforms in space to permit us to estimate Soviet capabilities in this regard. We believe, however, that the USSR would be capable of placing a very large satellite (say about 25,000 pounds) into orbit in 1961–1962. Such a vehicle could serve some of the scientific functions of a space platform without the difficulties of joining and constructing such a platform in space from parts separately orbited.

ANNEX A

DETAILED TABULAR SUMMARY

Probable Soviet Guided Missile Development Programs

and

Possible Soviet Space Development Program

TABLE 1

PROBABLE SOVIET DEVELOPMENT PROGRAM FOR SURFACE-TO-AIR MISSILE SYSTEMS [1]

ARBITRARY REFERENCE DESIGNATION	FIRST OPERATIONAL CAPABILITY DATE [2]	ALTITUDE [3] (in feet)	MAXIMUM [3] HORIZONTAL RANGE (nm)	ACCURACY (CEP in feet)	PAYLOAD [4] (lbs and type)	GUIDANCE	REMARKS
Ground Launched							
SA-1 *	1954	Optimum design altitude 30,000–60,000 Limited effectiveness at 80,000	20–30	65–120	500–800 **	Track-while-scan radar (US designation: YO-YO), radio command	Single stage missile deployed in sites around Moscow. Soviet designation B-200.
SA-2 *	1957	Optimum design altitude 20,000–60,000 Limited effectiveness at 80,000	15–30	65–120	500–700 **	Radar track/radio command	Boosted missile appeared in 7 November 1957 Moscow Parade. Could be employed with ground-guidance system with 360° coverage capability and semi-mobility. Could also be adapted with little difficulty to SA-1 system.
SA-3	1959–1960	Optimum design altitude 50 ft. to 40,000 ft. Limited effectiveness at 60,000	15	20–50	150–250 **	Semi-active continuous wave radar homing	Basic low altitude system with growth potential for longer ranges and higher altitudes.
SA-4	1960–1961	Up to 90,000	75–100	100	500 **	Mid-course command, terminal radar homing	Provides improved range capabilities in defense of critical areas. Ramjet engines could be used although solid propellant would be preferable.
SA-5	Operational missile system with limited capability against ICBMs in 1963–1966, capable of subsequent improvement. Specific characteristics of this system cannot be estimated. This system could possibly have some effectiveness against IRBMs. By using a different, simpler missile, the original system could have a capability against high altitude aircraft and cruise-type missiles.						

TABLE 1 — continued

PROBABLE SOVIET DEVELOPMENT PROGRAM FOR SURFACE-TO-AIR MISSILE SYSTEMS [1]

ARBITRARY REFERENCE DESIGNATION	FIRST OPERATIONAL CAPABILITY DATE [2]	ALTITUDE [3] (in feet)	MAXIMUM [3] HORIZONTAL RANGE (nm)	ACCURACY (CEP in feet)	PAYLOAD [4] (lbs and type)	GUIDANCE	REMARKS
Naval Launched							
SA-6	1959-1960	Optimum design altitude 50 ft. to 40,000 ft. Limited effectiveness at 60,000	20	20-50	150-250 **	Semi-active continuous wave radar homing	Basic SA-3 system for high or low altitudes with dual capability against surface targets.
SA-7	1960-1961	Up to 90,000	75-100	100	500 **	Mid-course command, terminal radar homing	Basic SA-4 system with certain modifications for shipboard use. Capable of dual employment against surface targets.

[1] We evaluate this program as "probable" with varying degrees of confidence concerning detailed characteristics. Each missile listed will probably go through various stages of development which are not necessarily reflected in this table. For discussion of Soviet capabilities to develop an anti-satellite system, considered as a possibility, see paragraph 31.

[2] Date at which one or more missiles could have been placed in the hands of trained personnel in one operational unit.

[3] Maximum altitude is not necessarily achieved at maximum horizontal range.

[4] Payload includes the explosive device and its associated fuzing and firing mechanisms.

[5] Those missile types for which our estimates are supported by significant current intelligence are indicated by an asterisk following the missile designation.

** Nuclear warheads would increase the kill probabilities achievable with these missiles and will be a requirement for effective use of the missiles under some conditions. However, HE warheads will be effective in most applications.

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TABLE 2

PROBABLE SOVIET DEVELOPMENT PROGRAM FOR AIR-TO-AIR MISSILE SYSTEMS[1]

ARBITRARY REFERENCE DESIGNATION	FIRST OPERATIONAL CAPABILITY DATE[2]	GUIDANCE	ACCURACY (CEP in feet)	PAYLOAD[3] (lbs and type)	APPROXIMATE GROSS WEIGHT (lbs)	COMPATIBLE AIRCRAFT: Aircraft	COMPATIBLE AIRCRAFT: Attack Capability	RANGE (nm)	REMARKS[4]
AA-1 *	1955–1956	Radar beam-rider	20	70 (HE)	270	Flashlight A Modified Flashlight	Rear quarter 360°	2½ (Tail) 5 (Head-on)	All-weather Soviet designation "ShM"
AA-2	1955–1956	Infared homing	10	25 (HE)	175	Fagot Fresco A, B, C Farmer A Faceplate Fitter	Day fighter	Limited by radar range to approximately 1 nm	Limited to tail-cone attack in good weather
						Fresco D Farmer B Flashlight	Limited all-weather	2½	
						Modified Flashlight Fishpot	All-weather		
AA-3	1958	Semi-active radar homing	15	50 (HE)	300	Fresco D Farmer B Flashlight	Rear	6 (Head-on) 2½–3 (Tail)	All-weather
AA-4	1960	Semi-active radar homing	50	150 **	800	Modified Flashlight Fishpot		15–20 (Head-on) 5 (Tail)	All-weather
	1960	Passive infrared homing						5 (Tail Only)	Weather limited
	1963	Combined semi-active radar and passive homing (infrared or ECM)						15–20 (Head-on) 5 (Tail)	All-weather All angle attack

[1] We evaluate this program as "probable" with varying degrees of confidence concerning detailed characteristics. Each missile listed will probably go through various stages of development which are not necessarily reflected in this table.

[2] The date at which one or more missiles could have been placed in the hands of trained personnel in one operational unit.

[3] Payload includes the explosive device and its associated fuzing and firing mechanism.

[4] Speed for these missiles has not been indicated on the chart. Mach 2 plus the speed of the launching aircraft is considered reasonable speed for all the missiles estimated except for AA-1 which probably has a velocity of Mach 1.

* Those missile types for which our estimates are supported by significant intelligence are indicated by an asterisk following the missile designation.

** Nuclear warheads would increase the kill probabilities achievable with these missiles and will be a requirement for effective use of the missiles under some conditions. However, HE warheads will be effective in some applications.

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TABLE 3

PROBABLE SOVIET DEVELOPMENT PROGRAM FOR AIR-TO-SURFACE MISSILE SYSTEMS[1]

ARBITRARY REFERENCE DESIGNATION	FIRST OPERATIONAL CAPABILITY DATE[2]	MAXIMUM OPERATIONAL RANGE (nm)	GUIDANCE	ACCURACY (CEP)	PAYLOAD[3] (lbs and type)	REMARKS **
AS-1 *	1956-1957	55	Beam-rider with semi-active radar homing	150 feet	3,000 Nuclear, possibly HE	Launched from aircraft at altitudes of 10,000 to 20,000 feet. Missile flies flat angle approach against well defined radar targets such as ships. Soviet designation: "Komet"
						Alternate guidance by use of radar track/radio command guidance system for use against less well defined targets providing a CEP of approximately 1,500 feet.
AS-2	1960-1961	at least 100	Any of several guidance systems including radar or inertial types with or without terminal homing	½-2 nm depending on guidance system. Terminal homing can improve accuracy to 150 feet.	3,000 Nuclear	General use missile. The accuracy will be dependent upon target characteristics as well as type of guidance.

The USSR is probably developing and may now have operational an air-launched decoy to simulate medium or heavy bombers.

[1] We evaluate this program as "probable" with varying degrees of confidence concerning detailed characteristics. Each missile listed will probably go through various stages of development which are not necessarily reflected in this table.

[2] The date at which one or more missiles could have been placed in the hands of trained personnel in one operational unit.

[3] Payload includes the explosive device and its associated fuzing and firing mechanism.

* Those missile types for which our estimates are supported by significant current intelligence are indicated by an asterisk following the missile designation.

** Some of these missiles could be modified to home on air defense radar.

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TABLE 4

PROBABLE SOVIET DEVELOPMENT PROGRAM FOR GROUND-LAUNCHED SURFACE-TO-SURFACE GUIDED MISSILES[1]

ARBITRARY REFERENCE DESIGNATION	FIRST OPERATIONAL CAPABILITY DATE[2]	MAXIMUM OPERATIONAL RANGE[3]	GUIDANCE[4]	ACCURACY[5] (CEP)	PAYLOAD[6] (lbs and type)	CONFIGURATION	REMARKS
SS–1[7]	1954	100 nm	1954–radar track-radio command/ inertial with terminal correction. 1958–59 – all inertial with comparable accuracy.	1,200 feet	1,500 HE, Nuclear, CW	Single stage ballistic	Mobile. Either liquid or solid propellant. Probably liquid at first operational date; however, may now be solid.
SS–2[7]	1954	200 nm	1954–radar track-radio command/ inertial. 1958–60 – all inertial with approximately 1958 accuracy.	1954 — 1–2 nm 1958 — ⅓–⅔ nm	2,000 HE, Nuclear, CW	Single stage ballistic	There is some evidence that this missile may have become operational as early as 1951.
SS–3[7]	1954	350 nm	1954–radar track-radio command/ inertial. 1958–60 – all inertial with approximately 1958 accuracy.	1954 — 1–2 nm 1958 — ½–1 nm	Up to 5,000–6,000 HE, Nuclear, CW	Single stage ballistic	
SS–4[7]	1956	700 nm	1956–radar track-radio command/ inertial. 1958–60 – all inertial with comparable accuracy.	1–2 nm	Up to 5,000–6,000 Nuclear, possibly CW	Single stage ballistic	
SS–5[7]	1958	1,100 nm	1958–radar track-radio command/ inertial. 1958–60 – all inertial with comparable accuracy.	2 nm	Up to 3,000 Nuclear	Single stage ballistic	Availability of this missile in 1958 is dependent upon its being a relatively simple modification to the 700 nm missile, for example, reduction in payload weight, or possibly change in propellant or tankage.

TABLE 4 — continued

PROBABLE SOVIET DEVELOPMENT PROGRAM FOR GROUND-LAUNCHED SURFACE-TO-SURFACE GUIDED MISSILES [1]

ARBITRARY REFERENCE DESIGNATION	FIRST OPERATIONAL CAPABILITY DATE [2]	MAXIMUM OPERATIONAL RANGE [3]	GUIDANCE [4]	ACCURACY [5] (CEP)	PAYLOAD [6] (lbs and type)	CONFIGURATION	REMARKS
SS-6 * ICBM	1959	5,500 nm	1959-radar track-radio command/inertial 1960-63-all inertial with subsequent improvement.	1959 — 5 nm 1962-66 — 2 nm 1960-63 — 3-5 nm	2,000 possibly 5,000 [7]. Nuclear	Probably two stage ballistic	The possibility is not excluded that a limited operational capability will be established in latter 1958 with missiles comparatively unproven as to accuracy and reliability.
SS-anti-tank	prior to 1958	6,000 yards	Command wire link.	2 ft.	20-40 shaped charge HE	Single stage	There is no intelligence to support estimate of this missile, which is based on logical development to meet an estimated Soviet requirement.

[1] We evaluate this program as "probable" with varying degrees of confidence concerning detailed characteristics. Each missile listed will probably go through various stages of development which are not necessarily reflected in this table. We estimate that considerable energy will be expended in second generation longer-range missiles, particularly on an ICBM of greatly improved operational characteristics. For a discussion of ground-launched cruise-type missiles and decoys see paragraphs 78-79; 1600 nm ballistic missiles, paragraph 72; very short range tactical missiles, paragraph 64.

[2] Date at which one or more missiles could have been placed in the hands of trained personnel in one operational unit.

[3] Generally a ballistic missile can be fired to ranges as short as approximately one-third the maximum operational range without serious increase in CEP.

[4] In the initial versions of the SS-1 through SS-6, the guidance system may not be solely electronic, but may include some inertial components. For this reason a radar track-radio command/inertial guidance system is indicated.

[5] CEP is the radius of a circle in which, statistically, one-half of the impacts will occur. Inherent missile accuracies are somewhat better than the accuracies specified in the table which take into consideration average degradation factors.

[6] Payload includes the explosive device and its associated fuzing and firing mechanism. The weight of the structure and the heat protection of the nosecone are not included in "payload." For missiles up to 350 nautical miles range, we believe HE, Nuclear or CW warheads will be employed in accordance with Soviet military policy and dependent upon nuclear stockpiles, missile accuracy, character of the target and results desired. We estimate that for missiles with ranges of 700 nautical miles and over, only nuclear warheads will be employed. However, we do not exclude the possibility of CW use in the 700 nm missile.

[7] For discussion of Soviet ICBM payload-carrying capacity, see paragraph 76.

[8] Those missile types for which our estimates are supported by significant current intelligence are indicated by an asterisk following the missile designation.

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TABLE 5

PROBABLE SOVIET DEVELOPMENT PROGRAM FOR NAVAL-LAUNCHED SURFACE-TO-SURFACE GUIDED MISSILES[1]

ARBITRARY REFERENCE DESIGNATION	FIRST OPERATIONAL CAPABILITY DATE[2]	MAXIMUM OPERATIONAL RANGE (nm)	GUIDANCE	ACCURACY[3] (CEP in nm)	PAYLOAD[4] (lbs and type)	CONFIGURATION	REMARKS
SS-7	1955-1956	200	Radar track/radio command from launching submarine	2	2,000 Nuclear	Cruise-type	Subsonic missile for surface launch by submarines. Current capability for employment with limited number of converted submarines. Also compatible for launching from surface ships.
SS-8	1961-1963	1,000	Inertial	About 4	1,000 Nuclear	Ballistic	Submarine launched from surface or underwater. Solid or storable liquid missile propellants.

Late in the period of this estimate, the USSR will probably have available a guided missile system for use in antisubmarine warfare. Characteristics cannot be estimated at present.

[1] We evaluate this program as "probable" with varying degrees of confidence concerning detailed characteristics. Each missile listed will probably go through various stages of development which are not necessarily reflected in this table. For a discussion of the possible development of a 1,000 nm naval-launched cruise-type missile see paragraph 100.

[2] Date at which one or more missiles could have been placed in the hands of trained personnel in one operational unit.

[3] CEP is the radius of a circle in which, statistically, one-half of the impacts will occur. Inherent missile accuracies are somewhat better than the accuracies specified in the table which take into consideration average degradation factors.

[4] Payload includes the explosive device and its associated firing and fuzing mechanism. In the case of SS-8, the weight of the structure and the heat protection of the nosecone are not included in "payload."

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TABLE 6

POSSIBLE SOVIET SPACE DEVELOPMENT PROGRAM

SPACE PROGRAM OBJECTIVES	FIRST POSSIBLE CAPABILITY DATE[1]
Unmanned Satellites	
IGY[2]	1957–1958
Aeromedical (recoverable)	1958–1959
Surveillance (weather and limited military application)	1958–1959
Lunar Rockets	
Exploratory probes and impacts	1958
Lunar satellite	1958–1959
Soft landings	1959–early 1960
Manned Earth Satellites (Recoverable)	
Capsule-type satellites	1959–1960
Glide-type vehicles	1960–1961
Heavy satellites (25,000 pounds)	1961–1962
Planetary Probes	
Mars	August 1958
Venus	June 1959
Manned Circumlunar Flights	1961–1962
Manned Lunar Landings	After 1965

[1] These dates represent the earliest possible time period in which each specific event could be successfully accomplished. However, competition between the space program and the military missile program as well as within the space program itself makes it unlikely that all of these objectives will be achieved within the specified time periods.

[2] We estimate that the USSR could orbit a scientific satellite weighing on the order of 5,000 pounds within the next several months.

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