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The Soviet Space Program

CIA HISTORICAL REVIEW PROGRAM
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The following intelligence organizations participated in the preparation of this estimate:

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

Concurring:

Director of Intelligence and Research, Department of State

Director, Defense Intelligence Agency

The Atomic Energy Commission Representative to the USIB

Director of the National Security Agency

Abstaining:

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

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ANNEX B: PRINCIPAL TYPES OF VEHICLES AND TECHNIQUES EMPLOYED IN SOVIET SPACE PROJECTS, 1957-1964

THE SOVIET SPACE PROGRAM

THE PROBLEM

To estimate Soviet capabilities and probable accomplishments in space over the next five to ten years.

CONCLUSIONS

A. The USSR's space program has become a key element in Soviet world prestige. Space remains the major area in which the Soviets can still propound a credible claim to world primacy. The USSR is also concerned to explore the military implications of space capabilities, and at least one military support system is already operational. We believe that the Soviet space program will retain its priority, that its accomplishment will continue to be impressive, and that it will focus on goals for which the USSR can most favorably compete. (*Paras. 35-36*)

B. The Soviet program has been focused so far on four main categories of activity:

> a lunar and interplanetary probes project which scored some initial successes but has been consistently unsuccessful since 1959;
>
> a manned space flight project emphasizing biomedical research, which has accumulated a total of more than 450 man hours in seven launches;
>
> a strategic photo-reconnaissance project which began in late 1962 and now apparently is performing its mission successfully;
>
> unmanned scientific exploration of near-space, a project recently plagued by numerous equipment failures. (*Paras. 1, 5-7, 10-18*)

C. Soviet launchings have sharply increased in the past year. This has been due almost wholly to the reconnaissance project which appears to enjoy a high priority. A number of satellites recently launched by new and diversified techniques could be precursors to meteorological, communications, navigation, or electromagnetic-reconnaissance systems. (*Paras. 1, 8-9, 19-20*)

D. The Soviet space effort has been characterized by repeated use of a few components and techniques, plus a total reliance on military boosters and an extensive sharing of other equipment and facilities with the ballistic missile program. This practice has kept down costs, but the space effort has been expensive and it now appears to have reached a stage where new and more costly systems will be necessary to sustain the previous rate of progress. Like Khrushchev, the new Soviet leaders will balance economic and other considerations carefully in decisions about future space projects. (*Paras. 2-4, 21-23, 28-32*)

E. Future missions will include unmanned space vehicles for the exploration of near-space, the moon, Mars, and Venus. The Soviets will probably continue to take advantage of each opportunity for the launching of probes to Mars and Venus to analyze the atmosphere and surface of the two planets. Lunar probes will be equipped for investigating the lunar surface. (*Paras 37-39, 42-47*)

F. In the near term the Soviets will probably seek to rendezvous and dock two or more vehicles in earth-orbit and thereby to develop techniques for the assembly and resupply of space stations. If they can use current spacecraft, initial docking experiments could take place during 1965, and a space station to accommodate two or three persons could be achieved in 1966. We have no evidence, however, that existing Soviet manned spacecraft are suitable for this mission. If a wholly new spacecraft is required, rendezvous and docking is unlikely before 1966; a small manned space station could probably be placed in orbit about a year later. (*Paras. 48-52*)

G. We believe that a new large booster with a thrust on the order of two million pounds is under development in the USSR, and that it could be available for manned operations as early as 1966. A year or two after its first manned flight, the Soviets will probably use it and appropriate space hardware to create a large manned space station. Such a station might weigh as much as 100,000 pounds and accommodate a rotational crew of five to ten persons for extended periods. It could be created in about the same time frame, by multiple rendezvous operations using existing boosters, but we consider this approach unlikely. (*Paras. 24-25, 53*)

H. The propaganda value of a manned circumlunar flight, and its simplicity and low cost relative to a manned lunar landing, lead us to consider this as a prime Soviet goal. If the USSR is not seeking to beat the US in a manned lunar landing, this project would probably be timed to precede the Apollo mission in an attempt to detract from the US achievement and to identify the USSR with manned exploration of the moon. Use of the present space booster for the circumlunar mission is possible but unlikely. Using the new, large booster noted above, the mission could be accomplished as early as 1967, but considering the problems of technology and cost, we think it more likely that the flight would not occur before 1968, and it might be even later—especially if the project is planned to incorporate advanced hardware required in a subsequent manned lunar landing project. (*Paras. 54-58*)

I. We do not believe that a manned lunar landing competitive with the present Apollo schedule, i.e., aimed at the 1968-1969 period, is a Soviet objective. The apparent status of Soviet space technology, economic considerations, statements by the leadership, and continued commitments to other major space missions all lead us to this conclusion. It seems certain, however, that the Soviets intend to land a man on the moon sometime in the future, and some R&D effort toward this goal is almost certainly in progress. (*Paras. 33-34, 59, 61*)

J. We estimate that another, very large booster with a thrust on the order of five million pounds is under development and could become available for manned space flight as early as 1968. Using this booster and an earth-orbital rendezvous technique, and with a very high degree of success in all phases of the project, the first Soviet attempt at a manned lunar landing might occur as early as 1969. In view of the magnitude of the technological problems and the level of resources which the Soviets are likely to commit to this project, we believe a more probable date for such an attempt to be a few years later. (*Paras. 26-27, 60, 62*)

K. If the Soviets choose to direct their efforts toward even more extensive manned exploration of space, they may develop very large, quasi-permanent stations for the assembly and launching of spacecraft from near earth orbit. A suitably large space station could be created in the early 1970s using the very large booster discussed above. If so, a manned lunar landing mission launched from a space station could occur in the middle 1970s. (*Para. 63*)

L. We believe that the Soviets will experiment with a variety of space systems for military purposes, that they will employ those systems which can be economically and militarily justified, and that some military role for man in space may emerge by the end of the period, particularly as the ability to operate manned space stations grows. Within the next five to ten years, additional military support systems will probably become operational. Considering the capabilities of current boosters and other available indicators, we think that the systems most likely to be deployed in the next few years are those for communications and TV relay, weather forecasting, geodesy, and navigation. A maneuverable satellite for electromagnetic and photographic reconnaissance may also be developed. Penetration aid satellites with electronic payloads could be operational late in this decade. (*Paras. 64-66*)

M. We do not estimate that the Soviets will deploy offensive or defensive weapons in space within the next five to ten years. This conclusion is based upon our judgment that such systems will not compare favorably in cost and effectiveness with ground-based systems and, to a lesser extent, upon our view that the Soviets would see political disadvantages in deploying weapons in space. Soviet technology applicable to this field, however, will improve in the normal course of development of nuclear technology, ICBMs, and space projects. Further, we recognize that the Soviets might reach different conclusions as to relative cost, effectiveness, and political impact. Even if they should elect to deploy space weapons, however, we believe that they would regard them primarily as a means of supplementing existing forces, of introducing additional complications into US defense planning, and of supporting Soviet claims to strategic parity or even superiority.[1] (*Paras. 67-69*)

[1] For a fuller discussion of possible Soviet development and deployment of space weapons see NIE 11-9-63, "Soviet Capabilities and Intentions to Orbit Nuclear Weapons" (Secret, 15 July 1963), and pertinent sections of NIE 11-8-64, "Soviet Capabilities for Strategic Attack" (Top Secret, Limited Distribution, 8 October 1964) and NIE 11-3-64, "Soviet Air and Missile Defense Capabilities Through Mid-1970" (Top Secret, 16 December 1964).

DISCUSSION

I. THE SOVIET SPACE RECORD

1. In the seven years since Sputnik I, the Soviet space program has come to encompass four main categories of activity:

a. Unmanned, scientific exploration of near space;

b. Lunar and planetary probes;

c. Manned space flight; and

d. Strategic reconnaissance.

Some of these efforts have been spectacularly successful, others consistently unsuccessful. The program has expanded in scope and complexity, and recently has accelerated. Of the slightly more than 100 launches to date, almost one-third took place in 1964.[2]

2. The Soviets have focused, at least until recently, on a few well defined objectives. While amassing a number of space "firsts," the program has been characterized by the repeated use of a limited number of proven techniques and components.[3] It has made maximum use of boosters and other hardware developed for military purposes and has relied heavily on military facilities for the launch, tracking, and control of space missions. Moreover, the managerial and engineering base for the space program, while characterized by a very high competence, appears to have been concentrated for the most part in existing institutions. From all these indications, we infer that the Soviets have been attempting to carry out an ambitious program with a remarkable economy of means.

3. From the beginning, the mainstay of the program has been the SS-6 (first generation) ICBM booster which has been used for some 80 space launches. The Soviets regularly have launched this 900,000 pound thrust booster from Tyuratam within a few seconds of pre-determined times, after periods of on-pad preparation as short as a day or two, even for manned missions. In 1961, the Soviets began to use a second military booster, the SS-4 MRBM, to launch from Kapustin Yar small satellites into near-earth orbits. This very much less expensive booster has now been used more than 20 times.

4. The SS-6 booster is combined with an upper stage to increase its payload capacity for space missions. The first such upper stage, the Lunik, was introduced in 1958 on a lunar probe. It has also been used in the launching of recoverable satellites weighing some 10,500 pounds, including all six of the one-man Vostok and most of the reconnaissance vehicles. A larger upper stage,

[2] For chronological summaries of the several categories of launchings in the Soviet space program to date, see Annex A.

[3] For graphics illustrating the principal types of vehicles and techniques employed to date, see Annex B.

the Venik, has been used for a variety of missions in the past four years. The SS-6/Venik combination has been used with an additional stage to launch all lunar and planetary probes since the fall of 1960. Since late 1963, this combination also has been used to launch recoverable satellites weighing some 12,000 pounds, including four reconnaissance vehicles and, most recently, the new three-man spacecraft, Voskhod. Full utilization of this combination could result in a payload weight on the order of 15,000 pounds.

Unmanned Scientific Satellites

5. The first Soviet scientific satellites were Sputniks 1, 2, and 3, launched from Tyuratam in the period October 1957-May 1958. These were instrumented satellites weighing up to 2,925 pounds, designed to collect astrogeophysical and biological data at altitudes up to 1,000 n.m. Data collection was fairly limited and selective and there was subsequently an apparent lack of systematic and comprehensive measurement of the space environment needed for future space ventures.

6. After a long pause in this project, the Soviets initiated in late 1961 a new series of satellites from Kapustin Yar using the SS-4 MRBM booster. These satellites, identified by the Soviets as part of the Cosmos series, are spin-stabilized, space-oriented, and nonrecoverable. [redacted] analysis indicates that they are not highly advanced technologically and that the program is limited in scope relative to comparable US projects: all have been launched on an inclination of 49° from the Equator; numerous failures have resulted from a continuing inability to develop useful, reliable equipment for a payload of 300-500 pounds; and orbital altitudes have been concentrated in a range below 900 n.m., probably the maximum achievable with this booster payload combination.

7. In 1964, four scientific satellites—Electrons 1 through 4—were launched in pairs aboard SS-6s from Tyuratam. They appear to be similar in design and purpose to some of the Kapustin Yar Cosmos satellites. Use of the SS-6 booster permitted the orbits to extend out some 35,000 n.m.

8. A number of non-recoverable satellites launched in August 1964 from Tyuratam and Kapustin Yar—Cosmos 38 through 44—were described in Soviet announcements as additional scientific satellites in the Cosmos series. We are unable to gauge the purpose or degree of success of all the satellites in this series. However, the available evidence leads us to believe that several were to conduct radiopropagation experiments and that others were precursors of navigation or communications-relay systems.

9. In the launching of all these satellites, the Soviets tested new and varied orbiting techniques suitable for a variety of specialized space systems. In one instance, three satellites (Cosmos 38, 39, and 40) were placed into orbit by a single booster launched from Tyuratam. Similarly, two small satellites (Cosmos

42 and 43) were launched from Kapustin Yar by a single booster. This technique is useful to extend the coverage of scientific payloads or to launch navigation, communication, or ELINT collection satellites. In another instance, Cosmos 41 was injected from a parking orbit into a highly elliptical orbit; this technique is adaptable to placing vehicles into synchronous orbits useful for communications systems or possibly for an advanced ELINT collection system. Finally, Cosmos 44 was placed into a high circular orbit, which would be suitable for a solar laboratory, an ELINT collector, or a weather satellite.

Lunar and Planetary Probes

10. From late 1958 to early 1960, the Soviet space program concentrated heavily on the moon, with an estimated nine firings. These early probes, of less than 1,000 pounds, were launched by direct ascent using the SS-6/Lunik combination.. Three were successful, including Lunik III which in late 1959 passed behind the moon and later transmitted photographs of the hidden side. But after two apparent failures in 1960, the USSR abandoned the direct-ascent technique.

11. In late 1960, the Soviets introduced a new technique to launch substantially heavier probes toward Mars, Venus, or the moon. The SS-6/Venik combination places the probe and its own propulsion stage into a low parking orbit around the earth, after which they coast to a point where the probe can be ejected and put on the desired trajectory. Some 18 launchings have been attempted with this technique. During each opportune time since 1960, the Soviets have launched at least one and sometimes three 1,900 pound probes toward Mars and Venus. The launching of lunar probes, weighing some 3,100 pounds, was resumed in January 1963.

12. Since the fall of 1958, this project of lunar and planetary probes has used an average of four SS-6 boosters per year. The total of 27 accounts for about one-third of all SS-6 boosters allocated to the space program. In 1964, at least two probes were launched to Venus, two to the moon, and one to Mars. The project, however, has been marked by failure since Lunik III in 1959. Of the 21 subsequent launches, none has been successful enough to collect any significant scientific data, or even to provide the Soviets with confirmation of the payload's ability to perform its mission. Our evidence indicates that the most recent planetary probe, Zond-2, which was launched toward Mars on 30 November 1964, will miss the planet by about 750,000 miles. The many persistent difficulties, particularly with the ejection stage, may handicap or modify Soviet plans for lunar and planetary exploration in the future.

Manned Space Flight

13. The Soviet manned space flight project has accomplished significant results while proceeding at a cautious and methodical pace. No undue risks have been taken, and no human being has been committed until there was a high degree of confidence that all equipment would function to complete the flight without the participation of the cosmonaut. The Vostok spacecraft, first flown

in 1960, was tested extensively before initial manned use, and probably the Voskhod as well. Measurements of the space radiation hazard have been made within the unmanned craft prior to manned flights. In the case of Vostok, a failure in any project using the same hardware was followed by two successful unmanned missions before the next manned flight. Cosmos 47, launched one week before the three-man Voskhod, was a dress rehearsal complete with dummies in the spacecraft.

14. The 12,000-pound Voskhod has retained many of the technical features of the 10,500-pound, one-man Vostok, including an essentially similar life support system. Separate automatic and manual systems for spacecraft orientation were retained, as well as a globe device permitting the cosmonaut to ascertain his position and orientation without the aid of ground stations. Soviet cosmonauts have used the manual systems sparingly during flight, and de-orbiting has been accomplished by the automatic system under ground control. No out-of-orbit maneuvering has taken place and no attempts at rendezvous and docking have been made. However, some preliminary experience of value to these ends was obtained in the two dual Vostok missions of 1962 and 1963.

15. In the seven manned flights thus far (including one of five days), over 450 man hours have been amassed. The Soviet project has emphasized biomedical experimentation, and these flights have given rise to serious Soviet concern about the possible effects of space flight of several weeks or more on human beings. The inclusion of a doctor aboard Voskhod was an effort to acquire first-hand medical data.

Strategic Reconnaissance

16. In December 1961, the Soviets began to launch a new series of Vostok-like, recoverable earth satellites from Tyuratam. They described these as part of the scientific Cosmos series, a designation which they have applied to satellites launched for a variety of purposes. The rate of launchings has increased from six in the first year of the project to eight in the second and 13 in the third. Of the 24 which have achieved orbit, all but one were successfully recovered in the USSR. Like the lunar and planetary program, this project has consumed about one-third of the SS-6 boosters allocated to space.

17. [ ] most if not all of these recoverable vehicles have had a photo-reconnaissance mission. It is clear from the pattern of launch times that the Soviets desire the perigee of these satellites (about 110 n.m.) to occur over North America during prime daylight hours. This is probably dictated by photographic requirements, but we cannot exclude the possibility that other data, such as Comint, Elint, and infra-red, are also being collected.

18. The majority of these satellites weigh about 10,000 pounds and have conducted strategic reconnaissance missions over land targets. The best photography from these satellites would probably be adequate to detect and identify most military installations, aircraft and major naval vessels, industrial installa-

tions, and lines of communication. Beginning with Cosmos 22 in November 1963, however, four have weighed about 12,000 pounds and appear to perform a higher resolution mission. The best photography from these satellites may be comparable to good World War II aerial photography, which would be adequate for detailed analysis of targets located by the system of lesser resolution or by other means.

19. We do not know what success the Soviets have actually achieved with photo-reconnaissance satellites. Whatever the degree of success, the project clearly has a high priority. The pace of launchings and the timing of flights in 1964 suggest that the system is considered operational and is performing routine missions satisfactorily.

20. We have no direct information on why the Soviets are conducting this extensive photo-reconnaissance project or what their objectives are.

the Soviet program probably was undertaken to accomplish the following:

a. to target as precisely as possible US nuclear strike forces, especially ICBM sites, to monitor their operational status, and to detect new deployments;[6]

b. to map areas of military interest, especially in the area from Turkey east through Afghanistan;

c. to monitor the development and test of new military systems, not only in the US but probably also in Communist China; and

d. to monitor large-scale military and naval activity.

Satellite photo-reconnaissance probably also provides the Soviets with several other types of information, including an evaluation of the US potential for satellite reconnaissance. In any case, their satellites give the Soviets a collection mechanism which is subject to their own control and quickly covers a vast area of the world.

Costs

21. No direct information is available on the USSR's actual expenditures for its space program. Our calculations derive from indirect data, primarily US analogy, and our cost figures reflect the costs of the Soviet program as though they were incurred in the US. These figures do not include the costs of constructing facilities and developing hardware used in the space program but intended primarily for military purposes.

22. We estimate that through mid-1964 the Soviets had spent the equivalent of some $4-6 billion for those space projects which resulted in launchings and hence can be identified. (About one-third of this total was probably expended

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[6] We currently estimate that the Soviet geodetic error in location of US missile launch sites is on the order of 1,200-2,500 feet. We believe that, by using all available means, including reconnaissance satellites, the USSR will be able to reduce the geodetic error to about 700-1,500 feet by the end of the decade.

on the lunar and planetary probe project, while the strategic reconnaissance project has absorbed about $1 billion.) Additional expenditures for programs that are underway but not yet identified by means of launchings may be on the order of some $2-4 billion. Thus, we estimate that total Soviet outlays for space through fiscal 1964 lie within a range of $6-10 billion. We believe that annual expenditures have steadily increased over the past seven years, and recent indications of increased activity indicate that they will continue to grow as the result of new projects evidently programed for the next several years.

II. FACTORS AFFECTING FUTURE PROSPECTS

23. The major space missions to be undertaken in this decade will reflect decisions made during the last several years. These decisions were reached at a time when the economic constraints normally operative on Soviet policy have been accentuated, consumer and defense industries have given rise to greatly increased demands for scarce, high-quality resources, and expensive new strategic weapons programs are underway. Even so, all recent evidence indicates that the Soviets have decided to enlarge and diversify the space program. A number of techniques not previously attempted by the Soviets have recently been used in the orbiting of earth satellites. More important, we have evidence that new, more powerful boosters will become available for space launchings. However, evidence of the nature of new space projects appears only late in the development cycle; thus we can not yet determine what missions may have been planned for the new boosters.

Booster Capabilities and Costs

24. The payload capacity of the SS-6 is substantial enough to permit a wide range of significant new missions in near space. These include a variety of military support missions, manned and unmanned rendezvous and docking experiments, and the creation of a small space station. With this propulsion system, it would also be marginally possible to conduct a manned circumlunar flight. The payload limitations evident in the Kapustin Yar Cosmos project, which uses the SS-4 booster, probably can be overcome. Other currently available military boosters also could be adapted to space missions.

25. We believe that the Soviets soon will begin flight testing a considerably larger booster which could be used as a "global rocket," as a carrier for the 100 MT warhead, or as a space booster. This booster, which we associate with the SS-large ICBM, may have a thrust on the order of 2 million pounds, roughly equivalent to that of the US Saturn I. Such a booster probably will be available for unmanned space launchings in 1965. It could be available for manned launchings as early as 1966, but we consider 1967 a more likely date. This new system with a suitable upper stage probably will be able to place payloads of as much as 50,000 pounds into low earth orbit. Along with appropriate manned spacecraft, it could be used to create and resupply a larger space station more efficiently than the SS-6 and would offer more realistic prospects for a manned circumlunar flight. The costs of these projects, if purchased in the

US, would be perhaps $6-8 billion, not including the cost of development of the booster.

26. We estimate that the Soviets also have under development a very large booster with a thrust on the order of five million pounds. We believe it unlikely that this vehicle will be flight-tested before 1967, but it is possible that such a test could occur in the latter half of 1966. Thus, such a booster could be ready for initial manned missions as early as 1968, but we think it more likely that they would occur a year or so later. Such a large booster would be unlikely for ICBM application; in this case, the cost of its development, perhaps on the order of $4-5 billion, would be chargeable to the space program.

27. Should this new booster prove to have a thrust of some five million pounds, it probably would be able to place payloads weighing on the order of 100,000-150,000 pounds into low earth orbit. This would be adequate for the establishment of a large manned space station. Considering the variety of techniques open to the Soviets for conducting a manned lunar landing, such a new booster also could be used for this mission.

Scientific and Technical Considerations[6]

28. We believe that Soviet capabilities in the basic and applied sciences will be adequate throughout the period of this estimate to support an ambitious space program. Difficulties in the program are more likely to arise from technological than from scientific limitations. While current Soviet space technology can be extended with comparative ease to meet the requirements for at least a small manned space station, requirements considerably more complex and demanding must be met in such missions as a manned circumlunar flight or a manned lunar landing and return.

29. The Soviets probably now have sufficient biomedical data to plan with confidence a manned flight of one to two weeks; this would be more than adequate for either a circumlunar or lunar landing mission. From all indications, however, they appear to be more concerned at this time with the effects on human beings of considerably longer missions, such as manned vehicles in earth orbit for 30 days or so. There are few indications of how the Soviets will solve the biomedical problems now believed to be associated with missions of such duration, but we see no reason why practical solutions should not be ready in time for projects late in the decade.

30. Soviet engineers may already be working on other problems of manned lunar flight, such as parabolic re-entry into the earth's atmosphere and aerodynamically-maneuverable spacecraft, but we have no evidence that this is the case. Some limited success is evident in solving other problems related to this mission, such as light-weight power supplies, spacesuits, and space-restartable motors, but much work apparently remains to be done. A comparison of Vostok and Voskhod indicates that the Voskhod life-support system is similar to the earlier system. It will require modification for inclusion in a spacecraft which

[6] For a detailed discussion of this topic, see Annex C.

could meet the rigid weight restrictions which would be imposed by the manned lunar landing mission.

31. The USSR's lack of sites outside Soviet territory for tracking and data acquisition has imposed limitations on several of its space projects, particularly the launching of lunar probes. At present, the principal facilities for tracking and communications in lunar and planetary operations are located in the Crimea. The Soviets probably will not undertake manned lunar flights until they can establish the additional sites necessary to maintain continuous contact. To achieve such a capability, they would need to establish two additional major sites, which ideally should be spaced about 120 degrees apart, and located near the equator. One of these new sites could be located in the Soviet Far East; this would improve their capabilities to a point which they might consider sufficient to risk a manned lunar mission.

Other Indirect Evidence of Future Prospects

32. In sum, the Soviet space program appears to be in a state of transition. While we can estimate technically feasible extension of all current projects, we believe that the Soviets do not have in hand the necessary economic and technical resources for undertaking all such projects simultaneously. We therefore believe that some potential projects will not be undertaken, others will be slowly paced, and substantial resources will be committed to only a few. The expansion of the reconnaissance project over the past year shows that projects of demonstrable strategic value can and will be funded. Moreover, other useful missions can still be accomplished with existing boosters and hardware. Beyond these activities, the Soviet leaders will have weighed the costs of various projects which could be accomplished with the advanced boosters under development and the other hardware likely to be within the capabilities of their scientists and engineers. They probably considered a manned lunar landing as the most demanding space venture that could be undertaken in the next five to ten years.

33. Soviet statements relating to the manned lunar mission can be traced back to 1961, when President Kennedy challenged the USSR to a space race with this as the specific goal. In considering how to respond to the US challenge, the Soviets would have had to assess carefully the benefits from such a project against those to be derived from other uses—military, space, and civilian—of the same resources. Equally important would be the Soviet leaders' view of their ability to compete successfully and their assessment of the consequences for Soviet prestige should disaster result from a project whose timing was dictated by the US.

34. Some ambivalence in public statements by Soviet leaders suggests that they may be trying to keep their options open, but during the past year or so they have shown increasing caution, implying that the USSR has not in fact entered a lunar race. Thus, Khrushchev voiced both deep concern about the technical difficulties of such an undertaking and a willingness to profit from US experience and possible US failures. He and others expressed concern over the high cost of undertaking a manned lunar landing. His remarks in the past year clearly

were intended to convey the impression that the USSR was not competing with the US in any race to the moon and to lay the foundation in the minds of the Soviet people that the US might be first. The new Soviet leaders have made public statements in a similar vein. After the flight of Voskhod, Brezhnev stated: "We Soviet people do not regard our space research as an end in itself, as a kind of race . . . The spirit of frantic gamblers is alien to us." At the Kremlin reception for the Voskhod cosmonauts, Kosygin pointed out that the economic needs of earthly projects must not be forgotten in the rush into space.

35. For political reasons, however, the Soviets could ill afford to slacken in the space race and from all indications they have no intention of doing so. The USSR's space program has become a key element in Soviet world prestige. Space remains the major area in which the Soviets can still propound a credible claim to world primacy. We expect that the Soviet space program will involve a range of undertakings which in their overall impact will be strongly competitive with the US program during the next five to ten years. The world reaction to the flight of Voskhod (the first "manned space laboratory") has again demonstrated to the Soviet leaders the value of scoring space "firsts." The Soviet desire to project a strong national image, in conjunction with the other considerations we have mentioned, makes it likely that they will continue to endeavor to focus the space race on goals for which they can most favorably compete.

36. Available evidence does not of itself indicate whether or not the Soviets now have programs for the military use of space, apart from the military support capability provided by the Cosmos satellites. The limitations of this evidence, however, are such that our chances of identifying military programs are poor. Soviet decisions to develop military space systems will depend on their expected cost and effectiveness as compared with alternative systems, the political and military advantages and risks which could be expected, and the Soviet estimate of US intentions and capabilities in comparable fields. We believe that the USSR will produce and deploy those military space systems which it finds to be feasible and advantageous in comparison with other types of weapons and military equipment.

III. OUTLOOK FOR THE PROGRAM

Introduction

37. The USSR's Chief Designer of Spacecraft, in an interview published in *Izvestiya* on 1 January 1964, spoke about likely space missions for the following three to five years. Commenting on "near space" (i.e., short of the moon), he outlined Soviet objectives:

a. astrogeophysical satellites, with special emphasis on the study of radiation;

b. meteorological satellites;

c. synchronous satellites for radio and TV relay;

d. suborbital vehicles for transport of mail and later of passengers;

e. manned orbital space stations, to serve as bases for servicing systems of unmanned satellites for scientific research.

As for "far space," he stated that research in the immediate vicinity of the moon and on its surface could be accomplished only with the aid of small, automatic vehicles in this time period.

38. Clearly, the foregoing represents at most the unclassified portion of the Soviet space program. The strategic reconnaissance project, for example, is not mentioned. Aside from classified reconnaissance and other possible military support projects, however, the Soviet statement is consistent with what we know of the USSR's activities and capabilities, and it gives some guidance concerning Soviet expectations over the next several years.

39. An estimate of Soviet goals for the next 10 years, however, must be based on additional evidence. The pattern of Soviet technological accomplishments to date, as well as Soviet statements on the subject, lead us to believe that their present priority efforts involve an ambitious project for unmanned lunar and planetary explorations, and a project to establish manned, earth-orbiting stations with increasingly longer and more complex missions. In addition, Khrushchev, despite his open pessimism as to the near-term feasibility of a manned lunar landing, stated as recently as June 1964 that the USSR did in fact have such a project, and we believe that work to accomplish this mission is underway. Additional military space projects probably will also be undertaken.

40. We consider it unlikely that the Soviets will seek to establish a large space station and to achieve a manned lunar landing concurrently. We estimate that the first of these projects would cost on the order of $12-16 billion, including the cost of booster development. The cost of a manned lunar landing project, again including the cost of booster development, might be on the order of $15-20 billion through the first landing and recovery; for several years preceding this mission, peak expenditures would probably run about $3-4.5 billion per year. Because the two projects would involve a number of common developments, the combined cost of attempting both would be less than the sum of these estimated costs. But it would be considerably more than the cost of either single project.

Probable Timing[7]

41. An estimate of the dates by which major goals might be achieved is precarious at best, since our sources of space intelligence provide definite evidence of a new project only late in the development cycle, usually not until major components reach the flight test stage. In our estimates of timing, therefore, we consider official statements and other indications of Soviet priorities, the trends in the program to date, the current Soviet state-of-the-art, and the USSR's capability to undertake projects of more demanding sophistication. In arriving at likely dates for specific missions, we have assumed a high but not unreasonable level of success and a sharing of priorities among several categories of projects. In general, the likely date for any given mission would be a year or so later than what we consider to be the earliest practicable date. We note that delays and

[7] For a graphic summary of this subject, see Tables on pages 23-27.

failures have occurred and have sometimes plagued the Soviets for long periods. Such difficulties can recur at any time—especially upon the introduction of hardware based on new and more complex technology—and could delay achievement of a specific mission by a year or two.

Unmanned Exploration of Near Space

42. Soviet scientists have identified a wide range of scientific problems to be studied by means of satellites and space probes during the International Year of the Quiet Sun (IQSY), 1964 and 1965.[8] Soviet plans for the IQSY include rockets and satellites for observing solar electromagnetic radiation, corpuscular streams, cosmic rays and radiation belts, magnetic fields, and the upper atmosphere. Many of these objectives may be carried out by the small Kapustin Yar Cosmos satellites. Other IQSY objectives suggest that additional Elektron satellites will be launched from Tyuratam. In connection with the Soviet Cloud Year, which runs concurrently with the IQSY, the USSR is also likely to launch satellites to aid cloud research.

43. Under the US-USSR bilateral agreement on scientific cooperation in space, signed in 1962 and since amended, the Soviets have agreed to exchange meteorological data and cloud pictures from satellites beginning early in 1965. The original agreement called for the exchange of data to commence in the second half of 1964. Soviet hedging on this agreement and the absence to date of an operational Soviet meteorological satellite suggest that the Soviet project has encountered difficulties. Nevertheless, we believe that Soviet meteorological satellites will be operational within the next few months.

Lunar and Interplanetary Probes

44. Soviet statements and recent attempts to launch instrumented lunar and planetary probes reveal a continuing interest in deep space exploration. As part of the IQSY, the Soviets have also announced plans to monitor interplanetary magnetic fields both by probes and satellites.

45. We believe the Soviets will launch probes to Mars and to Venus when periods of opportunity next occur; for Venus, the fall of 1965, and for Mars, late 1966. Probes to Venus probably will investigate the planet's atmosphere and may attempt to penetrate it. Soviet probes to Mars are likely to attempt high-resolution photography, spectrographic analysis of the planet's atmosphere and surface, and investigation of magnetic fields and any radiation belts.

46. The Soviets almost certainly will launch additional unmanned lunar probes within the coming year. The precise times chosen for the launch of five such probes since early 1963 suggest one of two objectives: either to obtain photographs from a lunar-orbiting vehicle for lunar mapping or to obtain data on the

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[8] Solar activity—in the form of solar flares and sunspots—is cyclic in nature. During 1964 and 1965, activity will be at the bottom of the 11-year cycle. By the late 1960s, solar activity will rise to maximum levels, creating increased cosmic ray and other radiation hazards for man in space.

properties of the lunar surface by means of a soft landing. The precise conditions required to repeat these missions were passed up in December 1964 and January 1965, but will recur on a few days in February and March and again late in the year.

47. Throughout the decade, we expect the Soviets to continue to launch lunar and planetary probes. Despite the poor record to date, the Soviets will come to achieve some success. More sophisticated missions probably will be undertaken as new and more powerful launch systems become available.

Manned Space Flight

48. We see no indication that the Soviet space technologists are likely to depart from the orderly, evolutionary development which has characterized their manned space project thus far. The evident Soviet concern with the biomedical problems of prolonged flight probably will have considerable influence on manned flights scheduled for the near future. The Soviets will probably conduct short flights—five days or less—which concentrate on engineering advances and somewhat longer flights designed to explore further the effects of weightlessness and solar radiation and to evaluate potential countermeasures.

49. *Rendezvous and Docking.* Soviet statements for several years have indicated an intent to rendezvous and dock two or more vehicles in earth orbit. Docking experiments involving manned vehicles probably will await further flight testing of the new Voskhod space craft and of necessary propulsion and control systems. According to reliable Soviet sources, the Voskhod possesses no capability for out-of-orbit maneuvering. The only Soviet vehicle which has demonstrated a maneuver capability to date has been the unmanned Polyot. In November 1963 and April 1964, the Soviets placed two of these 6,000-pound vehicles in orbit, each as the sole payload aboard an SS-6 booster. These vehicles incorporated restartable engines, and Polyot II successfully accomplished a modest, one-degree change of its orbital plane some hours after launch.

50. If the Voskhod is suitable for docking the first manned rendezvous and docking operation could occur in 1965. We do not know, however, whether this is the case, and wholly new manned spacecraft may be required for rendezvous and docking. If so, the mission woud be unlikely before 1966. Unmanned flight tests of a new spacecraft would require about one year, and we have no evidence suggesting that any have begun.

51. *Manned Space Station.* The Soviets have expressed much interest in space stations during the past few years and are doing considerable research in long-duration life support systems. We believe that one of their goals is to have a station in operation within the next several years. The Soviet press has carried numerous articles describing the advantages of earth-orbiting space stations for future progress in space exploration and linking the dual Vostok, Polyot, and Voskhod missions with this goal. Docking such a manned spacecraft with a station module having a capability for extended life support is a practical and economical approach for the USSR.

52. An early space station consisting of two vehicles would probably weigh on the order of 25,000 pounds, carry a crew of two or three persons, and have an orbital lifetime of a few weeks. If the requisite rendezvous and docking operation is demonstrated successfully early in 1965, such a small space station utilizing the Vostok/Voskhod technology and currently available boosters could be assembled in orbit in 1966. The mission could be accomplished with a wholly new spacecraft design about one year after successful rendezvous and docking. We do not believe multiple rendezvous and docking operations for purposes of resupply would be attempted with such an early station.

53. Establishment of a larger manned space station could be accomplished by multiple rendezvous operations using existing boosters. However, we think it more likely that the Soviets would employ a larger booster, which we estimate could become available for manned operations as early as 1966. All things considered, we think it probable that a year or two after the initial manned flight with this booster (the SS-Large) the Soviets will use it and appropriate space hardware to create a large manned space station in earth orbit. Such a station might weigh as much as 100,000 pounds, assuming a single rendezvous and assembly in orbit. A station of this size with a rotational crew of five to ten persons could be maintained for extended periods with repeated rendezvous and docking operations for purposes of re-supply.

54. *Manned Circumlunar Flight.* There are no specific indications of Soviet intent to carry out a manned circumlunar project, but its relative simplicity compared to the manned landing mission, as well as its propaganda value as a major "first," lead us to consider it (along with earth-orbiting space stations) as a prime Soviet goal. If the USSR is not seeking to beat the US in a manned lunar landing, this project probably will be timed to precede the Apollo mission in an attempt to detract from the US achievement and to identify the USSR with manned exploration on the moon.

55. Chief prerequisites for the manned circumlunar mission are very precise guidance systems and a technique for re-entry into the earth's atmosphere at parabolic velocity, i.e., on the order of 36,000 ft/sec. Recovery problems would be greatly simplified if the Soviets were to develop systems for recovery of the spacecraft at sea, but this is not absolutely essential. There are two basic techniques by which the Soviets could carry out the manned circumlunar mission. The first would call for rendezvous and docking in earth orbit before embarking on the lunar trajectory. The second would involve launching a sufficiently large vehicle so that rendezvous and docking would not be required. Total flight time in either case would be about one week.

56. The manned circumlunar mission could be accomplished as early as 1967, but a number of substantial technological problems, indicating those we have cited above, would have to be solved in the next two years. By resorting to rendezvous and docking, the Soviets theoretically could accomplish the manned circumlunar mission with the SS-6 booster. For example, with as few as three launches and two rendezvous and dockings, they might assemble in earth orbit

a vehicle adequate for the mission. We believe the Soviets will have acquired sufficient experience to permit them to solve the rendezvous and docking aspect of the problem in time for an attempt in 1967-1968, but we consider this approach unlikely.

57. We estimate that the SS-Large booster, which will probably be available in the same period, will be adequate to accomplish this mission without docking. The Soviets are more likely to select this alternative, primarily because it avoids the risks inherent in the multiple rendezvous and docking operations. With the SS-Large booster, the Soviets could accomplish the manned circumlunar mission as early as 1967, but for a number of reasons we consider it unlikely to occur before 1968 or later.

58. It is possible that the Soviets will seek to reduce the competition for funds and technological resources by phasing their manned projects over a period of several years. Stretch out could also occur for technical reasons, especially if the project is planned to incorporate advanced hardware required in a subsequent manned lunar landing project. Finally, deliberate delay could occur if the Soviets perceived lags in the US Apollo project and wished to time their circumlunar attempt to precede it.

59. *Manned Lunar Landing.* It seems certain that the Soviets intend to land a man on the moon sometime in the future, but there are at present no specific indications of any such project aimed at 1968-1969, i.e., intended to be competitive with the US Apollo project. Some R&D effort toward a manned lunar landing is almost certainly in progress and we note that considerable preparatory work could have been going on without as yet providing firm indications of its nature. Although many of the critical prerequisites for a manned lunar landing have not been observed in Soviet space operations, we would not necessarily see them this early.

60. We have estimated that a very large booster (about five million pounds thrust) could become available for manned space flight in 1968 (see paragraph 26). We doubt that the thrust of this booster would be sufficient for a manned lunar landing mission without earth-orbit rendezvous or the US technique of lunar-orbit rendezvous. If the earth-orbit rendezvous technique were used, some one to three rendezvous probably would be required, depending on the actual thrust of the booster and Soviet success in reducing the weights of structures and components below present levels. Thus a Soviet attempt at a manned lunar landing in a period competitive with the present US Apollo schedule cannot be ruled out.

61. To compete in this fashion, however, the Soviets would have had to make an initial decision to this effect several years ago and to have sustained a high priority for the project in the ensuing period. This would have required them to undertake a burdensome and rapid extension of their space technology and to reconcile the heavy demands of this project with those of other important space ventures and military programs, all with no clear assurance that they would triumph. The appearance and non-appearance of various technical de-

velopments, economic considerations, leadership statements, and continued commitments to other major space missions all lead us to the conclusion that a manned lunar landing ahead of the present Apollo schedule probably is not a Soviet objective.

62. With a very high degree of success in all phases of the project, the first Soviet attempt at a manned lunar landing might occur as early as 1969. In view of the magnitude of the technological problems and the level of resources which the Soviets are likely to commit to this project, we believe a more probable date for such an attempt to be a few years later.

63. If the Soviets choose to direct their space station efforts toward even more extensive manned exploration of space, they may develop very large quasi-permanent stations for the assembly and launching of spacecraft from near-earth orbit. Indeed, a number of Soviet statements suggest that they view this as an attractive approach to subsequent manned flight into deep space. A suitably large space station probably could be created in the early 1970s by making use of the same very large booster we have discussed above. If so, a manned lunar landing mission launched from a space station could occur in the middle 1970s.

Possible Soviet Military Uses of Space

64. Throughout the period of the estimate, new military space applications will be introduced as Soviet technology advances and as requirements for such systems are developed. We believe that they will experiment with a variety of space systems which could be used for military purposes, that they will employ those systems which can be economically and militarily justified, and that some military role for man in space may emerge by the end of the period, particularly as the ability to operate manned space stations grows.

65. *Military Support Systems.* The launching of recoverable photo-reconnaissance satellites from Tyuratam probably will continue, and this project may come to involve missions of longer duration as well as various orbital parameters (e.g., altitude and inclination). There is also some evidence that a photo-video reconnaissance system was under investigation. In 1962-1963, several Tyuratam Cosmos satellites were orbited with a photo-video system.

This project has been inactive for several years, but Soviet military authors have written that such a system is needed and it may be resumed.

66. The high priority evident in the recoverable photo-reconnaissance satellite project will probably be applied to other selected military support systems which the Soviet leaders decide are essential. Considering the capabilities of current boosters and other available indicators, we think that the systems most likely to become operational in the next few years will be for these purposes: communications and TV relay, weather forecasting, geodesy, and navigation. Multi-purpose vehicles incorporating combinations of these missions are possible, and it may be that both Soviet military and nonmilitary interests in such satellites

can be accomplished with a single project. A maneuverable satellite for electromagnetic and photo-reconnaissance may also be developed (using Polyot technology) to meet military needs in the next few years. Penetration aid satellites with electronic payloads probably could not be operational until late in the decade because of power requirements, although feasibility demonstrations using existing hardware could occur at any time.

67. *Offensive Weapons Systems.*[9] Although the USSR almost certainly is investigating the feasibility of space systems for use as offensive weapons, we have no evidence that the Soviet leadership seriously contemplates a program to establish an orbital bombardment capability. For the foreseeable future, we think that orbital weapons will not compare favorably with ICBMs in terms of effectiveness, reaction time, targeting flexibility, vulnerability, average life, and positive control. In view of these considerations, the much greater cost of orbital weapon systems, and Soviet endorsement of the UN resolution against nuclear weapons in space, we believe that the Soviets are unlikely to develop and deploy an orbital weapon system within the next five to ten years.

68. Even without any special efforts, however, Soviet technology applicable to this field will improve in the normal course of continued development of nuclear technology, ICBMs, and space projects. We recognize that the Soviets might reach different conclusions as to cost and effectiveness, and that altered political considerations in some future phase of East-West relations might lead them to a different decision. Even in these circumstances, we believe that they would regard space weapons primarily as means of supplementing existing forces, of introducing additional complications into US defense planning, and of supporting Soviet claims to strategic parity or even superiority.

69. *Defensive Weapons Systems.* Undoubtedly, the Soviets have given consideration to space systems for use against satellites.[10] As their general space technology increases, they may elect to start active R&D on such a project. Booster and hardware costs would be high, and the advantages over a ground-based system would be questionable. Should they elect to do so, they probably could develop by the late 1960s a launch and rendezvous technique against a nonmaneuvering satellite for unmanned inspection. The use of nuclear warheads for destruction would be subject to the same restrictions cited in the case of offensive space systems. We do not expect, however, that during the period of the estimate any Soviet manned or unmanned vehicles already in orbit will have the capability to maneuver and rendezvous with a US vehicle for purposes of examination and neutralization because of the great costs and technical complexities inherent in such a project.

[9] For a fuller discussion of possible Soviet development and deployment of offensive space weapons, see NIE 11-9-63, "Soviet Capabilities and Intentions to Orbit Nuclear Weapons" (Secret, 15 July 1963) and pertinent sections of NIE 11-8-64, "Soviet Capabilities for Strategic Attack" (Top Secret Limited Distribution, 8 October 1964).

[10] For Soviet capabilities to counter enemy satellites from ground-based facilities, see NIE 11-3-64, "Soviet Air and Missile Defense Capabilities Through Mid-1970" (Top Secret, 16 December 1964).

ESTIMATED TIMING OF THE SOVIET MANNED SPACE FLIGHT PROJECTS

TABLE 1

ESTIMATED TIMING

PROJECT

I. Rendezvous and Docking
   - A. Using existing hardware (SS-6, Lunik, Venik, Polyot, Vostok, Voskhod)
   - B. Using new spacecraft (if required) and existing propulsion units

II. Small Space Station
(Two or three men for several weeks)
   - A. Using technology and experience from I-A
   - B. Using technology and experience from I-B

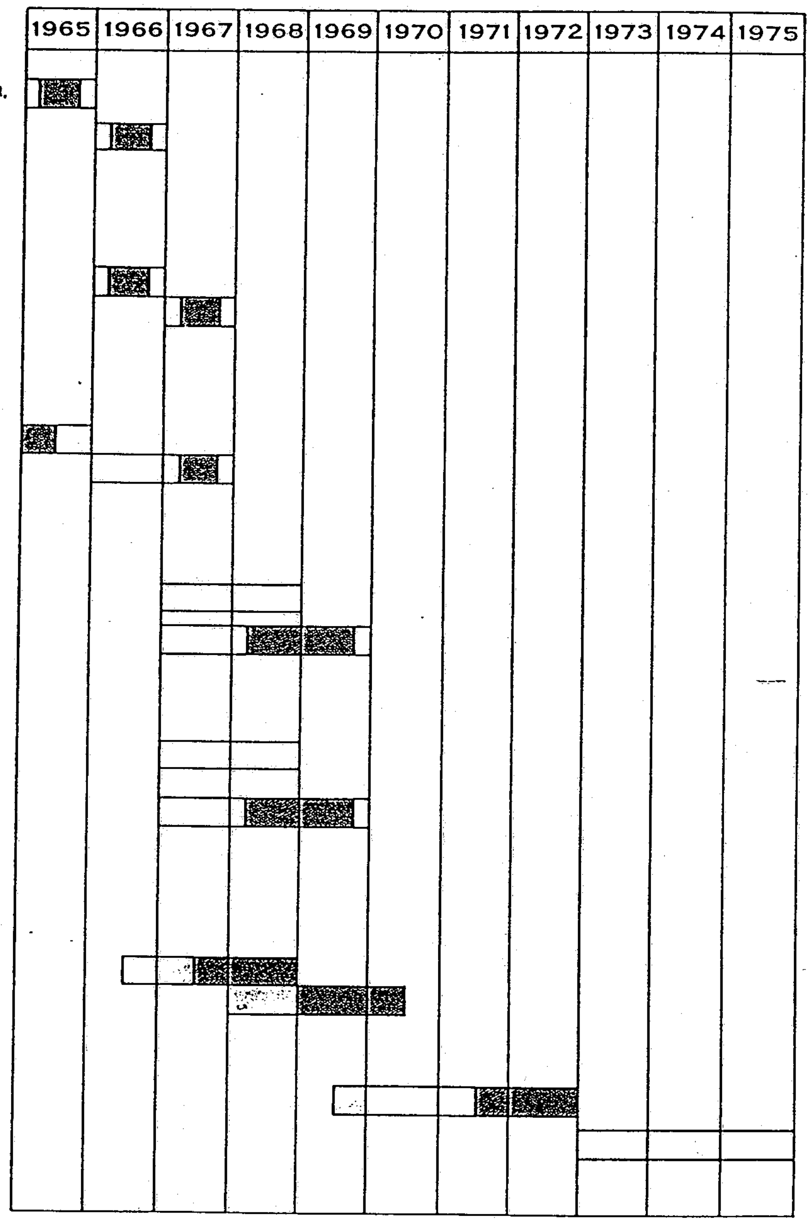
III. SS-Large Booster
(Some 2 million pounds of thrust)
   - A. Unmanned Flight Tests
   - B. Manned Flight Tests

IV. Large Space Station
(Rotational crew of 5-10 men for some months)
   - A. Using technology and experience from I-A/B (Less likely technique)
   - B. Using technology and hardware from III-B (More likely technique)

V. Circumlunar Flight
   - A. Using technology and hardware from I-B; three launches and two docking operations; ejection from earth orbit (Feasible but unlikely)
   - B. Using technology and hardware from III-B; no rendezvous and docking; ejection from earth orbit (Likely technique)

VI. Very Large Booster
(On the order of 5 million pounds of thrust)
   - A. Unmanned Flight Tests
   - B. Manned Flight Test

VII. Lunar Landing and Return
   - A. Using technology and hardware from VI-B; 1-3 rendezvous and docking; ejection from earth orbit
   - B. Launched from suitably large space station; requires technology from VI-B



NOTE: The chart reflects our estimates of major events in Soviet manned space flight over the next ten years. Our judgments as to the timing of these events and the techniques likely to be employed are indicated by shading. The darker shading indicates what we consider to be probable developments. The lighter shading, which in each case begins with the earliest possible date of accomplishment, indicates those developments considered to be possible, but less likely.

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TABLE 2

ESTIMATED TIMING OF SOVIET UNMANNED SPACE PROJECTS

MISSION	DATE
I. *Military Support Projects* [a]	
Reconnaissance—Photo (TT Cosmos)	
1. Non-Maneuverable	Since 1962
2. Maneuverable (based on Polyot)	1965-1966
Reconnaissance—COMINT, ELINT	
Infra-red [b]	1965-1968
Meteorology [c]	1965
Communications and TV Relay	1965-1968
Navigation	1965-1968
Geodesy	1965-1968
Quick-Response Surveillance (Photo-video)	[d]
Penetration Aid—Electronic	
Payload Only	
1. Demonstration	1965
2. Operational	Late in decade
II. *Lunar Probes*	
Photo reconnaissance (based on Cosmos 4, 7, 9, and 15)	1965
Soft-Landing of Instruments	1965-1967
III. Interplanetary Probes [e]	
Mars	December 1966-January 1967 February-March 1969
Venus	October-November 1965 May-June 1967 December 1968-January 1969
IV. *Astrogeophysical Missions*	
Near-Space Satellites	IQSY (1964-1965)
Solar Probes	IQSY (1964-1965)

[a] Considering current Soviet orbital-payload capabilities, multi-purpose vehicles incorporating combinations of these missions are possible.

[b] We cannot exclude the possibility that such electromagnetic reconnaissance is already being accomplished aboard the TT Cosmos photo reconnaissance satellites.

[c] The estimated date for a meteorological satellite is based on the US-USSR agreement to begin exchange of data in 1965.

[d] [ ] The project apparently is now inactive.

[e] Since October 1960, the USSR has launched at least 1 and as many as 3 probes during each opportune launch period. ZOND 2, a Mars probe launched on 30 November 1964, will reach the vicinity of the planet in August.

ANNEX A

CHRONOLOGICAL SUMMARIES OF SOVIET SPACE LAUNCHINGS, 1957-1964

TABLE 1: Soviet Launchings of Non-Recoverable Earth Satellites

TABLE 2: Soviet Launchings of Lunar and Planetary Probes

TABLE 3: Soviet Manned Spaceflight Projects

TABLE 4: Soviet Launchings of Photo-reconnaissance Satellites

Table 1

SOVIET LAUNCHINGS OF NON-RECOVERABLE EARTH SATELLITIES[a]

Designation	Launch Date	Launch Point	Remarks
Sputnik 1	4 Oct 57	TT	World's first artificial satellite.
Sputnik 2	4 Nov 57	TT	Astrogeophysical payload plus dog; experimentation on biotelemetry, testing life support system, animal tolerance to flight acceleration, etc.
Sputnik 3	15 May 58	TT	Biological astrogeophysical payload for I.G.Y.
Cosmos—[b]	27 Oct 61	KY	Launch failure.
Cosmos—[b]	21 Dec 61	KY	Launch failure.
Cosmos 1	16 Mar 62	KY	First successful launch.
Cosmos 2	6 Apr 62	KY	Ionospheric beacon; early failure of system.
Cosmos 3	24 Apr 62	KY	Measurement of soft electrons; partial success.
Cosmos 5	28 May 62	KY	Repeat of Cosmos 3 with higher apogee.
Cosmos 6	30 Jun 62	KY	Cosmic ray measurements; generally successful.
Cosmos 8	18 Aug 62	KY	Unknown mission; apparent system failure.
Cosmos 11	20 Oct 62	KY	Measurement of artificial radiation belt, system failure.
Cosmos 14	13 Apr 63	KY	Possibly to measure micrometeorites; system failure.
Cosmos 17	22 May 63	KY	Measurement of artificial radiation belt generally successful, (Repeat of Cosmos 11).
Cosmos 19	6 Aug 63	KY	Cosmic ray measurements; generally successful. (Repeat of Cosmos 6).
Cosmos—[b]	24 Oct 63	KY	Launch failure.
Polyot 1	1 Nov 63	TT	Stage intended to maneuver.
Cosmos 21	11 Nov 63	TT	Mission undetermined.
Cosmos 23	13 Dec 63	KY	Micrometeorite measurement; possibly successful. (Repeat of Cosmos 14).
Electron 1 & 2	30 Jan 64	TT	Multi-purpose astrogeophysical payloads, with emphasis on artificial and solar radiation; Apogees of some 3,800 and 36,000 n.m.
Cosmos—[b]	19 Feb 64	TT	Mission undetermined; failed to achieve orbit.
Cosmos 25	27 Feb 64	KY	Cosmic ray measurements; generally successful. (Repeat of Cosmos 6 and 19).
Cosmos 26	18 Mar 64	KY	Geomagnetic field data; partial success.
Polyot 2	12 Apr 64	TT	Accomplished small maneuvers which changed orbital inclination by about one degree.
Cosmos—[b]	4 Jun 64	TT	Mission undetermined; failed to achieve orbit.
Cosmos 31	6 Jun 64	KY	Possible micrometeorite measurement; apparent system failure.

See footnotes at end of table.

Table 1 (*Continued*)

Designation	Launch Date	Launch Point	Remarks
Electron 3 & 4	11 Jul 64	TT	Repeat of Electrons 1 and 2.
Cosmos 36	30 Jul 64	KY	Cosmic ray measurements; generally successful. (Repeat of Cosmos 6, 19, and 25).
Cosmos 38, 39, 40	18 Aug 64	TT	First Soviet triple payload; spaced in single orbit. [ ] (See Discussion para. 9).
Cosmos 41	22 Aug 64	TT	Mission undetermined; ejected from parking orbit into a highly elliptical orbit.
Cosmos 42 & 43	22 Aug 64	KY	First double payload launched from Kapustin Yar; spaced in single orbit. (See Discussion para. 9).
Cosmos 44	28 Aug 64	TT	Placed into circular orbit; solar panel power supply; spin-stabilized. Possible meteorological satellite.
Cosmos 49	24 Oct 64	KY	Geomagnetic field data; generally successful. (Repeat of Cosmos 26).
Cosmos 51	9 Dec 64	KY	Micrometeorite measurement; generally successful. (Repeat of Cosmos 14 and 23).

[a] In addition to the launchings noted on this table, we believe that there was a launch failure in this series in early 1958.

[b] Undesignated; not announced by the Soviets.

Table 2

SOVIET LAUNCHINGS OF LUNAR AND PLANETARY PROBES

Note: All launchings have been from Tyuratum

LAUNCH DATE	TARGET	PAYLOADS (LBS.)	REMARKS
		—Use of Direct-Ascent Technique—[a]	
4 Dec 58	Moon	1,000 [b]	Launch failure.
2 Jan 59	Moon	1,000	*Lunik I.* Missed moon and went into orbit around sun.
18 Jun 59	Moon	1,000 [b]	Launch failure.
12 Sep 59	Moon	1,000	*Lunik II.* Impacted moon.
4 Oct 59	Moon	1,000	*Lunik III.* Circumlunar. Successfully photographed hidden side of moon.
15 Apr 60	Moon	1,000	Insufficient velocity. Nearest approach to moon was 100,000 miles.
		—Beginning of Parking-Orbit Technique—[c]	
10 Oct 60	Mars	[d]	Premature cutoff of Venik stage engine; parking orbit not achieved.
14 Oct 60	Mars	[d]	Premature cutoff of Venik stage engine; parking orbit not achieved.
4 Feb 61	Venus	[d]	USSR announced an ESV
12 Feb 61	Venus	1,400	USSR announced success; communication failure during the interplanetary-coast phase.
25 Aug 62	Venus	1,900 [b]	Unsuccessful; tumbling 4th stage producing no useful thrust.
1 Sep 62	Venus	1,900 [b]	Unsuccessful; tumbling 4th stage producing no useful thrust.
12 Sep 62	Venus	1,900 [b]	Unsuccessful; possible partial attitude stabilization failure of 4th stage producing no useful thrust.
24 Oct 62	Mars	1,900 [b]	Unsuccessful; malfunctions subsequent to 4th stage ignition.
1 Nov 62	Mars	1,900	Soviets announce Mars I communication failure with the probe in March 1963.
4 Nov 62	Mars	1,900 [b]	Unsuccessful;
4 Jan 63	Moon	3,100 [b]	Achieved parking orbit; 4th stage failed.
3 Feb 63	Moon	3,100 [b]	Venik stage failed; parking orbit not achieved.
2 Apr 63	Moon	3,100	*Lunik IV.* Passed within 4,000–8,000 miles of moon after mid-course correction.
21 Mar 64	Moon	3,100 [b]	Venik stage failed; parking orbit not achieved.
27 Mar 64	Venus	1,900 [b]	Announced as Cosmos 27 after 4th stage failed.
2 Apr 64	Venus	1,900	*Zond I.* Initial trajectory would have caused probe to pass within 24,000 miles of Venus. Soviets announced two mid-course corrections (3 April 64 and 15 May 64); miss-distance increased and contact apparently lost before passing Venus.

See footnotes at end of table.

Table 2 (*Continued*)

LAUNCH DATE	TARGET	PAYLOADS (LBS.)	REMARKS
	—Beginning of Parking-Orbit Technique (*Continued*)—[c]		
20 Apr 64	Moon	3,100 [b]	Venik stage failed; parking orbit not achieved.
30 Nov 64	Mars	1,900	*Zond II* power encountered difficulties in first day of flight. Will arrive in the vicinity of Mars during the early part of August 1965; present indications are that it will miss the planet by about 750,000 miles.

[a] All direct-ascent launches used the SS–6 booster and the Lunik upper stage. In addition to the launch attempts noted in this series, we believe that there were three launch failures, two in the fall of 1958 and one in early 1960.

[b] Payload estimated. Other payloads were announced by the Soviet and substantiated by other evidence.

[c] All these launches have used the SS–6 booster and Venik upper stage to place into earth orbit a 15,000-lb package consisting of the payload and its propulsion stage. This stage (known as the 4th or ejection stage) is used to eject the payload from earth orbit and to place it on a trajectory towards its target.

[d] Payloads unknown. Believed to be the same as the 1,400 lbs. announced by the Soviets for the Venus shot of 12 February 1961.

Table 3

SOVIET MANNED SPACEFLIGHT PROJECTS [a]

Note: Although there have been a number of failures in the Soviet program, we have no evidence supporting the failure of any Soviet manned spacecraft.

Designation	Launch Date	Recovery Date	Recovery Orbit	Remarks
Korabl' 1	15 May 60	18 May 60 (attempted)	48	Payload: 9,988 lbs. First known Soviet use of the expression "Cosmic Space Ship." Retro-rocket failure; decayed Sep 62.
(Unannounced)	28 Jul 60	..	..	Failure of SS–6 booster.
Korabl' 2 (Sputnik 5)	19 Aug 60	20 Aug 60	16	Payload: 10,120 lbs. Contained two dogs and other biological specimens. First successful recovery of Vostok-like spacecraft. Comprehensive biotelemetry experimentation; in-flight television monitoring of dog; effects of acceleration, weightlessness, radiation on animals, plants, organisms including immunological, microbiological and cytological studies.
Korabl' 3 (Sputnik 6)	1 Dec 60	2 Dec 60 (attempted)	17	Payload: 10,038 lbs. Similiar to Korabl' 2. Burned up on re-entry. Two dogs.
(Unannounced)	22 Dec 60	..	..	Failure of SS–6 booster. Two dogs.
Korabl' 4 (Sputnik 9)	9 Mar 61	9 May 61	1	Payload: 10,340 lbs. Contained one dog. Continuation of man-rating of Vostok.
Korabl' 5 (Sputnik 10)	25 Mar 61	25 Mar 61	1	Payload: 10,309 lbs. Contained one dog. Continuation of man-rating of Vostok.
Vostok 1	12 Apr 61	12 Apr 61	1	Payload: 10,395 lbs. Gagarin; first manned orbital space flight.
Vostok 2	6 Aug 61	7 Aug 61	17	Payload: 10,408 lbs. Titov; first one-day mission; demonstrated human ability to eat, sleep, and work under conditions of space flight; vestibular disturbances suffered by cosmonaut.
Vostok 3	11 Aug 62	15 Aug 62	64	Payload: 10,412 lbs. Nikolayev; along with Vostok 4, the first test of two subjects under generally similar conditions of space flight.
Vostok 4	12 Aug 62	15 Aug 62	48	Payload: 10,425 lbs. Popovich.
Vostok 5	14 Jun 63	19 Jun 63	81	Payload: 10,340 lbs. Bykovskiy; further evaluation of human reactions to extended space flight, especially cardiovasular deconditioning.
Vostok 6	16 Jun 63	19 Jun 63	48	Payload: 10,340 lbs. Tereshkova; along with Vostok 5 first test of male and female subjects under generally similar conditions; first flight of a non-pilot.
Cosmos 47 [b]	6 Oct 64	7 Oct 64	16	Voskhod with dummies. Computed payload same as Voskhod.
Voskhod I [b]	12 Oct 64	13 Oct 64	16	Payload: 11,730 lbs. Col. V. M. Komarov, Dr. B.B. Yegerov, and Eng. K. Feoktistov; first flight without spacesuits; first flight with direct in-flight medical observations, including sampling of body fluids.

[a] All launchings have employed the SS–6 booster. Vostok-related flights (15 May 1960–16 June 1963) employed the Lunik upper stage. The Polyots were launched as the sole payload aboard SS–6's. Voskhod-related flights, beginning with Cosmos 22 on 16 Nov 1963, have employed the Venik upper stage. Payload weights are those announced by Soviets, and substantiated by other evidence.

[b] Six days prior to the launch of Voskhod, Cosmos 47 provided final flight qualification of the new spacecraft. This constituted the only full flight test of the Voskhod carrying all of its associated subsystems. Four other Cosmos operations (22, 30, 34, and 45), in addition to performing their primary reconnaissance missions, served to man-rate the Venik propulsion stage and possibly provided testing of Venik/Voskhod compatability and of Voskhod structural integrity.

Table 4

SOVIET LAUNCHINGS OF PHOTO-RECONNAISSANCE SATELLITES [a]

Designation	Launch Date	Operating Mode [b]	Days in Orbit	Orbital Parameters [c] Perigee (nm)	Apogee (nm)	Inclination
(Failure)	11 Dec 61	..	(Did not achieve orbit)			
Cosmos 4	26 Apr 62	A [d]	3 days	161	178	65°
Cosmos 7	28 Jul 62	A [d]	4 days	113	199	65°
Cosmos 9	27 Sep 62	A [d]	4 days	163	191	65°
Cosmos 10	17 Oct 62	A	4 days	113	205	65°
Cosmos 12	22 Dec 62	A	8 days	114	243	65°
Cosmos 13	21 Mar 63	A	8 days	111	182	65°
Cosmos 15	22 Apr 63	A [d]	5 days	93	200	65°
Cosmos 16	28 Apr 63	A	10 days	112	218	65°
Cosmos 18	24 May 63	A	9 days	113	173	65°
Cosmos 20	18 Oct 63	A	8 days	111	168	65°
Cosmos 22	16 Nov 63	B	6 days	111	211	65°
(Failure)	28 Nov 63		(Did not achieve orbit)			
Cosmos 24	19 Dec 63	A	9 days	114	220	65°
Cosmos 28	4 Apr 64	A	8 days	113	213	65°
Cosmos 29	25 Apr 64	A	8 days	111	159	65°
Cosmos 30	18 May 64	B	8 days	112	207	65°
Cosmos 32	10 Jun 64	A	8 days	113	180	51°
Cosmos 33	23 Jun 64	A	8 days	113	158	65°
Cosmos 34	1 Jul 64	B	8 days	111	194	65°
Cosmos 35	15 Jul 64	A	8 days	117	145	51°
Cosmos 37	14 Aug 64	A	8 days	111	161	65°
Cosmos 45	13 Sep 64	B	5 days	111	176	65°
Cosmos 46	24 Sep 64	A	8 days	115	146	51°
Cosmos 48	14 Oct 64	A	6 days	109	159	65°
Cosmos 50	28 Oct 64	A	Deorbit attempt on eighth day failed	106	130	51°
Cosmos 52	11 Jan 65	A	8 days	106	165	65°

[a] All launchings have been from Tyuratam and all successful recoveries have been made on land in the USSR. It is clear from the pattern of launch times that the Soviets desire the perigees of these satellites to occur over North America during prime daylight hours. This points to photographic missions, but we cannot exclude the possibility that other electromagnetic data such as Comint, Elint, and infra-red, are also being collected.

[b] The satellites which have operated in what we designate as Mode A weigh about 10,000 lbs., and appear to be performing a general search and surveillance mission. Mode B satellites weigh about 12,000 lbs., and appear to be performing a higher-resolution mission. (See discussion para. 18.)

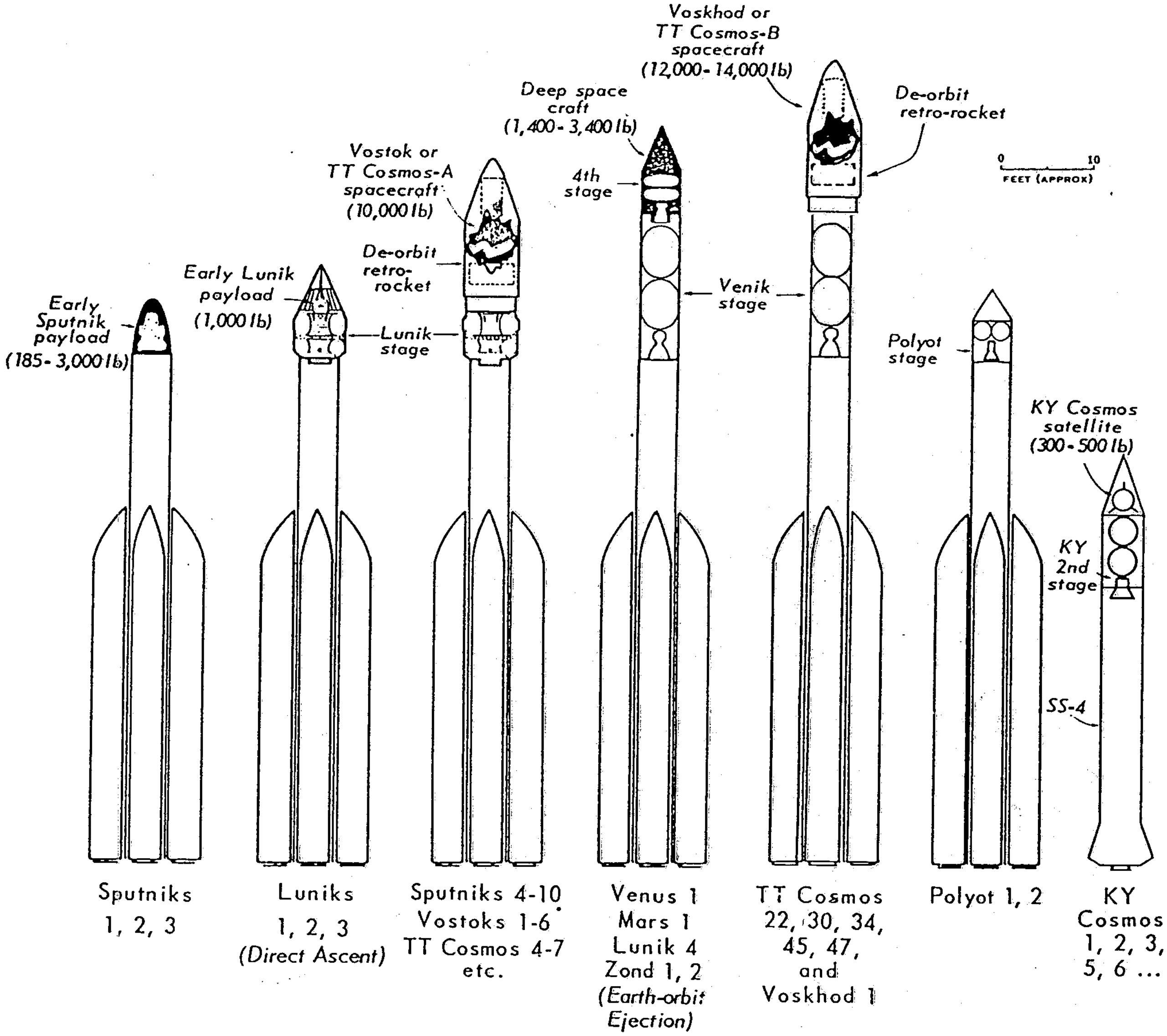
[c] These orbital parameters have been taken from Soviet announcements.

ANNEX B

PRINCIPAL TYPES OF VEHICLES AND TECHNIQUES EMPLOYED IN SOVIET SPACE PROJECTS, 1957-1964

Annex B
Figure 1

VEHICLE STAGES	GROSS WEIGHT (lbs)	THRUST (lbs)	IN USE 1957	1958	1959	1960	1961	1962	1963	1964
SS-6 Booster/Sustainer	500,000	900,000								
Lunik Stage	17,000	11,000								
Venik Stage	51,000	65,000								
4th Stage	13,000	15,700								
KY Booster (SS-4)	88,000	130,000								
KY Second Stage	16,000	19,000								
Polyot Stage	6,400	?								



FAMILY OF SOVIET SPACE VEHICLES USED, 1957 - 1964

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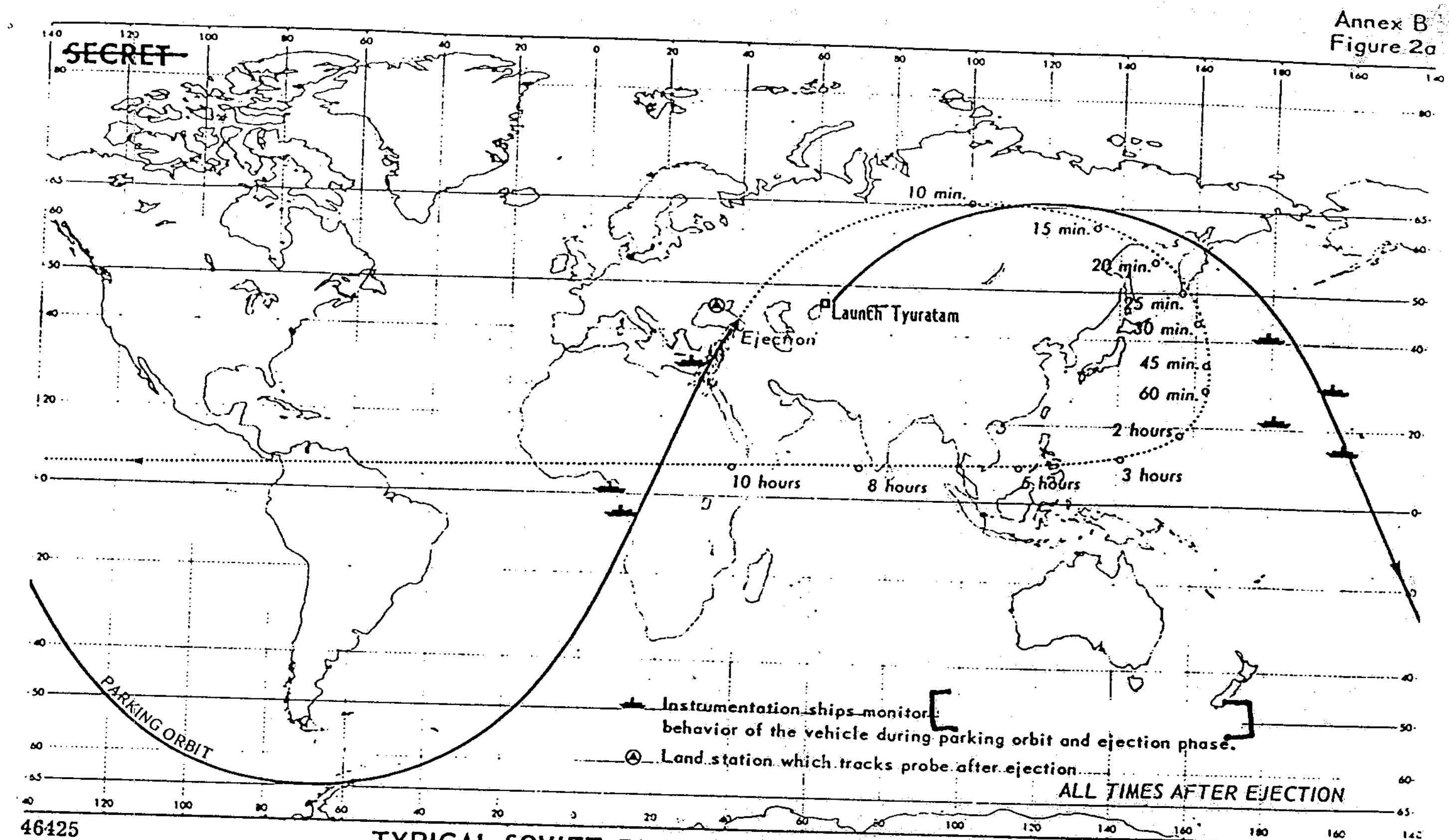
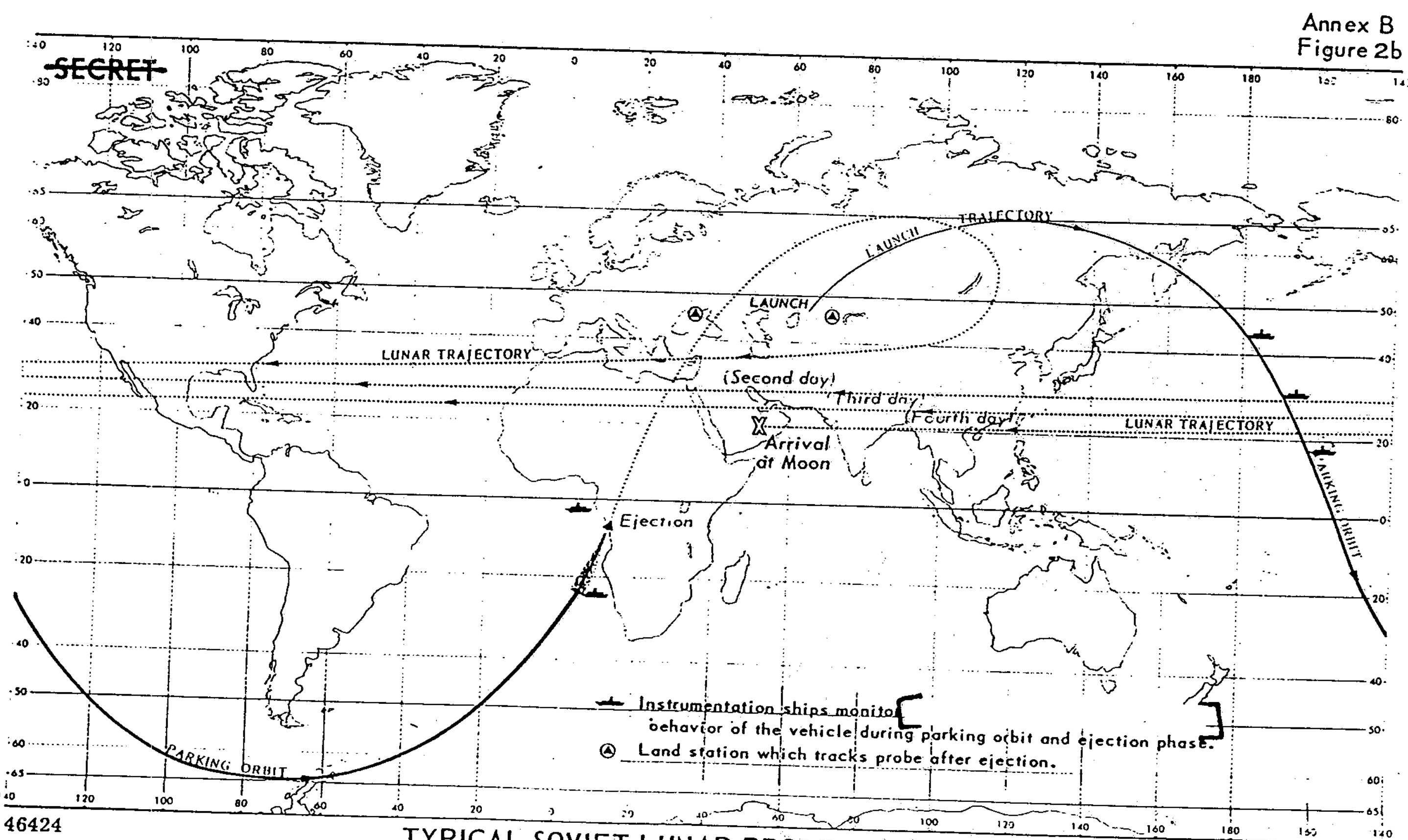


TYPICAL SOVIET PLANETARY PROBE OPERATION

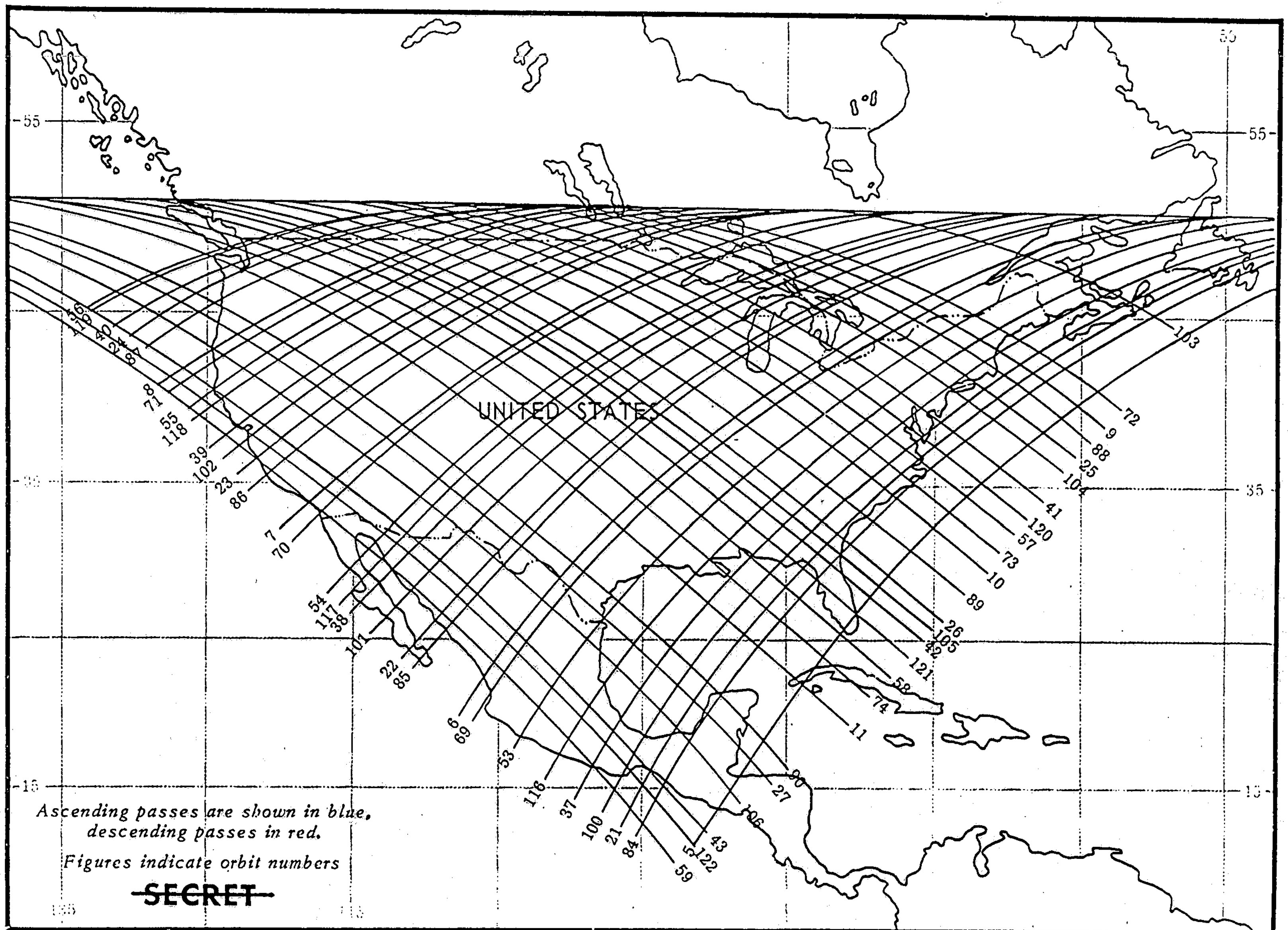


TYPICAL SOVIET LUNAR PROBE OPERATION

Annex B
Figure 3

SECRET

SECRET



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EARTH TRACES OF COVERAGE OF THE U S
BY A SOVIET PHOTORECONNAISSANCE SATELLITE LAUNCHED ON A 51 DEGREE INCLINATION
(Shown for a typical 8-day mission)

Annex B
Figure 4

ANNEX C

ANNEX C

Soviet Scientific and Technical Capabilities for Space Flight

1. We believe that Soviet capabilities in the basic and applied sciences will be adequate throughout the period of this estimate to support an ambitious space program. This judgment is based on Soviet space achievements to date, and on a comprehensive review in the major fields of science directly contributing to the space program. In a few fields, the Soviets are outstanding, notably in astronomy (particularly radio astronomy and celestial mechanics), astrogeophysics, space medicine, and theoretical mathematics. Moreover, they are closely following US developments in these and other areas. Difficulties in the Soviet space program are more likely to arise from technological than from scientific limitations. Very complex and demanding requirements must be met in such missions as orbiting a large space station or conducting a manned lunar flight.

2. Responsibility for the direction of the Soviet space program apparently rests with an unknown authority directly under the Council of Ministers. The program itself has been carried out, for the most part within the framework of existing institutions. The Academy of Sciences has been responsible for the scientific experimentation carried out by most unmanned space shots, and coordination has been through the Commission on the Exploration and Utilization of Cosmic Space. Basic biomedical research in support of the space program is the responsibility of the Academy of Medical Sciences. The Soviet air forces have played a major role in physiological research, in first-generation manned spacecraft design, and in the selection and training of cosmonauts. Subsystem, space suit, and capsule development is largely the responsibility of the State Committee for Aviation Technology. The test ranges are under the control of the Strategic Rocket Forces, which have provided launching services. We think it likely that the Tyuratam Cosmos military support program is sponsored by the Ministry of Defense, but there is no evidence as to the operational control of such systems.

3. We have been unable to identify many of the individuals responsible for research and development. Technical analysis indicates that two design teams are responsible for the boosters and upper stages in all the strategic missile and space projects which the USSR has undertaken. Similarly, the strong family resemblance evident in the Soviet photographs of scientific satellites and equipment used in lunar and planetary probes of the last five years indicates that a single team of scientists and engineers has been responsible for this project. This and other evidence indicates that research and development for strategic missiles and for space has been closely integrated in the USSR.

New Propulsion Systems

4. We have estimated that the Soviets are developing two new large boosters with thrusts on the order of two and five million pounds, respectively; the first of these could be available for manned operations in 1966, and the other in 1968-1969. The development of improved upper stages to capitalize on the lift-off capabilities of these large new boosters is likely in the same time frame. Although there is no evidence that the Soviets have undertaken the development of high-energy upper stages, Soviet literature has reflected an interest in such propellants as liquid hydrogen and fluorine. We believe that the Soviets could begin test launches of an oxygen-hydrogen system at any time, and of a fluorine-hydrogen system in the 1965-1966 period. US experience with the former combination, and Soviet conservatism to date, suggest that an extensive flight test program requiring a year or more would be undertaken before such stages would be acceptable in a manned launch combination.

5. The Soviets are actively engaged in the investigation of advanced electric propulsion systems. They claim to have tested such a device aboard Zond-II. In the near term, the Soviets could have available electric propulsion devices with thrusts of .01-.1 pound, which could be used experimentally in orientation control systems for the proper positioning of antennas or optic systems, or to prevent orbit decay of long-lived vehicles from atmospheric drag. Systems capable of thrusts up to one pound could be available late in the decade. Because of power/weight requirements, the probable application of these systems would be confined to missions of long duration such as deep space probes.

Guidance

6. Soviet space operations to date have been planned so as to make repeated use of established ground equipment and methods for guiding satellites and manned spacecraft into the desired earth orbit. Since 1957, almost all vehicles flown from Tyuratam have been launched along the standard ICBM azimuth, deviating by only a small fraction from a 65° angle of inclination to the equator. Thus, only minor alterations in techniques and coordination of facilities have been necessary for the various types of orbital missions. The principal exception to this standardization has occurred only recently with the launching of some reconnaissance satellites with an inclination of 51°. The launching of all Cosmos satellites from Kapustin Yar at an approximate 49° angle has also facilitated standardization of these operations.

7. Soviet space vehicles launched from Tyuratam have thus far used the basic first-generation SS-6 ICBM guidance—a radio-inertial system—during the boost phase. Although the Soviets have an all-inertial system operational with their ballistic missiles, they probably will choose to continue with the radio-inertial system for space ventures. This well-tried system is capable of a high degree of precision. For example, the orbital parameters of Voskhod differed only slightly from those of the dress-rehearsal vehicle, Cosmos 47. For future missions,

such as manned circumlunar flight, more precision will be required in mid-course and terminal guidance than the Soviets have exhibited to date.

Tracking and Communications Systems

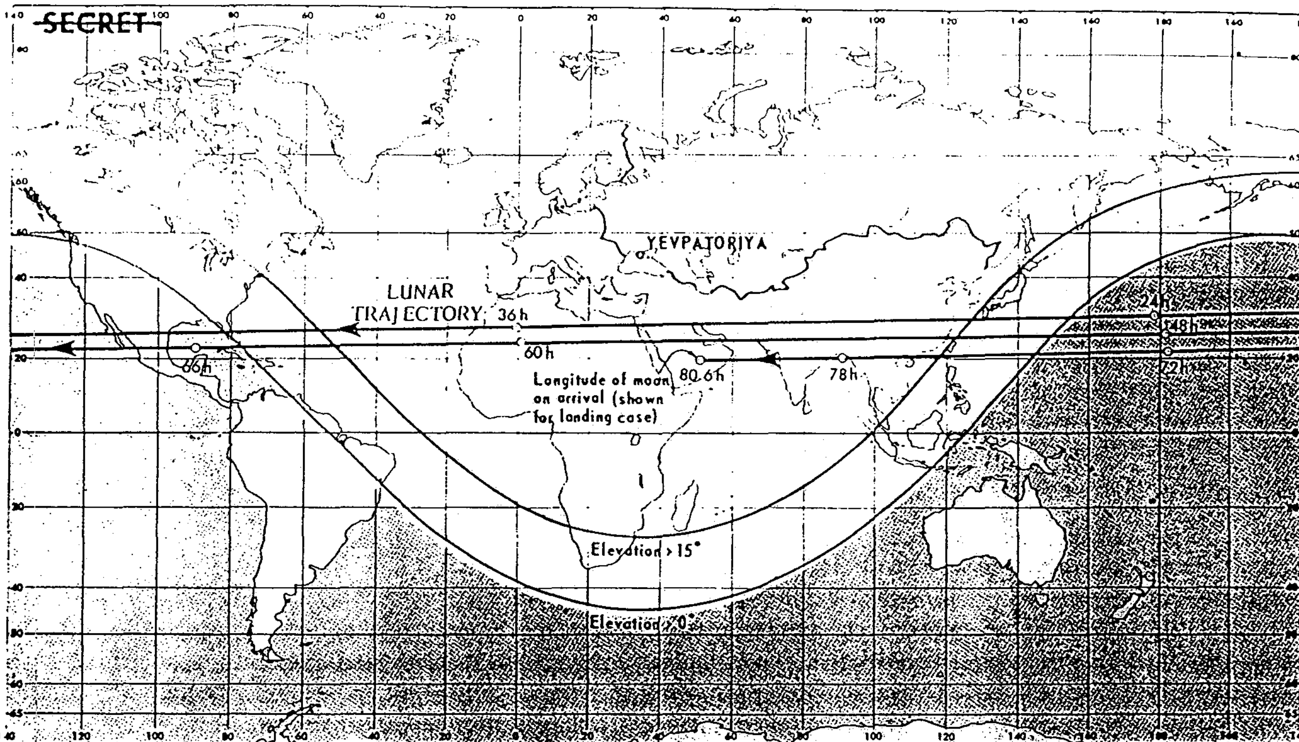
8. The chief limitation on Soviet capabilities for tracking and communication with space vehicles is the lack of a global network capable of continuous tracking and communications with satellites and space probes. Facilities first developed for the guided missile program are adequate to determine the initial trajectory with a high degree of accuracy; this system also provides high-quality tracking of satellites while over the USSR. The functioning of the system, however, requires that the satellite cooperate; i.e., transmit a signal in a pre-arranged manner. In addition, the Soviets have developed large phased array radars which could be used for surveillance and tracking of objects in space over the USSR.

9. To extend their monitoring capability, the Soviets rely on a number of supporting techniques. Specially instrumented ships have been deployed into the Pacific Ocean and off the coasts of Africa. These are of principal value during the first and last earth orbits. Their value is otherwise limited by the difficulty of accurately determining their positions and the more fundamental problem that optimum locations for some missions are inland.

10. Special space tracking and telemetry reception stations are located in the Crimea. At the principal station for lunar operations, located near Simferopol, a number of multiple yagi and large helical arrays and a 100-foot parabolic dish have been constructed. The primary instrumentation facility for planetary probes is the Center for Long-Distance Space Radio Communications, which is located near Yevpatoriya. It comprises two areas—one a transmitter site equipped with single steerable antenna array mounting eight parabolic dishes each 50 feet in diameter, and the other a receiving site equipped with two of these arrays.[11] Deep space shots appear to be under the operational control of a central computer complex in Moscow.

11. Additional land-based tracking stations would be a major aid to the tracking of all Soviet space vehicles and to the guidance of lunar and interplanetary probes. The Soviets probably will not undertake manned lunar flights until they can establish the additional sites necessary to maintain continuous contact. To achieve such a capability, they would need to establish two additional sites, which ideally should be spaced about 120 degrees apart, and located near the equator. One of these new sites could be located in the Soviet Far East; this would improve their capabilities to a point which they might consider sufficient to risk a manned lunar mission. There is evidence that the USSR is seeking to

[11] See Figure 1 of this Annex.



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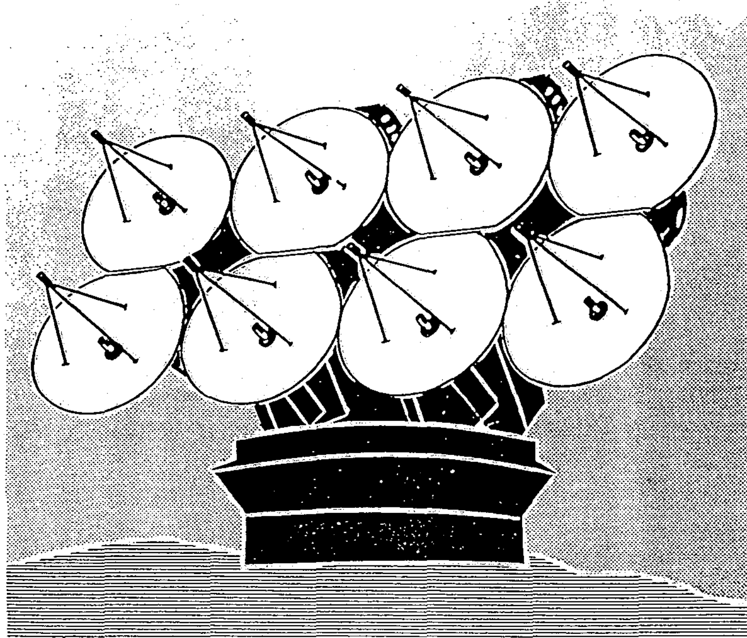
SOVIET DEEP-SPACE TRACKING STATIONS AT YEVPATORIYA

Above: *Tracking horizons of stations at Yevpatoriya.*

Left and below: *Photograph and sketch of one of three tracking and communication antennas at Yevpatoriya. Each is steerable in elevation and azimuth. One array is used for transmitting, two for receiving. Parabolic dishes are each 50 feet in diameter.*



acquire sites for monitoring space vehicles in South America, Africa, and the Far East. Communications satellites could be used to relay communications and data transmissions from and to orbiting vehicles.

Spacecraft Power Supplies

12. A major element in space tracking, control, and communications is the provision of adequate power supplies for the space vehicles themselves. Soviet space vehicles, both manned and unmanned, have not demonstrated a capability for sustained communications over long periods of time. A number of planetary probes have failed because of loss of power for communications, and Vostok cosmonauts were cautioned to reduce use of their transmitters to conserve power.

13. Necessary power for the missions accomplished thus far has been provided either by chemical batteries or solar cells, or combinations of them. Manned spacecraft have included thousands of pounds of batteries; some 3,000 pounds of the 10,000 pound Vostok was devoted to batteries. These sources are inadequate for many types of long-lived, unmanned vehicles and for manned missions of more than a week or so. The Soviets are conducting high quality research and development on other energy sources such as thermoelectric and thermionic devices. Small radioisotope-powered thermoelectric generators are available now. One using Polonium-210 yields 10 watts and another using Cesium-144 yields five watts.

14. Power requirements for a space station of several months duration are considerably higher, on the order of several kilowatts over those mentioned above. In addition to improvements likely in solar batteries and other auxiliary power sources, the Soviets probably are developing improved nuclear-power sources for future use in these space vehicles. After 1965, they could have a nuclear-isotope power supply with an output of several hundred watts. The Soviets could have a thermoelectric device for unmanned vehicles capable of generating about eight kilowatts by 1967. In contrast, in the area of fuel cell development, the Soviets have not made a substantial research and development effort and they are not expected to have such units available for flight use prior to 1967.

Facilities for Simulating Space Environment

15. The Soviets announced recently that a spacecraft containing a cosmonaut was tested in a new cloud physics chamber, operated by the Institute of Applied Geophysics of the Academy of Sciences, USSR. The chamber, completed in early 1964, is roughly cylindrical in shape, with an internal diameter of about 10 feet and height of 52 feet. Its capability to simulate an altitude of only some 130,000 feet and a temperature of only −45° C. falls far short of the near-vacuum conditions of outer space. Also, the chamber has no means of simulating radiation conditions encountered in space. This chamber cannot approach the overall performance of space simulation chambers currently in use in the US in the development of satellites and space probes. In addition, a

test chamber is known to exist at a training center for manned space flight at Tomilino, outside of Moscow, and another is possibly located at an aerohydrodynamics research institute near Moscow. These also do not simulate the vacuum conditions of outer space, but are useful for evaluating subsystems or integrated human-equipment testing. We cannot exclude the possibility that smaller, more adequate chambers exist, but a lack of suitable space simulation facilities could have been a contributing factor in some of the Soviet satellite and space probe failures.

16. In any case, while the chamber mentioned in the announcement probably was large enough to test the Voskhod spacecraft, we believe a larger, more adequate chamber or an extensive unmanned flight program will be required to certify any new spacecraft for manned use. A chamber for the test of rocket engines is now under construction, but we do not know its probable date of availability, size, or space simulation capability.

Life Support Systems

17. In the Vostok manned spacecraft, designed before 1961, the Soviets have a life-support system which has the capability to sustain one man for a period of up to 12 days in earth orbit. Fundamental to the design of this open-ended system is the use of an air-like mixture of oxygen and nitrogen at a sea-level pressure of one atmosphere (14.7 psi). Compressed air is used to maintain this pressure and chemical compounds (potassium superoxide and lithium hydroxide) which absorb carbon dioxide and release oxygen have served for atmosphere regeneration. A generally similar cabin environment was created by the life-support system aboard the Voskhod spacecraft. The cabin pressure was again one atmosphere and other environmental parameters, such as gas composition, temperature, and humidity were also within previous limits. The CO_2 content of the Voskhod atmosphere was about double, however, and increased during the mission from 1.1 to 1.7 percent. While not outside safe limits, this and the atypical rising of the cabin temperature probably represented a taxing of the life-support system. This comparison with Vostok environmental parameters indicates that the Voskhod life-support system is little changed from the Vostok system.

18. Soviet success and confidence in this system has permitted them to minimize the problems and hazards associated with oxygen-rich atmospheres and reduced pressures both in the cabin and in the instrument compartment. They can adapt this system and their experience to a small, manned earth-orbiting station as well as to a manned circumlunar mission. For those future missions in which weight would be a greater limiting factor or in which flight duration would be substantially prolonged, such as a manned lunar landing or a large space station, wholly new techniques probably would be required. These could be partial regenerative or closed-loop systems. The first Soviet flight with such a new environmental control system would be experimental and would involve limited objectives, primarily biomedical in nature.

19. Soviet research and development on pressure suits has not been extensive and certain features from early US suits have been adopted. During Vostok missions, the suit was not pressurized and the face shield was open. In the event of cabin depressurization, the suit was to be pressurized automatically. While the design is adequate for safety, cosmonaut mobility would be severely hampered. The cosmonauts aboard Voskhod wore no pressure suits. While this undoubtedly reflected a high confidence in the spacecraft, it implies that the Voskhod's construction and life-support system do not involve radical departure from the Vostok technology. Considerable modification of the Vostok suit or one of new design would be necessary for operating outside the vehicle in space or on the lunar surface. Currently, the Soviets appear to favor the "hard suit" concept for extravehicular operations and are actively developing a prototype along these lines.

20. Our knowledge of the Soviet capability to predict solar flare events is limited to open source literature, but we believe that they have a fair capability to forecast two or three days in advance these events, which produce hazardous levels of cosmic radiation. Their research program is expanding and a new, large solar observatory was completed early in 1964 in the mountains southwest of Irkutsk. Space radiation hazards, with the exception of cosmic rays generated by solar flares, are sufficiently understood by the Soviets that they should present no major difficulties. These problems probably can be solved for manned orbital, circumlunar, or lunar landing missions of minimum duration by the use of suitable shielding or an appropriate arrangement of on-board equipment. But, solar flares will remain a problem for flights to outer space.

21. A profound Soviet concern for the post-flight effects of weightlessness became apparent after the five-day mission of Vostok V in 1963. Soviet scientists believe that it will be necessary to provide artificial gravity to offset the deleterious effects of weightlessness in manned flights lasting over several weeks. We do not attribute any artificial gravity capability to current manned spacecraft systems. While incorporation of an artificial gravity system (such as a centrifugal force arrangement) into a spacecraft or space station is theoretically feasible, it involves serious technological problems which preclude its appearance in a manned flight for several years.

Data Processing

22. Of vital importance in complex space operations is a high-speed system incorporating provisions for the rapid transmission of data from field stations to a central processing center where it can be evaluated and corrective measures supplied to other field stations better located for transmitting them to the space vehicles. In the Soviet parking orbit technique for launching lunar and interplanetary vehicles, about 70 minutes elapse from the time the launch vehicle passes the last tracking station in the Soviet Far East before ejection stage must be ignited at a precise moment somewhere over Africa. The same constraint is operative in the recovery of manned and unmanned vehicles from earth orbit. The Soviet data-processing accomplishments implied in successful com-

pletion of such missions indicate that high performance computers are being used. While Soviet propaganda films on their earlier manned space flights revealed use of vacuum-tube computers capable of 20,000 arithmetical operations per second for space track computations and data handling, it is estimated that even more advanced computers have been used in support of recent missions. In 1965-1970, the Soviets probably could develop computers utilizing only solid-state devices and capable of performing a million operations per second.

23. During the same period, the Soviets probably will continue to press development of computers with greater reliability and will seek to reduce size, weight, and power requirements. Onboard computers will become necessary on manned vehicles to facilitate the process of making decisions concerning guidance and other vital operations. They also will be necessary with deep space probes for preliminary data processing to reduce the volume of information to be sent to earth over radio communications links having limited capability for data transmission, as well as to handle the severe guidance and navigation problem associated with such flights. While some success in microminiturization will probably be achieved in developing computers for use in space vehicles, we are aware of no practical Soviet experience to date even in the field of missile guidance.

Orientation and Stabilization of Space Vehicles

24. A sophisticated complex of equipment is required to sense a space vehicle's orientation and to effect changes in this orientation to accomplish the stabilization prescribed by mission objectives. The only exception occurs in some vehicles such as the Kapustin Yar Cosmos series, where autorotation, or spin-stabilization, is adequate to prevent tumbling. All Soviet space vehicles to date requiring such control have been provided with fully automatic systems and manned vehicles have included a completely isolated system for manual operations.

25. Automatic earth orientation, at least in manned vehicles, has been based on gyroscopes and sun and horizon seekers, with a manual capability based solely on visual techniques for back-up. Lunar and planetary probes have included sun seekers both to orient the vehicle and to orient solar-power panels. The system has failed on a number of probes. Less is known about the orientation system aboard reconnaissance satellites [ ]

26. All known Soviet stabilization systems are believed to employ a cold-gas, jet-reaction apparatus for attitude control. Soviet announcements indicate that the cosmonauts have practiced at least some manual control. Our evidence indicates that during the flight of Vostok III, the cosmonaut attempted manual con-

trol so as to witness the launch of Vostok IV. The mission duration of the manual system apparently permits only a few minutes of continuous operation. We have no evidence that any Soviet cosmonaut has used this manual system to accomplish orientation for recovery.

Maneuver, Rendezvous and Docking

27. The earth-orbit-rendezvous technique is so basic to a whole range of future space operations that there can be little doubt that the Soviets will soon experiment with it. The paired flights of Vostok 3 and 4, as well as Vostoks 5 and 6, although not used to attempt a rendezvous/docking operation, did represent an initial step in that direction. Rendezvous and docking, even with a cooperative target, imposes fairly stringent requirements on a number of basic technologies, the most critical of which are launch guidance, tracking, and orbital maneuver. Maneuver, as distinct from orientation control, implies a substantial propulsive capability to permit the vehicle to transfer from one orbit to another.

28. Specific guidance requirements for rendezvous are difficult to establish because of the many modes by which rendezvous can be accomplished. The use of pre-programmed trajectories and having rendezvous occur soon after injection into orbit of the second vehicle lessen requirements for in-orbit guidance. The specific Soviet approach to rendezvous is unknown but this technique appears most likely in light of the Vostok 3 and 4 operation.

29. A major problem in any case is the need for accurate orbital data, or ephemeris, on both the vehicle already in orbit and the new arrival. Tracking to determine ephemeris can be accomplished from on-board equipment, but operations can be timed so as to take maximum advantage of ground tracking to minimize on-board requirements. Current Soviet ground tracking equipment and technology are adequate to perform this function for two cooperating vehicles providing that the operation occurs over the USSR. There are no known Soviet efforts to develop an on-board capability to track one satellite from another.

30. The maneuvering necessary for most rendezvous schemes requires a propulsion system incorporating both thrust modulation and a restart capability. The Soviets are experiencing considerable difficulty with the in-space ignition and operation of upper stages in lunar and planetary probes. At the same time, their retro-rocket engine has a high reliability. There is little intelligence on further Soviet development of such propulsion systems. The maneuverable Polyot probably is intended for use in rendezvous, but a useful maneuver capability is yet to be demonstrated. Once developed, it could be adapted to complicate Western attempts to counter Soviet satellites.

31. A significant reliability problem appears in any mission requiring repeated launchings under serious time constraints, as would be necessary if a substantial number of rendezvous were intended. On this basis, the overall probability of mission success to the moment of the last required docking declines very rapidly as more than one rendezvous operation is attempted. Even with a

booster of demonstrated reliability, such as the SS-6, we believe that more than three launches (and two rendezvous) would involve excessive risk for any mission which depends on all for its success.

Re-entry and Recovery

32. The final step in any manned mission is the recovery. The Soviets have repeatedly shown their capability to successfully de-orbit and recover both unmanned and manned vehicles. Since its introduction in 1960, the same type of liquid-fueled retro-rocket assembly has been used to de-orbit these two types of satellites. All operations to date have been essentially the same.

33. Landing occurs in daylight in the central USSR, some 70 minutes after initiation of the sequence. The Soviets regularly announce that manned craft have landed in the designated area and that the cosmonauts have been reached within a few minutes. We do not doubt the latter point but we have reason to believe that the designated landing area encompasses thousands of square miles. The basic search technique for the downed payload probably involves the Soviet HF/DF system, supplemented by aircraft. Final recovery is accomplished by helicopters.

34. The Soviets have utilized an ablative-type (possibly ceramic) heat shield for protection against the heat flux brought about by atmospheric re-entry from earth orbit. We believe the heat protection material and structure on the Vostok vehicle (10,400 pounds) weighs about 1,400 pounds.

35. For the final phase of recovery, i.e., after re-entry into the earth's atmosphere, the Soviets have used two techniques. The Vostok, and probably all 10,000 pound reconnaissance satellites, deploy parachutes when they have descended to about 20,000 feet. Then, at the cosmonaut's option, he either remains in the re-entry vehicle until impact or ejects himself in his seat to descend separately by parachute. The seat includes equipment for an unplanned water landing. Only the pilot of Vostok I elected to remain within the recovery vehicle. Seat ejection presumably would have been used in case of booster malfunction during the initial launch phase.

36. The Soviets have announced that the Voskhod does not employ this technique. No provision has been made for seat ejection, but rather, after the deployment of parachutes, a second retro-rocket is activated near the ground to minimize impact of the spacecraft and crew. (As for an unplanned recovery at sea, the Soviets have described the Voskhod as unsinkable.) The reliability of the technique must have been proven during the recovery of the 12,000-14,000 pound reconnaissance satellites over the past year.

37. If the Soviets plan to undertake manned lunar missions, they will have to address themselves to the problems involved in re-entering the earth's atmosphere at parabolic velocities, i.e., those on the order of 36,000 ft/sec. While these velocities constitute a very significant increase over velocities of re-entry for vehicles in near-earth orbit (26,000 ft/sec), it appears that heat-shield problem can be overcome with a current state-of-the-art solution, probably utilizing polymers. The employment of these materials is perhaps a step beyond current Soviet usage in space vehicle applications, but Soviet work in this field is going on and there are indications that charring polymer ablators have been flown on ICBM vehicles targeted to the Pacific. The problems most likely to emerge will be those of maintaining low heat-shield weights through extensive materials testing and the improvement of bonding techniques. Testing of re-entry materials by means of vertical firings with boosted re-entries is a practical approach to the problem of acquiring data early in any project for the design of a recoverable lunar spacecraft. As yet, we have detected no such tests.

38. A spacecraft designed to be recovered from a lunar mission would almost certainly incorporate some provision for aerodynamic lift after atmospheric re-entry. As the declination of the moon changes during the month, so does the location of the re-entry point of the return trajectory. This produces a longitudinal range variation of some 2,000 to 10,000 miles from the re-entry point to an established landing area; the actual variation is a function of the inclination of the return trajectory to the equator. Aerodynamic re-entry utilizing a low, roll-modulated, lift-to-drag ratio of about 0.5 can provide control over a range from re-entry to landing points of about 1,500 to 3,500 n.m., as well as broaden the re-entry corridor depth to manageable guidance proportions. There are no indications that the Soviets have conducted aerodynamic re-entry experiments in the manned space project.

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