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MILITARY OPERATIONS IN SPACE (U)

SUMMARY

January 1963

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MILITARY OPERATIONS IN SPACE

SUMMARY

The fundamental mission of the Department of Defense, and therefore of the Air Force, is to prepare for the military operations essential to protection of the vital interests of the United States. Until recently, these preparations have been based on land, sea, and air forces. The development and deployment of the intercontinental range ballistic missiles have extended potential military operations beyond the earth's atmosphere.

There should be two major objectives in the formulation of a basic approach to military operations in space. The first must be to augment the existing military capabilities of earth-based forces by suitable military forces in space. The second major goal must be to achieve the military in-space patrol capabilities essential for protecting U.S. activities in space and to prevent attacks from space upon the United States and her Allies.

Early military capabilities will be limited to operations at the lower orbital altitudes. Thus, the principal military interest at this time must be to make sure that the near-earth region will not be dominated by a hostile power. This emphasis on near-space activities is different from the fundamental program objectives of NASA; even the early NASA efforts are directed toward deeper space. Furthermore, it is not imperative that the NASA systems operate on a repetitive, economical, and reactive basis.

The basic difficulties, hazards, and costs of putting men into space raise questions concerning their value in military space systems. Therefore, an investigation of the extent of man's use in military space systems must be conducted as an

integral part of the National Space Plan. Specifically, present efforts must be directed toward establishing the necessary technological base and gaining military operating experience in space. Then manned military operations in space can be achieved with the shortest possible delay whenever firm missions and requirements are established.

The basic military strategy of the Free World has been founded, in recent years, on technological superiority in all combat media. It would be difficult to conclude that all of the probable military applications of Soviet advances in space technology could be countered by land, sea, and air forces alone. Thus, military systems which operate in space are now and will increasingly become a necessary part of a flexible force structure.

Certain military tasks may require the use of space systems, while others may be performed with the aid of space systems at lower relative costs than by ground-based systems alone. Decisions to employ space systems for military purposes will be based upon these considerations and upon the knowledge that space systems in concert with other systems will provide a more effective total force structure.

Early military space operations, including support operations, fulfill distinct military needs and will result in a more effective total force structure. These include: (1) target identification and location, (2) warning of ballistic-missile attack, (3) detection of nuclear detonations, (4) geodetic measurements, (5) aids to terrestrial navigation, (6) meteorological observation, (7) global communications, (8) active defense against satellites, and (9) R&D operations in space.

Also, future military support operations probably will be required in space. Examples include space-environment monitoring, logistic and rescue operations in space, and crew training.

Finally, certain future military space operations now seem to offer distinct advantages over nonspace operations. These are: (1) ballistic-missile defense, (2) command and control in space, (3) strikes from earth orbits, and (4) space-based satellite surveillance and tracking.

Each of these possibilities has technical problem areas. These problem areas, with a more detailed discussion of the capabilities, are treated at somewhat greater length under individual headings in the full paper.

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MILITARY OPERATIONS

IN SPACE (U)

January 1963

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I. INTRODUCTION

The fundamental mission of the Department of Defense, and thus of the Air Force, is to prepare for the military operations which are essential for protection of the vital interests of the United States. Until recently, these preparations have been based upon the concept of employment of land, sea, and air forces. The development and deployment of the intercontinental range ballistic missile has extended potential military operations beyond the earth's atmosphere, and, today, both military and civilian systems operating largely in space have come into being.

As these developments have taken place, our national interest in space has grown accordingly. A large measure of this interest has been in potential military applications of space, because it was recognized early that space systems can enhance present military capabilities and that they offer possibilities in the future for further enhancement of the military power and effectiveness of the United States. Implicit in these motivations toward a wider use of military space systems is a need to know, and a need to prepare for actions to counter, military capabilities in space achieved by the Soviet Union.

The purpose of this paper is to examine—and to clarify where indicated—the reasons which have led to the firm conviction that military space operations are basic to satisfying certain U.S. needs.

Certain military tasks may require the use of space systems, while others may be performed in space at lower relative costs. Decisions to employ space systems for military purposes will be based upon these considerations and upon the knowledge that space systems in concert with other systems will provide a more effective total force structure. However, since the uses of space are at the very earliest stages of development, it is prudent and necessary to plan, not only for applications clearly visible now, but also for future applications indicated by advances in military space technology now only vaguely foreseen. Thus, as a preventive against any nation achieving a position in space which could threaten the security of the United States, a broad range of military capabilities must be and are being developed.

Development of these capabilities requires both the early military exploitation of space, wherever this is technically and economically indicated, and the rapid development of new military space technology. Because of the uncertainty of the time required by the U.S.S.R. to develop a possible space-based challenge to the security of the United States, each of these goals should be pursued at a rate consistent with the maximum rate of technological growth and the available resources.

II. APPROACH

In the formulation of a basic approach to military operations in space, it has become increasingly clear that there are two major objectives toward which attention should now be directed. Convincing evidence indicates that the present military capabilities of the United States can be improved by the use of military space systems. Therefore, the first major objective must be to augment the existing military capabilities of earth-based forces by the employment of suitable military forces in space. Equally apparent is the possibility of future, hostile Soviet actions, either in space or from space. Consequently, the second major goal must be to achieve the military in-space patrol capabilities essential for protecting the civilian and military activities of the United States in space and for preventing attacks from space upon the United States and her Allies. To a degree, these two broad objectives determine the character of both immediate and future military operations in space.

Considered judgment of Soviet actions leads to the conclusion that the earliest threat which could arise would result from activities in the near-earth regions of space (see Appendix A). Further, early capabilities will be limited to military operations at the lower orbital altitudes. Hence, the principal military interest, at this time, must be ensuring that the near-earth region will not be dominated by a hostile power. Nevertheless, certain early military operations will extend to synchronous orbital altitudes; e.g., military satellite communications. Present indications are that future possibilities also will arise for military missions in the deeper space environment.

That the assigned role of the Department of Defense defines a logical element of the National Space Program becomes clearer when DOD's objectives are compared with the fundamental program objectives of the National Aeronautical and Space Administration. The basic direction of even the early NASA efforts is toward deeper space. NASA's lunar program, for example, requires that the APOLLO system operate through the near-earth environment—although not necessarily that it operate on a repetitive, economical, and reactive basis within that environment. This distinction is a fundamental difference in approach between civilian and military activities in space planned at present and establishes a meaningful basis for deciding which elements of the National Space Program relate more closely to civilian and which to military space developments and operations.

The basic difficulties and hazards, as well as the costs, of putting men into space raise questions concerning the value of men in military systems in space. After much study, it is the opinion of the Air Force and of major segments of the scientific and industrial community that men will probably prove essential in certain future military space systems. This is particularly true at the lower orbital altitudes, of prime military interest where the problems of radiation exposure appear surmountable. Therefore, an investigation of the extent of the use of men in military space systems is important to national security and must be conducted as an integral part of the National Space Program. Specifically, present efforts must be, and are being, directed toward establishing the necessary technological base and gaining military operating experience, so that manned military operations in space can be achieved with the shortest possible delay whenever firm missions and requirements are established.

There is a consistency between the view that military space systems—both manned and unmanned—must be developed for needs evident now and the view that effort must be aimed toward new opportunities by creating a viable and broad base of new technology. Both undertakings provide insurance against an uncertain future.

It is well understood that the basic military strategy of the Free World has been founded, in recent years, on technological superiority in all combat media. Retention of this superiority is even now being challenged by the major space efforts and accomplishments of the Soviet Union. It would be difficult to conclude that all of the probable military applications of Soviet advances in space technology could be countered by land, sea, and air forces alone.

The possibility of thermonuclear war has led the Department of Defense to place increasing emphasis upon achieving military capabilities which can provide a controlled and measured response at the level of force appropriate to the threat. A future Soviet threat in or from space must be met and disposed of without devastating nuclear exchanges on the earth's surface. For this very basic reason, military systems which operate in space are now, and will increasingly become, a necessary part of a flexible force structure.

The following section discusses probable applications of systems toward which effort must be directed now to achieve the fundamental objective of the Department of Defense; i.e., to make the essential military preparations required for the protection of the vital interests of the United States.

III. MILITARY SPACE APPLICATIONS

The developing of space technology provides means for improving and maintaining the Nation's defenses as well as for ensuring the availability of space for peaceful purposes. To capitalize upon these means requires that full advantage be taken of existing technologies to meet early military needs and to obtain operating experience and proficiency in the use of military space systems. Research, exploratory development, and advanced development programs must be conducted in such a way as to achieve the technical gains responsive to operational needs and to ensure that the military potential of new technologies will be promptly identified. As an outgrowth of research and development programs so conducted, early decisions can be made to pursue vigorously engineering programs for operational capabilities ensuring the security of the Nation.

Decisions in development and operational employment must include consideration of space systems in relation to all systems. With certain exceptions, the following discussion is primarily directed toward military applications of earth-orbiting systems. Its purpose is to show: (1) that early military space operations, including support operations, fulfill distinct military needs and will result in a more effective total force structure; (2) that future supporting military operations probably will be required in space; and (3) that certain future military space operations now appear to offer distinct advantages over nonspace operations.

A. Early Military Space Operations

Certain early contributions of space systems have been generally accepted. During the next 5 to 7 years, space systems could provide superior capabilities in the applications discussed below.

1. <u>Target Identification and Location</u>

"The United States has, and will continue to have for the foreseeable future, a high-priority requirement for reconnaissance of the Soviet Union and other desired areas." This quotation is from a 1960 report of the United States Intelligence Board (USIB), which concluded that it was essential that the United States develop and maintain an operational satellite reconnaissance system possessing a wide range of capabilities. Development, based upon the employment of unmanned satellites, is now under way.

The need for military reconnaissance is essentially twofold: (1) a one-time need for on-demand observation of either localized areas or specific points and (2) a need for periodic observation of whole areas of military interest (e.g., the Sino-Soviet land mass). The second aspect (i.e., periodic observation of areas) is required to:

-a Determine the current status and activity levels of military installations and their weapons

-b Detect and determine the locations, nature, and relative importance of military installations for targeting purposes

-c Acquire basic intelligence needed for military planning, including such data as the physical characteristics of missiles and aircraft, weapon deployment patterns, and radio frequencies and other characteristics of radar and radar control links, and for detection and evaluation of new weapons and other items of military significance.

In the future, manned and unmanned suborbital and recallable satellites may prove useful for on-demand reconnaissance, particularly in securing post-strike damage assessment information. However, it is in the second application given above that early military reconnaissance of the earth's surface can be, and needs now to be, conducted from space. The acuteness of this need and the problems inherent in the employment of nonspace systems are exemplified by the considerable difficulty and risk associated with U-2 overflight and RB-47 peripheral intelligence collection programs. Within an early period, unmanned earth satellites can provide a large share of reconnaissance information by methods which are now considered politically acceptable. It has been concluded, therefore, that the employment of unmanned satellites for military reconnaissance of the earth's surface is a significantly better way to collect some critical intelligence data important to defense needs associated with maintaining capabilities for a selective and controlled response.

2. Warning of Ballistic-Missile Attack

Early-warning satellites are unique in their ability to come sufficiently close to enemy launch areas to permit the detection of ballistic missiles during boost. They can also relay, with minimum delay, data to ground readout stations which can be defended against enemy attack or interference; e.g., bases in the United States, Canada, or the United Kingdom. Thus, their capabilities will provide early-warning times (before impact) of these magnitudes: 20 minutes or greater for ICBM's having about 30 minutes time-of-flight and 85 minutes for extended range ballistic missiles (ERBM) having about 90 minutes time-of-flight.

In the future, the use of triangulation and multiple satellites containing infrared sensors should allow launch position to be determined within 8 nautical miles. The system would require the use of relatively few early-warning satellites and could furnish global coverage. It would permit detection of ICBM, ERBM, or IRBM attacks against the zone of interior, and possibly even third country attacks against the zone of interior and other countries. A system such as this is considered to be operationally feasible by 1969, although expanded efforts will be needed to obtain sensors having adequate signal-to-background-noise characteristics, particularly against intermediate range ballistic missiles. In addition, data transfer between early-warning satellites via space-based communications relays, would be required.

In contrast, BMEWS or other ground-based radar systems can be only individually positioned for surveillance of specific avenues of attack and can detect only the attack of specific types of missiles against specific target areas. For example, BMEWS coverage can be either overflown by ERBM's or under flown by low-angle ICBM's. However, the implementing of present plans for improvements to the present BMEWS would obviate some of these deficiencies. The addition of gap-filling radars and an extended range, high-angle ballistic missile and satellite detection system would provide improved surveillance capabilities.

One possible way that early warning of an IRBM raid on the continental United States could be obtained as quickly as with a global, space-based system would be to construct a battery of phased-array radars along the Southern, Eastern, and Western boundaries of the United States plus North-looking BMEWS gap fillers. Although a system such as this would also provide more accurate impact prediction than would some possible space systems, it would give shorter warning times of ERBM attacks and less accurate data concerning enemy ICBM or ERBM launch positions. Adequate ERBM warning would probably require construction of massive radar installations along the Southern border of the USSR and China, although radars located on islands near the South Pole could possibly prove adequate. However, a ground-based network of these dimensions would almost surely prove to be less cost-effective than a space-based system when the political and technical problems associated with logistics and data transmission from globally separated sites are considered.

Detection of missiles during their passage through the ionosphere by high-frequency, forward-scatter radiation may be possible, although difficulties in reducing the high false-alarm rates caused by natural phenomena appear formidable. Also, this technique cannot provide information concerning missile launch—or impact—position location with the degree of accuracy expected from space-based systems.

Countermeasures against radar systems are likely to be more effective than those which appear practicable against IR sensors in space; and, although it seems possible to reduce the cross-sectional area of missiles by three orders of magnitude (with respect to BMEWS radar), reductions in missile IR radiation as seen by space-based sensors of only one order of magnitude are believed possible.

3. Detection of Nuclear Detonations

As long as on-site inspection of nuclear detonations remains politically unacceptable, means must be available for remote detection of any nuclear explosions. Ground-based or aircraft techniques exist, or are being developed, to detect explosions underground, in the atmosphere, or in near-space where large-scale effects are produced in the upper atmosphere. It may also be possible that low-orbit systems designed for use in detecting IR radiation from missile launches (e.g., systems which are now undergoing experimentation) may be able to confirm the occurrence and location of such explosions. Detonations farther out in space can be conducted in a way which precludes observation from either ground-based stations or low-orbit systems designed for earth surveillance of ballistic-missile launchings. It is judged that detonations could be detected over line-of-sight distances of many thousands of miles from an unmanned orbital platform containing available nuclear radiation instrumentation. By these techniques, continuous monitoring of cislunar space from two space platforms appears possible.

Future capabilities may be achieved for discriminating between the radiation from nuclear detonations and natural phenomena, for determining the type and size of a nuclear explosion, and for locating either single or multiple events with respect to the earth's geographic coordinate system.

4. Geodetic Measurements

Improved geodetic data are a fundamental need for accurate targeting of intercontinental range ballistic missiles, particularly in counterforce strikes. Also, improving prediction of the perturbations of a near-earth satellite is dependent upon obtaining better information on irregularities in the earth's shape and in its gravitational field. Some of this knowledge has already been gained through observing over long periods perturbations in the orbital paths of satellites. Results from these observations have demonstrated the value of special-purpose satellites carrying radio and optical beacons for acquiring geodetic data. In some cases, it may be the only way to acquire the data. These methods may reduce the present errors of perhaps 100 to 400 meters between intercontinental data planes to perhaps 8 meters or less.

At present, the potential accuracy in the locating of identifiable points in Eurasia with respect to the Department of Defense World Geodetic System varies from about 100 feet to 4 nautical miles. In many potential target areas, the uncertainty is on the order of from 0.5 to 1 nautical mile, and the accuracy of elevation at these locations also presents serious difficulties for effective, future strike systems.

There are other areas, however, where even these accuracies are not attainable. In these areas photographic reconnaissance satellite techniques may provide means for relating points in unfriendly territory to bench marks in friendly territory. Other than by actual invasion of enemy territories, however, even these techniques cannot provide all required data. A relatively few specially instrumented satellites at altitudes of 1,000 miles above earth and using long focal-length photography can identify and locate by simultaneous comparison with star backgrounds permanently identifiable points anywhere in Eurasia to within a few hundred feet in the horizontal plane.

5. <u>Terrestrial Navigation</u>

If a frequency-stabilized radio signal is transmitted from an earth satellite, the Doppler shift in the signal can be determined. Reception and measurement of the shift which results from the orbital motion of the satellite permit the determination of the geographical position of the receiver, regardless of its location on the earth's surface. In this system, the satellite broadcasts data on its ephemeris, which has previously been determined and relayed to the satellite by a ground station. Compensation for the additional non-Doppler shift in signal caused by passage through the ionosphere can be obtained by transmission and reception at two frequencies, since the ionospheric shift is frequency dependent.

Navigation by use of a satellite Doppler system has certain advantages over other present and possible navigation systems. Operations can be conducted in all kinds of weather; transmissions are not required from the vehicle to be navigated; accuracies comparable to other position-location techniques are possible; and knowledge is not required of the direction of either the local vertical or an azimuth reference. Because angle data are not required, stabilized antennas are not needed.

The extension of this navigational procedure to airborne strategic bomber applications will require the adaptation of the receiving equipment to aircraft weight limits and the adaptation of the computing procedure to take account of aircraft height. A minimum airborne navigation capability will be available by late 1964 from the satellites being developed to meet present naval navigational requirements.

If airborne navigational fixes are to be required within arbitrary portions of a relatively short flight, additional numbers of satellites probably will be required.

6. Meteorological Observation

Accurate and complete prediction of weather behavior requires large inputs of accurate data on the temperature, barometric pressure, wind direction, cloud cover, etc. These measurements preferably should be made in three dimensions at a great many locations. Sufficient data is not being gathered at the present, especially from over the oceans and throughout the entire Southern Hemisphere.

For global military operations, meteorological data is required for daily analyses and forecasts of the weather in all areas of military interest. Cloud height measurements, for example, are needed for strategic aircraft operations, such as for bomber-tanker refueling and for the planning of bomber and missile operations. Cloud cover photographs are also necessary for strategic purposes, including strike and reconnaissance missions. Beyond these requirements, and perhaps of more immediate urgency, is the need for world-wide weather data for limited war operations. These operations are most likely to occur in underdeveloped areas, where facilities are almost nonexistent for the ground-based determination of meteorological information. Satellite systems undoubtedly represent the most desirable method of overcoming these deficiencies and thus of providing weather data vital to limited war operational planning.

During daylight passes, television observations from satellites can give indications of the cloud cover patterns over virtually the entire surface of the earth. During night passes, the same cloud patterns can be detected with somewhat cruder detail by IR measurements. While these pictorial observations can provide only indirect measurements of atmospheric temperatures and pressures, these data are exceedingly useful to a trained observer in making accurate interpretations of atmospheric conditions between points of ground observations. From a cost-effectiveness standpoint, investment in weather observation satellites can greatly reduce the number of ground stations required to obtain a given amount of meteorological information. A proper mix of ground stations coupled with satellite observatories would provide at minimum cost capabilities for the collecting of any desirable level of meteorological data.

A satellite can also provide two other types of data which can be obtained only from space observations. Television pictures from satellites have already permitted the discovery of typhoons and hurricanes days before they were detected by conventional weather observations. Early detection of these storms could provide an invaluable aid in the planning of large scale military operations in areas where such weather conditions are prevalent; e.g., in the Caribbean and Pacific Ocean areas. The second application is associated with the possibility of achieving greatly increased accuracy in the prediction of the initiation and cessation of jet stream phenomena. The atmosphere can be considered as a very complex heat engine driven by a solar energy input. It is possible that jet stream phenomena can be explained by a mathematical model comparison of the atmosphere to a heat engine. Accurate evaluation of this model will require significant amounts of input data detailing both the incident solar energy and the albedo of the earth. Such data can be obtained only from space.

It is problematical whether or not civilian meteorological satellite systems in conjunction with ground-based stations can meet all military needs for weather data. Past experience tends to support a conviction that the necessity for close coordination between operating and support functions may require certain space elements of a satellite weather system to be operated by the military.

7. Global Communications

Existing communications facilities need to be augmented by military satellite systems to permit command and control over global distances. The necessity to communicate over these distances has resulted in such beyond-line-of-sight propagation means as low- and high-frequency radio, tropospheric scatter techniques, and submarine cable and multiple radio relays. All of these present methods suffer from one or more of the following limitations:

-1 High-frequency and ionospheric scatter links are limited in their bandwidth capabilities. In addition, outages due to magnetic storms and aurora disturbances occur up to 10 percent of the time for ionospheric scatter links, and up to 40 percent of the time for high-frequency links.

-2 Troposcatter and microwave links require an unacceptably large number of relays, which in numerous instances cannot be installed because suitable sites are not available.

-3 Costs associated with other methods offering possibilities for long-range communications—such as guided microwave techniques which employ submerged transmission lines and submerged cables which use broadband repeaters—are estimated to be substantially larger than those for satellite communications systems now proposed. As an example, the U.S. Army Signal Corps has estimated that the initial and annual recurring costs of providing a cable system to provide coverage in the Pacific Theater would be 16 times larger and 3½ times larger, respectively, than a system composed of communications satellites.

-4 The cost to the enemy to degrade the survivability and reliability of very-low-frequency, low-frequency, and high-frequency communications systems through high-altitude nuclear explosions would be significantly lower than it would be to degrade ground links or space-based components of a properly deployed satellite communications system.

Communications problems in limited war are aggravated by the variety of places in which these actions may develop and by the large distances between units of command. The theater commander at the end of a long communications line, is faced with the need for extending even more tenuous links to his widely dispersed forces. Other important factors are:

-1 Vulnerability to jamming

-2 The need for establishing links around or through neutral countries

-3 High traffic requirements during critical times in areas which have developed little or no communications capability.

Critical areas, such as Africa, the South Pacific, portions of South America, the Near East, and Southeast Asia are underdeveloped and far removed from existing wideband communications services. Extensions to present global networks which are planned for 1965 will alleviate this problem in some areas, but even minor contingencies would generate sufficient traffic to overload these facilities. The occurrence of multiple contingencies of this nature would clearly make the situation unmanageable. Estimates of the traffic requirements in such areas (including the transmission of weather, administrative, logistics, intelligence, and operational data) indicate that the traffic will greatly exceed maximum system capacity. Detailed studies indicate that during deployment, demand will surpass maximum capacity by about 200 percent.

A military communications satellite system, coupled with properly located fixed ground terminals and a number of air transportable terminals, offers a possible solution for future high-priority, limited-war communications traffic in the wide variety of situations which may develop.

8. Active Defense Against Satellites

It appears probable that the earliest threat from enemy satellites would arise from warheads which could be deorbited from satellites. The problems of defending against such attacks would be similar to those encountered in terminally defending against ballistic missiles. It is likely then that the earliest active defense systems would depend upon the use of ground- or air-launched nonorbiting interceptors. The need, however, is to identify potentially hostile satellites and to determine their intentions prior to actual deorbit. In the total picture, neither the nature nor the intent of unknown satellites can be determined from the ground, with the possible exceptions of an announcement made by the USSR for psychological effects or the determination of hostile intent from the presence of an inordinately large number of Soviet satellites in space.

Given these problems and the range limitations of suitable sensors, space-based inspection of satellites, at least on a sampling basis, will be mandatory before any decision on neutralization or destruction can be made. Crude, but possibly satisfactory, identification can be made from television transmissions from an inspection vehicle which effected rendezvous with the satellite to be inspected.

Two of the more useful physical determinations that can be made from space are a measurement of the total satellite mass and the presence or possible presence of fissionable material. This information would help provide inputs to our technical intelligence that is difficult or impossible to obtain from ground stations. If the satellite is in a high-altitude orbit, the atmospheric drag forces could be so small that a mass estimation from orbit perturbations would take an inordinately long time to determine. Several means proposed to determine satellite masses from space include observation of rate of heating for a given power input, backscattering of soft X rays, and an actual physical acceleration of the satellite. Presence of fissionable material could be determined by observation of the gamma rays normally emitted by the material, neutron irradiation or backscattering of soft X rays.

To do these on a sufficiently cost-effective basis, however, will require developments to achieve economical launch systems capable of continuous readiness and fast reaction, in-space propulsion for orbital transfer, and the ability to rendezvous with passive uncooperative targets over a wide range of altitudes from the earth. Extensions of these capabilities to include either neutralization or destruction appear to be the most effective means of future active defense against enemy satellites. Beyond these extensions, improved inspection of satellites may be attained later through the use of manned systems.

The discussion thus far has tacitly assumed that sufficient time would exist for inspecting, determining hostile intent, and either neutralizing or destroying if needed. This may not be true in the future, where first-pass satellite kill or neutralization may be required. The similarity of the problems associated with this requirement to those existing with the detection and destruction of ballistic missiles during boost make it difficult to specify at this time that a space-based system can be used in this application. Assuming that such problems can be solved, however, it seems clear that a first-pass satellite kill capability based upon the use of space systems would represent a necessary addition to the total force structure.

9. <u>R&D Operations in Space</u>

In carrying out exploratory and advanced developments and in engineering systems for operational use, tests under actual or closely simulated operating environments are necessary. Often, effective tests under simulated conditions require that the environment be duplicated or simulated with an extreme degree of precision. It is true that if a broad theoretical and practical body of knowledge of the environment exists, some meaningful testing can be done without complete simulation, but the lack of such knowledge can seriously depreciate capabilities for meaningful environmental simulations.

Space equipment and personnel are subjected to extreme environmental conditions and also to rapid rates of change. The long-term effects of these are barely understood at all, and the difficulties associated with simulating some aspects of the environment—e.g., weightlessness—appear insurmountable. In addition, technical problems and large costs discourage attempts to simulate simultaneously a large number of the environmental variables which will be encountered in space, particularly when the need is to test large physical objects. On the other hand, the adequacy for testing purposes of simulating only a few variables is questionable, because space systems will be subjected to the combined effects of the environment, not separately or a few at a time. It is for this reason that it appears more economical to conduct many research and development tests in manned and unmanned orbital facilities.

Although progress has been made in the past and will continue to be made even though necessary testing facilities are not provided, progress will be seriously retarded. Where time is not a factor, this slow rate of progress would be acceptable. Such may not be the case, however, when the possible threat from similar Soviet activities is considered.

Other research and development operations in space are required to gain basic knowledge needed for military purposes. Among such activities are those associated with the in-space collection of data on possible military space and ground targets as they would appear to operational sensors in space. Earth-background radiation must be measured by complex instruments in space, in probes or in satellites depending upon the relative cost to accumulate the required data. Experiments to date have been of a rudimentary nature and are insufficient to meet requirements relating to military surveillance of the earth's surface and aerospace. Information on weapon effects in space is needed and can most easily be acquired by the use of space systems. By observing Soviet space research and development activities from orbital platforms in space, considerable knowledge could be gained concerning their rate of progress and the objectives toward which their R&D efforts are being directed. These observations could include both space-to-space and space-to-earth monitoring. This would be of unusual value as an input to intelligence estimates of their present and future capabilities and intent. Thus, there are many R&D activities, ranging from vertical probes into space to manned orbital flights, which are necessary.

B. Future Military Support Operations in Space

In addition to earlier support tasks in space which have been described, other support tasks which are described below are considered essential for support of future military space systems.

1. Space Environmental Monitoring

The need for data on the space environment and its effects on men and equipment are common to all agencies concerned with the design and operation of systems capable of prolonged and dependable operations in space. In the case of manned spacecraft, the need for data becomes acute. For military space operations, there is particular interest in those aspects of the environment which influence the design and operation of military systems.

Much data about the space environment can be inferred or extrapolated from ground or aircraft measurements, and solar activity is monitored by observatories in various parts of the world. Data over a wide range of the electromagnetic spectrum can be attained from space probes or platforms, because atmospheric attenuation is eliminated. However, in the developing of solar flare prediction techniques, continuous monitoring of solar activity from a space platform is essential. Such knowledge is vital to manned space operations in high-latitude orbits or in orbits higher than about 300 nautical miles.

Even though data concerning the Van Allen and artificial radiation belts are being gathered for scientific purposes through the use of probes and satellites, continuous monitoring will be required if manned military missions above 300 nautical miles become practicable and necessary. Thus, a space environment monitoring system will be required which may consist of probes and unmanned orbiting platforms, and which may need to increase in complexity with time. By the use of this system, continuing information concerning the space environment and its time-dependent changes would be made available for military operational uses; even if operated by a civilian agency.

2. Logistics and Rescue Operations in Space

Military operations in space will introduce an increasing need for logistics support, and a space rescue capability is considered an essential adjunct to manned space systems. There is, however, considerable uncertainty concerning the direction in which space logistics may develop. For example, in-space repair may become practicable as military space systems become larger. (It may be cheaper to repair and maintain vehicles in space rather than to abandon and replace them.) As in this example, many of the uncertainties which now exist with respect to future space logistics operations in space are primarily economic rather than technical in nature.

Future logistics operations in space are expected to consist of (1) providing to manned space systems the services of crew rotation, emergency recovery or rescue, and resupply and (2) providing to unmanned missions the services of repair and possibly of recovery. The precise nature of the in-space logistics requirements which will arise and the means which will be employed in meeting those requirements will be, of course, strongly dependent upon the nature of other military space operations. It seems clear that the single, most important consideration affecting the development of future logistics systems is associated with manned military space operations. Regardless of these considerations and others which now appear somewhat less influential, it is expected that the growth of military operations in space will be accompanied by the corresponding need for the delivery of supplies and services from the earth to space.

The need also appears probable for additional logistics services between points in space. This application is readily distinguishable from the ground-based application, and would require the availability of systems capable of shuttling supplies and personnel between orbital vehicles.

Rescue of personnel in space will be of particular significance to manned military operations in space. Unless rescue units are brought into being, maintained on constant alert, and made capable of instantly responding under either combat or noncombat conditions to emergencies requiring rescue of military crews from space, the use of men in an operational military space role may be severely restricted, if not forestalled completely.

3. Crew Training

The need for training of military personnel in space operations is predicated upon the probability that manned military systems will become operationally useful. There may be a number of operational tasks which can be accomplished in space only if manned systems are employed. For example, if operational employment of offensive and defensive forces in space becomes both practicable and necessary, positive control of such forces will be required. Such employment may also require immediate correction of malfunctions, adjustment of instruments, and decisions on the nature of targets or the extent of target damage.

Because of man's ability to exercise control based upon judgment, manned space systems may prove to be the most effective solution to these problems. Thus, man's adaptability to rapidly changing situations, his ability to perceive unanticipated alternative courses of action, and his capability for arriving at reasonable conclusions upon which his actions are taken may provide the only key to the successful performance of many future military operational missions in space.

Based upon the foregoing, future requirements for manned military systems seem inevitable despite present uncertainties concerning the exact military role of men in space.

Preparing now to make available skilled manpower reserves, trained in the basic skills needed for military space flight and possessed of a balanced background in the astronautical sciences, is fundamental to future military competency and proficiency in military space operations. A necessary part of this training must be familiarization with the operation and control of military space systems by actual training in space.

Although some training and experience will be gained by a few selected military personnel by virtue of their participation in the civilian space program, the extent of this and the degree to which it will be applicable to military needs is far short of that which will be required. This is true, not only with respect to actual in-space training and experience, but also with respect to ground operations. Adequate support of future military operations in space will require trained personnel at launch sites, tracking and control stations, data acquisition and communications centers, and at other operational ground locations. The need will also exist for trained military personnel to carry out logistics and maintenance and repair tasks. Thus, in addition to the need to establish and operate suitable training facilities, including in-space facilities, there also exists the need to provide similar facilities for the training of large numbers of military ground-support personnel.

C. Future Military Space Operations

Although the exact nature of future (i.e., beyond the next 7 to 10 years) military space operations is difficult to predict with confidence, there are certain future operations which now appear probable. These are discussed in the following paragraphs.

1. Ballistic-Missile Defense

The technical, economical, or operational feasibility of active missile defense systems is problematical. The results of analyses vary widely, depending upon what areas of the United States are to be defended, the purposes for which defense is to be undertaken, and the performance characteristics which are to be achieved under the variety of circumstances which could arise. Through the development of improved techniques for discrimination between nose cones and decoys, terminal interception with ground-to-air missiles is a distinct probability. However, the destruction of extremely high-yield warheads with a sympathetic autodetonation capability during terminal flight would still lead to considerable surface damage even if the defense system had a kill probability of 100 percent against an individual target and was not saturated. Emphasis must therefore be placed on developing the potentialities of space systems in providing a capability to intercept the ICBM during period of boost or midcourse flight.

From a technical viewpoint, it is impossible to state at this time that the goal of obtaining an active defense against ballistic missiles through the use of military space systems can be achieved. The importance of this to the security of the Nation, however, makes mandatory the pursuit of this objective. The ballistic missile is particularly vulnerable during its launching phase. Earth satellites provide the only potential means for attack during the short time available.

Numerous problems are associated with the design of a space-based interceptor system for operation during missile boost or in midcourse. However, if these problems can be solved, it may be possible to develop a mix of systems including ground-based terminal defense, which may provide a cost-effective level of ballistic-missile defense. Among the technical problems involved in achieving these capabilities are:

-1 Surveillance problems, including IR background discrimination, decoy discrimination, and saturation

-2 Tracking problems associated with saturation, tracking dynamics, and discrimination

-3 Problems in fuzing the kill mechanism

-4 Difficulties in achieving required interceptor performance characteristics, particularly the needed velocity increment and the guidance capability

-5 Problems such as those associated with achieving reliability for long-term operations in space and those associated with operating in the presence of countermeasures.

2. Command-Control and Communications in Space

Evaluation of military command and control systems must include consideration of:

-1 The need for continuous readiness, quick reaction, and continuous positive control

-2 The global distribution of large numbers of units to be controlled

-3 The short time in which vast quantities of information must be collected, transmitted, processed, displayed, and acted upon

-4 The necessity for operating under combat conditions.

These fundamental factors are common to the control of both ground- and orbit-based systems. The extension of military operations into space adds to the magnitude of the problems associated with these factors by increasing the total volume throughout which control must be maintained. Also, weapon systems may possibly be introduced which could reduce even further the time available for exercising control functions. The use of command and control systems for space forces may ease some of these problems by offering wider dispersal of the command-control centers. However, in order for this to be technically and economically feasible, advances in technology and the proven feasibility of long-duration, manned space operations are required. Large amounts of in-space electrical power, for example, are clearly needed, and space-surveillance sensors must be made available.

Of particular significance to the control of in-space military forces from space would be the achieving of space-to-space communications capabilities. Long-range communications between space forces which may operate at altitudes of 500 nautical miles and lower require means for overcoming line-of-sight range restrictions. These may be overcome by methods based upon (1) use of earth-based relays, (2) use of the earth's reflection, (3) reflection from the ionosphere at frequencies below 30 mc/sec, or (4) by the use of aircraft or orbital relays.

The latter method is preferred because these transmission links may be operated at millimeter wavelengths. Certain frequencies in the millimeter band may be used which will be shielded from detection on earth by atmospheric attenuation. This feature affords a high degree of privacy in addition to the wide bandwidth available at these frequencies. Improved capabilities may be achieved later through the use of lasers. The cost to the enemy of interfering with or invading the privacy of such systems exceeds the cost required to similarly affect other known methods of long-range communications.

It may be possible in this period to combine the command-control and surveillance functions into a single military space system. The use of such a dual-function satellite could possibly yield increased cost-effectiveness.

When it is recognized that the survival of ground-based command and control systems is becoming increasingly problematical and that ground-to-space communications may be disrupted or degraded by enemy action, it is to be expected that dispersed space-based command and control stations will offer significant increases in survivability. While the primary application of space command and control stations is expected to be in the control of in-space military forces, such stations, at any given time, may be valuable supplements or the only available element with which to control the surviving ground forces.

3. Strikes from Earth Orbits

The ballistic missile is, at the present time, the most cost-effective weapon available for strategic bombardment. The ICBM is able to penetrate early enemy defenses, and it can survive an initial enemy attack. Given these relative capabilities plus its absolute characteristics of accuracy and lethality and its growth potential, the ICBM will probably remain superior to other known alternatives, including space-based offensive forces.

The strike characteristics of ICBM's and satellite-launched warheads are, in some ways, quite similar. Ballistic re-entry velocities from low orbits are of the same order as those achieved by ICBM re-entry warheads. Electronic and aerodynamic penetration aids are applicable to either system, and it is to be expected that the accuracy and lethality of orbiting systems will at least approach those of ballistic systems. Both systems can have improved penetration through terminal maneuver at the expense of warhead size. (On the other hand, the time of flight from deorbit command to target for satellite-launched weapons initially in correct orbit position is much shorter than the time from missile launch to target. This time could become critical for an element of the strike force; for instance, in producing timely communications blackout after tactical warning.)

If the enemy should achieve an effective AICBM defense system and if he should improve his strike capability, as must be expected with time, the initial survivability of ballistic-missile systems—and thus their cost-effectiveness—will be decreased. Techniques of hardening, dispersal, and mobility will certainly extend the life of the ICBM, but the long-range trend will inevitably be <u>toward</u> obsolescence. No positive claim can be made at the present time that orbiting bombardment systems, either manned or unmanned, will become more cost-effective than missile or aircraft systems. Certain advantages are, however, inherent in the employment of such systems in concert with other systems. The first of these is in the advantage to be gained from the dispersing of strike forces into the volume available within the vast region of cislunar space. The enemy's problems of locating and nullifying such retaliatory forces would add a tremendous load on his resources to the extremely heavy load which would be true at present, even though nuclear warheads may not in general be required for space attack. An additional benefit which may be derived is that the continental United States would be reduced in importance as a primary strategic target. In addition, warning of enemy attack against the strike forces might be earlier if attacks are conducted first against the dispersed forces. This earlier warning may permit more latitude for counterstrike decisions.

Detonations of high-yield nuclear devices either in orbit or at orbital altitude could possibly be used to create widespread thermal damage on the surface of the earth with very small nuclear contamination of the earth's surface. Because the difference between the velocity change required for an ICBM and a low-orbit satellite is small, the payload delivered by a given booster size would be comparable for the two payloads. Again, the advantages of such detonations to an over-all offensive force structure are unclear.

4. <u>Space-Based Satellite Surveillance and Tracking</u>

Satellites which contain high-resolution, multiple sensors which are sensitive to ultraviolet, optical, infrared, and microwave emissions may be able to detect, discriminate, and identify space objects. Because such sensors would be above the earth's atmosphere, freedom from attenuation, refraction, and scintillation should permit line-of-sight detection ranges unattainable with ground-based satellite surveillance systems. Thus, the probable need for high-resolution, all-weather surveillance, detection, and tracking of satellites and ballistic missiles after burnout could be probably met most effectively by space-based systems.

However, the present lack of knowledge concerning differences in target signatures (e.g., temperatures, emissivities, reflectance, and image or shape characteristics) and similar background or decoy signatures causes major uncertainties. Other uncertainties, which are of secondary importance, are concerned with the accuracy of present predictions of the time when suitable sensors of high sensitivities and resolutions can be developed for use in the space environment.

A space-based sensor system may also be the best method to provide continuous tracking and surveillance of satellite and ballistic-missile trajectories. The coverage of such a system may extend even beyond cislunar ranges and with higher precision and resolution than is possible from the ground.

The foregoing is not meant to imply that through future development continuous coverage could not be provided by a vast ground-based system of optical and radar stations. However, the problems of linking together a global, ground network and of processing and correlating data from widely separated areas within seconds may make ground-based systems more costly than space-based systems. Ground-based systems would face the difficulties associated with the atmosphere mentioned above. Although data handover problems also would have to be solved for space-based systems, the problems probably could be resolved in a simpler manner.

Several advantages can be gained by continuous, high-precision and high-resolution tracking of objects in space. If acquisition and tracking of ICBM nose cones can be effected prior to separation and if the warhead can be initially discriminated from any decoys which may be present, then it may be possible to continuously track the warhead through its midcourse trajectory. This would permit quite accurate predictions of instantaneous position information along the trajectory for interception or warning purposes. Smoothing of the trajectory data would be more effective over the longer observation period, and orbital maneuvers or perturbations might be detected immediately. The result of such orbital maneuvers or perturbations when using ground tracking stations (which usually requires iteration of data from many separate stations to establish an ephemeris) might be to lose track. In addition, space-based surveillance together with continuous track may be the best way to provide early warning of attack from deorbiting bombs.

There are many uncertainties connected with achieving space-based satellite surveillance and tracking capabilities. For example, continuous precision tracking will require the stabilizing of high-precision sensors whose orientation accuracies with respect to the fixed stars must be measured or calculated with an error of less than 1 microradian. This angular position, measured with respect to an inertial reference frame, must then be referenced to an earth-centered coordinate system. Problems such as these must be overcome prior to operational employment of space-based satellite surveillance systems.

Regardless of present uncertainties which exist with respect to the development and use of advanced space-based sensors, their basic utility to future military operations in space is clear. It is important, therefore, to press forward rapidly to resolve these uncertainties and, at the same time, to acquire basic data concerning sensor backgrounds in space, expected target characteristics, and other aspects of the space environment which will be important to the operating of sensors in space.

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INTELLIGENCE ESTIMATE OF THE SOVIET SPACE PROGRAM

A. Demonstrated Capabilities

1. General

A review of Soviet space accomplishments to date makes it clear that the USSR has been engaged in a well-planned, long-term program which has contributed to an impressive record of pioneering achievement over the past five years. The Soviet record includes: orbiting the world's first earth satellite and by far the heaviest satellites; launching the first vehicle to impact the moon; launching the first vehicle to transfer from earth orbit to a trajectory towards a planet; the first successful orbiting and recovery of a man; and, most recently, the first concurrent orbital flight and recovery of two manned satellites. These successes represented technical achievements of the first order.

2. Vertical Firings

Soviet space exploration began in 1949 with vertical launchings designed to investigate near-earth space and the effects of that environment on biological subjects. The purposes of these firings include upper atmosphere research, photographing the earth's cloud cover, and space biology. The first firings -- to altitudes of about 55 nautical miles (nm) -- probably involved the collection of geophysical data. Between 1951 and 1960, a series of geophysical and biological experiments were undertaken with vertical firings to about 60, 115, and 250 nm. Dogs were used as specimens in tests of sealed cabins, pressure suits, ejection methods, and re-entry techniques. The data obtained in the Soviet vertical firings contributed directly to the development of life-support equipment and recovery techniques for Soviet manned satellites.

3. Early Unmanned Satellites

Sputniks I, II, and III, launched in 1957 and 1958, were instrumented satellites designed to collect geophysical data on near-earth space, and to provide some biological data. After these three shots, Soviet launchings until the spring of 1962 were devoted to lunar and planetary exploration, and particularly to the man-in-space program.

4. Lunar Exploration

Other than vertical firings, the only Soviet space launchings conducted during 1959 were those related to lunar exploration. Lunik I,

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which was launched in January, scored a near miss, and went into solar orbit. Lunik II successfully impacted on the moon in September. Both of these flights provided some data on the nature of space between the earth and the moon. Three weeks later the Soviets successfully sent Lunik III on a circumlunar flight and obtained the first photographs of the hidden side of the moon.

5. Planetary Probes

In October 1960 the Soviets were twice unsuccessful in launching probes toward Mars. In February 1961, the Soviets failed in an attempt to launch a Venus probe from Sputnik VII. They succeeded later in the month with Sputnik VIII, but lost contact with the probe early in its flight, and thus failed to achieve their major scientific objectives. In late August-early September 1962 the Soviets made three attempts to launch a probe to Venus; in each case they succeeded in placing a satellite in parking orbit, but due to a malfunction of the injection stage, failed to launch the probe toward Venus. They experienced a similar failure in attempting to launch a Mars probe from an orbiting satellite in October. They succeeded on 1 November, but failed in yet another attempt on 4 November.

6. Man-in-Space

The major emphasis of the Soviet space program has been given to manned space flights. In 1960 three heavy satellites, Sputniks IV, V, and VI, were orbited for the purpose of checking out such design features as stabilization and control, life support equipment, retrorocket operation, and re-entry and recovery. In addition, Sputnik V carried a large variety of biological specimens. Sputniks IX and X, launched in March 1961, were prototype tests, probably simulating in all respects the first man-in-space shot except that the passenger in each case was a dog. Two weeks later came the flight of Major Gagarin in Vostok I, with recovery after a single orbit around the earth. In August 1961, Major Titov in Vostok II remained aloft more than 25 hours and completed 17 orbits around the earth. On 11 August 1962, Major Nikolayev was orbited in Vostok III, and about 24 hours later, Lt Colonel Popovich followed in Vostok IV. The two were brought down on 15 August -- Nikolayev after some 64 orbits in 95 hours, and Popovich after 48 orbits in 71 hours. We believe that the Soviets attempted to put the two satellites into nearly identical orbits. They were able to orbit the space ships in close proximity (about 5 nm) at one point, after which the distance between them widened. This achievement attests to the reliability of Soviet space boosters, guidance equipment, life support systems, and recovery techniques.

7. The "Cosmos" Series

Late in 1961, the Soviets began a new series of space launchings, the unmanned "Cosmos" series, with the stated purpose of collecting astrophysical and geophysical data, and of testing satellite structures. The first two launchings were unsuccessful. Since March 1962, a total of 12 "Cosmos" satellites have been successfully launched — 7 from Kapustin Yar and 5 from Tyuratam. Our evidence on the "Cosmos" series indicates that two programs are involved:

a. The satellites launched from Kapustin Yar have transmitted data on near-earth space compatible with the Soviet claim of a scientific collection effort, probably including data on nuclear tests. Our data on the vehicles suggest the use of a booster smaller than the first generation ICBM and a payload much smaller than the Vostok spacecraft.

b. The "Cosmos" satellites launched from Tyuratam appear to have been primarily associated with the man-in-space program. First-generation ICBM boosters were employed to put Vostok type vehicles (weighing approximately 10,000 pounds) into orbit. These vehicles were later recovered. The first two probably served to check out equipment and collect data for flights of Vostoks III and IV. In addition, preliminary analysis of telemetry from Cosmos IX indicates that cloud photography was attempted. However, we do not know the contents of the recovered capsules; their size and payload capabilities would have permitted other missions.

B. Developments Which Would Contribute to Military Capabilities

Since its inception, the USSR's space program has been closely linked to its military missile program. The two programs have used the same boosters and launching facilities, and are mutually supporting in other respects as well. We believe that many of the scientists, engineers, and technicians who are working on space projects are also involved in the Soviet missile program.

1. Propulsion Systems

The first-generation ICBM (termed Category "A" and SS-6 by US Intelligence) has been the workhorse of the Soviet space program to date. This reliable, powerful booster, with an estimated sea level thrust of 750,000 pounds, has enabled the Soviets to orbit the heaviest earth satellites. Employed with a powerful upper-stage propulsion unit, it has enabled the USSR to place some 14,000 pounds into orbit at an altitude of about 100 miles.

A new two-stage Soviet ICBM (termed Category "C" or SS-8 by US Intelligence) has been observed in flight testing on the Tyuratam range for more than a year. We have been unable to determine the size or thrust of this vehicle.

If the SS-8 is not a large vehicle, we believe that the Soviets are developing yet another ICBM to deliver very large payloads of up to 100 MT yield, and that they will begin test-firing the new vehicle within the next year or so. A reasonable range for the thrust of a new ICBM booster capable of delivering 100 MT payloads is one to one-and-one-half million pounds. Facilities at Tyuratam already exist to accommodate boosters of this size.

Such a booster would allow the USSR to undertake a number of space missions which are beyond the capability of the first-generation ICBM booster. Heavier planetary probes could be launched, facilitating unmanned planetary exploration. It could also be used for docking and transfer operations involving heavier weights of men and material. If such a booster becomes available within the next year or so, it could be used for the establishment of a manned space station or for a manned circumlunar flight somewhat earlier than the 1965-1966 date estimated for these accomplishments with a multimillion pound thrust space booster.

The development of improved upper stages is also indispensable to successful accomplishment of a manned lunar landing. There is no evidence that the Soviets have undertaken the development of upper stages which utilize high-energy propellants. However, they almost certainly are investigating the advantages of higher specific impulse fuels for use in future propulsion systems. The specific impulse generated by the oxygen-amine fuels now in use could be increased by about one-third with oxygen-hydrogen or fluorine-hydrogen. 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 1963-1965 period. Upper stages of these types, when employed with the SS-6 booster, could increase its payload capacity for near-earth satellites to some 20,000-25,000 pounds. For manned lunar landing operations, the Soviets probably would combine these advanced upper stages with new, large boosters.

At a later time period, perhaps toward the end of the present decade, the Soviets could probably have a nuclear-hydrogen powered upper stage available for first flight tests. Such a system could produce more than twice the specific impulse of present fuels, and would be useful for orbiting very heavy payloads, for deep space probes, and for interplanetary missions.

2. Guidance and Recovery

Soviet space vehicles launched from Tyuratam have thus far used the basic first-generation ICBM guidance -- a radio-inertial system -- during the boost phase. Although the Soviets have an all-inertial system operational with their missiles, they may choose to continue with the radio-inertial system for space ventures. The Vostok recoverable vehicles probably used an earth fixed reference system using optical and gyroscopic sensors. In addition, the manned Vostoks incorporated a system which enabled the pilot to assume control at will. The system has so far deorbited a satellite under only one set of conditions of time and place. The evidence does not indicate whether the system as designed could perform in any more generalized situations.

The orientation system used in orbiting and recovery of earth satellites has probably been adopted for the earth orbit portion of planetary probe operations. Although Soviet tracking appears capable of accurately defining the spatial location of the vehicle, the accuracy of orientation required for fully successful Mars or Venus probes may be beyond the capabilities of an earth fixed reference system. We have some evidence that the Soviets have developed a system based on stellar guidance or stellar attitude control.

3. Instrumentation

The Soviets have competent scientists and engineers in the instrumentation field, but they do not have enough to provide the wide variety of instruments and the number of refinements desirable for some advanced scientific space programs. By closely following Western developments in the field of instrumentation and by concentrating Bloc resources on priority programs, the Soviets have been able to meet the needs of their space programs. They will probably be able to provide the instrumentation adequate for the space ventures which could be undertaken in the period of this estimate.

4. Tracking and Communications

The chief limitation on Soviet capabilities for tracking and communicating with space vehicles is the lack of a global tracking network capable of continuous observation and communications with satellites and space probes. Facilities in the USSR are adequate to determine the initial trajectory with a high degree of accuracy. To extend their monitoring capability, the Soviets rely on specially instrumented ships, relieving to some degree the lack of land facilities. However, the value of these ships is limited, because of the difficulty of accurately determining their positions. Thus far, Soviet capabilities in this field have been generally adequate for the missions undertaken — indeed, they have probably, to some extent, shaped those missions.

The Soviets have demonstrated a capability for tracking and transmitting data to lunar distances, but they were less successful with the deep space shot to Venus in 1961. To date, we do not know the degree of success they are experiencing with the Mars probe launched 1 November. Although they can probably overcome the communications difficulties experienced with the Venus probe, they have not yet tested a tracking system with the sophistication necessary for deep space exploration. Tracking stations in other hemispheres would be a major aid to mid-course guidance and to achieving better terminal accuracy. There is evidence that the USSR is seeking to acquire sites for space tracking stations in Chile, Indonesia, Africa, and Australia.

A major element in tracking, control, and communications is the provision of adequate power supplies for the space vehicles themselves. Soviet space vehicles have not demonstrated a capability for sustained communications over long periods of time. We believe, however, that this apparent weakness can be overcome. In addition to improvements likely in solar batteries and other power sources, the Soviets probably are developing nuclear-power sources for use in space vehicles. In the near future, they could have a reactor-type power supply with an output of several hundred watts. By 1964 output could be increased to 75 kilowatts, and by 1971, it could possibly be further increased by a factor of 10.

5. Data Processing

Advanced data processing techniques are required for the rapid determination of orbits and trajectories from a large number of observations of space vehicles. The ability of the Soviets to process data for such missions as re-entry and extra-terrestrial launches from parking orbit indicates that high performance computers are being used. Indeed, a propaganda film on the Titov flight revealed that an advanced Soviet digital computer, capable of 20,000 arithmetic operations per second, was employed in space-track computations and data handling. Computers of lesser performance are probably used for pre-launch calculations and other operations where speed is not so vital.

The Soviets will probably continue to seek increased computer reliability and speed of operation, and will seek to reduce size, weight, and power requirements. The Soviets have in operation at least one computer capable of 50,000 operations per second, and are probably developing computers capable of 100,000 operations per second. In the 1965-1970 period, the Soviets could probably have computers utilizing only solid-state devices capable of a million operations per second. In developing computers for space vehicles, they will probably achieve some success in micro-miniaturization.

6. Rendezvous, Docking and Transfer

We believe that over the next few years the Soviets will conduct space experiments directed toward the development of rendezvous, docking, and transfer techniques. The recent launching of two satellites into similar orbits at the same time may have been a first step in this direction. Within about the next year, the Soviets could probably conduct rendezvous operations employing space vehicles having some maneuverability while in orbit. Docking operations, which might include an initial demonstration of the transfer of a man from one space vehicle to another, could probably be achieved shortly thereafter. In order to transfer men and materials in quantities sufficient for long-lived space stations, the Soviets would probably require considerable experience, heavy satellites, and a new large booster. Such a capability could probably be achieved in about 1965.

7. Life Support Systems

We believe that the Soviets now have a partially closed-cycle oxygen system which, with their current payload capability, would permit one-man orbital missions of up to 10 days. With modification of the Vostok vehicle, this system could support two men for a shorter period. Missions of over 90 days duration would require a reliable, fully-closed-cycle ecological system, capable of supporting more than one man. Barring any unexpected breakthrough, we do not expect such a Soviet development before 1966. Attainment of a capability to orbit larger payloads would ease some of the present constraints on the size and weight of life support systems, making possible the development of manned space stations. These could serve as orbital laboratories, for obtaining more knowledge of the space environment and for testing life support, navigation, communications, and operational techniques.

C. <u>Military Application vs Basic Scientific Investigations</u>

It seems clear that the underlying motives of the Soviet leaders in planning their future space effort — as in planning for other types of national effort — are to enhance the security of the USSR and to increase its power and prestige, gaining advantages over the US where possible. In making decisions about the specific projects to be included in their future space programs, the Soviet leaders will continue to be guided by such general considerations as: the political benefits that are likely to result from particular space accomplishments; the potential military value of the space projects which are considered, planned, or undertaken; and the technical and economic limitations that determine the range of their choices. We believe that these considerations, as well as the desire to achieve scientific gains, will incline the Soviets toward a much broader space program than in the past. Whether particular projects will be pursued, however, will depend on the Soviet view of their potential contribution to national power and prestige, weighed against the cost of accomplishing them.

Our evidence as to the future course of the Soviet space program is very limited. Soviet propaganda dealing with future space activities has canvassed the whole range of possibilities. Our estimates are therefore based largely on extrapolation from past Soviet space activities and on judgments as to likely advances in Soviet technology. Considering the available evidence and Soviet capabilities, this program probably will include a variety of specific objectives. It probably will be characterized by an expansion of man-in-space activities and by the acquisition of basic scientific information needed for future space missions. Greater emphasis than heretofore will probably be placed on military applications of space vehicles, both to meet specific Soviet requirements and to keep pace with military programs which the Soviets expect the US to undertake. Unmanned lunar exploration will probably soon be resumed, and interplanetary probes launched when favorable opportunities occur.

D. Military Goals

On the basis of evidence presently available, we are unable to determine the existence of Soviet plans or programs for the military use of space. Soviet motivations and objectives relating to the development of systems for space warfare would logically be subject to very stringent security and would therefore remain undeclared. However, we believe that the USSR most certainly is investigating the feasibility of space systems for military support and offensive and defensive weapons. The Soviet space program itself — its technical characteristics, its direction of development, its pace, its priority, and its position vis-a-vis the ICBM program and the use which has been made of it thus far in enhancing the national Soviet image — is its own best indicator of military capabilities and intent.

We believe the goal of world domination remains as a basic objective of the USSR. The development of a strong, flexible military force is consistent with this objective, and we do believe that they seek -- as an ultimate military goal -- the development of a clear military superiority over the US. How this could be achieved is not now apparent. We feel sure that they now recognize that a very large inventory of present offensive weapon systems, i.e. manned bombers and SSMs, will not lead to a position of military superiority. Vigorous Soviet efforts in the fields of space exploration and ABM defense support this belief. Development and exploitation of space warfare systems could be one means chosen by the Soviets to significantly upset the power balance vis-a-vis the US. However, the achievement of a space force of significant potential undoubtedly will be so sensitive to the imponderables of space research and exploration (both Soviet and US) that no timetable of positive space military force strengths or character can be postulated. We believe that the Soviets do have a requirement to investigate so as to determine the feasibility of space warfare systems and that they do plan to develop, produce, demonstrate, and/or deploy such systems when it is to their advantage to do so.

We believe that the first Soviet military space vehicles are likely to be earth satellites used in various support roles. We do not believe that the Soviets have as yet launched geodetic, communications, or navigation satellites for military purposes. The recovered satellites in the "Cosmos" series probably accomplished cloud photography, and could have performed photographic, electronic, and nuclear reconnaissance, at least experimentally. In addition, one "Cosmos" satellite launched from Kapustin Yar probably monitored the radiation from a Soviet nuclear test in space.

Soviet scientists and military experts almost certainly recognize that earth satellites have a greater potential than conventional techniques for some forms of reconnaissance, early warning (EW), weather surveillance, and communications. In view of the US ICBM threat, we believe that an EW satellite is probably a most pressing requirement in this field. The Soviets may also develop reconnaissance satellites. Although their intelligence on deployment of fixed US targets is probably adequate, such satellites could provide some useful information on certain mobile forces and could perform poststrike reconnaissance. Targeting requirements may also lead the Soviets to a geodetic space program. However, this would require improvements in tracking technology and the establishment of tracking facilities outside of the Soviet bloc, and particularly in the Southern Hemisphere. The Soviets amy also develop navigation satellites to improve the effectiveness of their missile submarine forces, as well as communications satellites.

We believe that the USSR will develop a capability to counter reconnaissance satellites. Surface-launched non-orbiting missiles are the simplest approach to the neutralization problem, and the most likely to be used by the Soviets throughout this decade. By assembling a system using radar and passive tracking facilities, missiles, and warheads from existing defensive systems, they might be able to intercept US satellites now, and they would almost certainly have a capability to do so within the next year or so.

The Soviets may be developing orbiting systems for anti-satellite employment. By 1964 the Soviets could use a rendezvous technique against a non-maneuvering satellite for inspection. A more sophisticated system with a damage assessment capability could be achieved late in the decade. However, an anti-satellite system designed to use a single satellite against multiple targets would be very complex and expensive, and we do not believe it will appear within the next 10 years.

Although we have not identified any Soviet offensive space weapon systems, the Soviets have the capability to develop an orbital bombardment satellite and could launch and deorbit a space weapon at an early date for propaganda or political reasons. A demonstration of such a satellite could occur at any time, but we believe that in the near term its military effectiveness would be minimal.

Within this decade, the basic factors of reaction time, targeting flexibility, accuracy, vulnerability, average life, and positive control for an orbital bombardment system almost certainly will not compare favorably with ICBMs. We believe that a Soviet decision to develop and deploy an orbital bombardment system would depend in large part upon the extent to which these drawbacks can be overcome. If the Soviets decide to develop an orbital bombardment force, it would be preceded by a developmental system of limited military effectiveness which could appear as early as 1965.

The ultimate potential of space as a medium for the development of offensive weapons of interference or destruction may rest with the creation of "kill" mechanisms of an as yet indeterminate category. It is possible that space exploration, which is totally new to human experience, will offer unforeseen opportunities for military application, and the Soviets certainly sense, if they do not actually know, some of the advantages that such a military capability may give them. This view is supported by a Soviet Defense Ministry Document which states:

"The Soviet Government is not limiting itself to those military means which the adversary already has. Undoubtedly this would be insufficient. The creation of new methods of combat which the imperialist aggressors still do not possess is the task of Soviet science and technology. Any pre-empting of the adversary's potential in the creation of the newest means of combat . . . gives undoubted superiority in case of war. . . ."

It is axiomatic that only after a nation has gotten into space in a permanent, routine, fashion will the principles and techniques for such new systems become evident. It is possible that the USSR will be the first to uncover new methods of warfare, and this in the ultimate, may be the real threat from space which one can postulate on the basis of current knowledge of the Soviet program.

In summary, military systems considered to be within Soviet capabilities include early warning and reconnaissance satellites from 1962 on; with meteorological, communications, geodetic, and navigation satellites, having commercial or military application, possible in the 1962-1963 period. With respect to defensive systems, a capability to inspect a single nonmaneuvering satellite is possible by 1964, with a more sophisticated co-orbital anti-satellite system probable later on in the decade. Offensive space weapon system possibilities include the capability to demonstrate an orbital bombardment satellite now, and a developmental system of limited effectiveness by 1965.