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THE STRATEGIC SIGNIFICANCE

OF

SPACE SATELLITES

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INTRODUCTION

> He /the student of Naval Warfare/ will observe also that changes of tactics have not only taken place after changes in weapons, which necessarily is the case, but that the interval between such changes has been unduly long. This doubtless arises from the fact that an improvement of weapons is due to the energy of one or two men, while changes in tactics have to overcome the inertia of a conservative class; but it is a great evil. It can be remedied only by a candid recognition of each change by careful study of the powers and limitations of the new ship or weapon, and by a consequent adaptation of the method of using it to the qualities it possesses, which will constitute its tactics. History shows that it is vain to hope that military men generally will be at pains to do this, but that the one who does will go into battle with a great advantage - a lesson in itself of no mean value.[1]

These words were written nearly three-quarters of a century ago during the transition from sail to steam in an era when the words "strategy" and "tactics" were well defined, when technological progress was so slow as to be almost accidental, when the energy of one or two men could effect the improvement of weapons, and when changes in tactics did necessarily take place after changes in weapons. Times have changed. Destroying a city in a flash of atomic fury is now a strategy. No single mind can even comprehend the stream of technological and scientific discoveries pouring from laboratories around the world in a daily flood. No one or two men can any longer claim credit for a major advance in weaponry, nor do tactics necessarily follow development of the weapon. Today, the tactical requirements of the situation are determined and then the weapon is designed to carry out the prescribed tactic. One thing has not changed. The inertia of the conservative class is with us still.

The initial reaction of public leaders to the launching of the first Russian satellite established the conservative

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[1]Captain A. T. Mahan, The Influence of Sea Power Upon History, pp 9-10.

attitude. Four days after the first launching, Secretary of Defense Wilson discounted the military significance of the Soviet Satellite and called it a neat scientific trick.[2] The same day, Secretary of State Dulles observed that it was not yet clear whether there would be any great value to satellites.[3] A day later, President Eisenhower said the satellite was not revolutionary in the military sense and predicted that even reconnaissance satellites ". . . able to transmit to the earth some kind of information with respect to what they see on the earth or what they find on the earth. . ." are ". . . a long ways off. . ."[4]

Struck by the modern connotation of Mahan's advice in contrast with the words of today's leaders, the author endeavors in this paper to study the powers and limitations of this new device and the extent to which these qualities could be adapted to military use. In order to permit the widest discussion of the subject, classified material has been avoided, nor is it necessary. The public press is overflowing with information and speculation on the subject. The difficulty is to separate the facts from the speculations. In this paper, the qualities attributed to the satellite of the future are those qualities for which the basic technology has been demonstrated for all to see. The performance of the satellite and its equipment is admitted to be an extrapolation of growth based on the demonstrated state of the various arts and assumes a high expenditure of national effort and resources. This is not a technical research paper although reference is made to sources of certain statements

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[2]New York Times, Oct. 9, 1957, p 1.

[3]New York Times, Oct. 9, 1957, p 1.

[4]New York Times, Oct. 10, 1957, p 14

which may not be widely known, but which establish the technical bases for the extrapolations. The extrapolations are the author's own. Since the author makes no claim to expertness in these technical fields, these opinions amount to speculation, as is any study of the shape of things to come, but an effort has been made to strike a reasonable compromise between the inertia of conservatism and the unbridled fancy of fanaticism.

THE STRATEGIC SIGNIFICANCE OF SPACE SATELLITES

CHAPTER I

BASIC CHARACTERISTICS OF SPACE SATELLITES

SPEED:

Speed is an inherent characteristic of satellites. Maintenance of an orbit depends upon maintaining a speed which will cause sufficient centrifugal force to counteract exactly the centripetal pull of gravity. This speed increases with closer orbits because of the greater pull of gravity and decreases with more distant orbits. Because of atmospheric drag, about 200 miles appears to be the minimum practical orbit height. At this level, satellite speed is approximately 18,000 miles per hour and a complete orbit will occur every hour and a half. The speed required for a 1,000 mile orbit is approximately 15,000 miles per hour and an orbit requires two hours.

Because of the rotation of the earth, orbits also appear to have a rotational speed, being displaced westward about fifteen degrees of longitude per hour or 900 miles per hour at the equator. In a 22,000 mile orbit, a satellite would complete an orbit every 24 hours. If traveling west above the equator in such an orbit, a satellite would appear to the earth observer to be fixed in space. In such an orbit, displaced north or south of west, the satellite would appear to move north and south between fixed latitudes, maintaining the same longitude.

CONTROL:

A true satellite, once established in orbit, cannot be controlled in its path. The path could be changed by the application of thrust, however, the vehicle would then no longer be a satellite, but a powered space craft. This is a natural, evolutionary development, but is beyond the scope of this paper. The control of true satellites is exercised only during launching. The orbit is established during powered flight by controlling azimuth, altitude, and speed. The three successful launchings of satellites at this writing have demonstrated a state of the art capable of controlling orbits to within two degrees in azimuth and less than 100 miles in minimum altitude. The lack of symmetry in the vertical plane of these satellites is undesirable in most military applications but should not be prohibitive even before further development of the art permits closer control.

Even without powered space flight, the selection of azimuth and altitude afford considerable flexibility of control over the terrestial track of the satellite. An hour and a half polar orbit, 200 miles up, will provide a track spacing of some 720 miles at the latitude of Moscow and 1350 miles at the equator. The same orbit inclined 30° from the polar axis would provide track spacing of about 300 miles at the latitude of Moscow and 1200 miles at the equator. If the altitude in the first example was increased to 1000 miles, giving a two hour orbit, the track spacing at the equator would be 1800 miles and at Moscow, 990 miles. The combinations are infinite, hence, for any single satellite, the track spacing and frequency of passage as well as height above the earth can be selected for any latitude of interest.

PAYLOAD:

There is no theoretical limit to the payload of a satellite, although the cost of designing and constructing mammoth, expendable launching vehicles does place a practical economic weight limit. In recognition of this undefined limit, both scientific and military thought has turned to construction of satellite stations assembled in space from individual, separately launched loads of constructing material. This technique is being studied but practical demonstration has not been achieved.

With rocket motors now available, payloads of 30 pounds have been launched by this country, while Russia claims a satellite of about 1120 pounds. This weight is believed to include the last stage rocket body, so that the actual payload is presumably less. Both the U.S. Army and the U.S. Air Force have announced proposals for launching satellites weighing up to 3000 pounds within the next year. The U.S. Navy has not released the details of its satellite planning beyond Vanguard which is only a 20 pound device. The Army launching of Explorer I demonstrated the feasibility of combining several rockets in one stage, a method of launching heavier payloads without increasing the size of basic propulsion units. Further advances in the size and efficiency of propulsion plants are planned or are under study and include a million pound thrust rocket and a nuclear powered rocket of unspecified size. It thus appears that military planners can think in terms of 3000 pound satellites in the near future (two years) and single-load satellites of several tons in the long term (two to twelve years), with the possibility within or following this period of multiple load satellites of practically unlimited size. Russian capabilities can only be surmised but should be no less than the above.

ENDURANCE:

One of the inherent characteristics of satellites is their endurance. The first Russian satellite had a life of three months. The second Russian satellite and the first U.S. satellite are still in orbit after four and two months respectively, with life expectancy forecasts varying from months to years. After data obtained in exploratory flights are assimilated, life expectancy can be predicted with reasonable accuracy.

POWER AND POWER SOURCES:

Unlike other military vehicles, a satellite requires no power to maintain its speed, since friction is virtually lacking in space. To be useful, however, a satellite must do something. To do anything useful, it must have a source of power for its equipment. Conventional sources of self-contained power, such as batteries, internal combustion engines, and reaction motors could be used, but weight limitations would drastically limit the endurance of these power sources and make them incompatible with the inherent endurance of the satellite itself.

The three satellites launched at this writing have depended upon battery power for energy. Vanguard satellite equipment will be powered by highly efficient storage batteries which will be recharged by solar units, photo-electric cells which produce electricity direct from sunlight. This is the same process which moves the needle in photographic light meters. The tiny units in Vanguard will produce only 40 milliwatts and then only during the half of any orbit which lies in sunlight. This tiny amount of power, however, is sufficient to extend the useful life of the scientific and radio equipment to about seven months before the batteries themselves fail. The Russians claim to have produced up to 50 watts of power with photo-electric cells.[1] Theoretically, at least, one square yard of photo-electric surface can produce 100 watts of power.[2] Considering the probable surface area of a 3000 pound satellite, and the added possibility of extending photo-electric panels, it should be possible to obtain sufficient power to operate most low-power equipment during its unrepaired life. Other approaches to this problem are using thermo-electric couples, solar heat, and radioactive fuels.[3]

CURRENT USES:

The first three satellites are useful for scientific research only. Ingenious miniature devices measure, record, and report such phenomonen as temperature, cosmic and solar radiation, the impact of meteorites and the erosion effect of meteorite dust. The second Russian satellite carries a dog and devices reported the physiological functioning of a mammal in weightless space. Each of the satellites, by their paths alone, provide significant data on the composition of space and the size, shape and mass distribution of the earth.

VULNERABILITY:

At present, satellites are invulnerable to man's destructive efforts. Potentially, a satellite is highly vulnerable to destruction.

The first element in any problem of destruction is detection. Satellites are relatively easy to detect, either

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[1] New York Times, Feb 3, 1958, p 20.

[2] Readers Digest, Jun, 1955, p 74.

[3] New York Times, Feb 3, 1958, p 20.

visually or electronically, through radio direction finding or radar. The Massachusetts Institute of Technology also reported that it was able to pick up the Russian satellites by infra-red detection.[4] Because a satellite is in a predictable orbit, it is easily tracked. It cannot take evasive action. Because of its speed and small size, the problem of deflection of the intercepting weapon would be greater than any ballistic problem yet solved.

Point-defense anti-missile missiles may not be effective against a satellite. Missile speeds need not be as great as satellite speeds. Since a missile must plunge to earth to destroy its target, an anti-missile missile launched from the vicinity of the target would have a down-the-throat shot in which deflection errors are minimized and extreme intercept speeds are not necessary. Interception could be effected within a layer of the stratosphere sufficiently dense to permit aerodynamic control of the interceptor in power-off flight.

The satellite intercept problem is more complex. The speed is higher, increasing the deflection problem. It does not present a down-the-throat shot, so that interceptor speed must be comparable to satellite speed if not greater. Interception must occur in space where aerodynamic control is not possible. Interceptor guidance must either be along a ballistic path, increasing the deflection error, or must be accomplished by powered flight all the way to the satellite, probably along a pursuit curve. Of course, none of these problems are insurmountable, involving only known techniques. In any case, the intercepting weapon will inherit the same

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[4] Aviation Week, Nov 4, 1957, p 31.

type of performance advantage over the satellite as the fighter has so long enjoyed over the bomber.

CHAPTER II

POTENTIAL DEVELOPMENT OF THE SATELLITE

RECONNAISSANCE VEHICLE:

Because of its high speed, long endurance, and high altitude, the satellite offers great potential as a reconnaissance vehicle. Most military detection mediums now known are applicable to space. There are exceptions, such as sonar and magnetic anomoly detection. Optics (both ocular and photographic), electronics (including radar and passive detection), and photo-electric means (including television, infra-red, and light amplification) are all applicable, in principal, to space-based reconnaissance. All would suffer in some degree from decreased accuracy in bearing, range, and resolution due to increased ranges and most suffer inaccuracies due to atmospheric refraction and diffusion.

Optics:

Optical reconnaissance, particularly photography, is probably the most revealing and accurate medium. Both darkness and atmospheric obscuration interfere with photography. This is a handicap which has been accepted in the past and is no reason to discount photography in the future. Space photography has been demonstrated. In May 1954, a Viking II rocket, fired to an altitude of 140 miles photographed much of the southwestern United States and northern Mexico.[1] In August 1957, a special telescope camera, suspended from a plastic balloon above 80,000 feet altitude, photographed the sun, not merely in its entirety, but in pre-selected

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[1]"On Top of the World", Interavia, July 1955, p 504.

areas of its rim.[2] This demonstrated an extremely high degree of directivity.

Lieutenant General Clarence S. Irvine, Deputy Chief of Staff, Air Force, has been quoted by the New York Times as stating that present development of optics and photography would permit observation of a ground position from a 5,000 mile orbit "as well as if we were flying an airplane at 10,000 feet."[3] The weight of such a device was not specified, but would of necessity be greater than that required for closer observation.

Satellite photography presents at least two obstacles not encountered in these experiments. The first is recovery of the film from orbit. The second is the limited load of film which could be carried relative to the high cost and long life of the satellite. Missile nose cones have been recovered so there is reasonable expectation of recovery of photographic film at some future time. This is a matter of development, not scientific break-through, and will undoubtedly be achieved in the near future, either by Russia or the West. The limited film load is a relative matter and the high cost of space photography must be accepted because of its value. There is compensation, too, in the fact that, with the useful life of a photographic satellite limited by film load, the satellite life can be made compatibly shorter by selecting a lower orbit, permitting more detailed photography.

Electronics:

Most of the problems now encountered in airborne

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[2] Aviation Week, Oct 28, 1957, p 27.

[3] New York Times, March 5, 1958, p C11

electronics will be encountered in space. Increased speed and line of sight ranges are the principal advantages, although weightlessness and lack of atmospheric drag in space may permit drastic reduction in structural weight, particularly in antenna systems. Antennas might well consist of coated plastic balloons similar to those now used in the Distant Early Warning line. Antenna scanning and stabilization might be obtained by spinning the entire device. Only by the use of tremendous antennas or extremely high frequencies, possibly even pulse modulated light, can satisfactory target discrimination be obtained at the extreme line of sight ranges offered by the satellite. The ranges themselves are already available in missile tracking radar and in passive direction finding equipment. An Army spokesman recently announced radar developments which would double the range of Air Force radar which is already capable of tracking ballistic missiles at a range of 3000 miles.[4] Ground return may limit the usefulness of space radar against land targets, but seaborne targets should be vulnerable to detection to the line-of-sight limit desired. Airborne or space targets would also be vulnerable to space radar, especially if in a position nearer to the satellite than the height of the satellite's orbit or if above the satellite's horizon. In connection with tracking the first Russian satellite during its disintegration orbit at about 180 miles altitude, scientists, with hastily assembled equipment, were able to detect the passage of the satellite by means of radio waves reflected by its ionized trail through this region of rare atmosphere. This is a form of radar. Similar

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[4] New York Times, March 5, 1958, p C11

trails are left by meteors and missiles.[5]

Although passive electronics detection is not affected by land return or sea return, the great number of transmitting stations in a large land area may well saturate the detection system to some degree, a problem not normally present in sea areas. Passive electronics detection systems do not yield target range directly, however, the speed and predictable path of the satellite should permit rapid location of the target station by automatic, continuous triangulation. Triangulation would also compensate for radar range errors caused by vertical bending of radio waves in the ionosphere.

Photo-electric:

Photo-electric detection will be considered in three parts: television, infra-red, and nuclear radiation. The major disadvantage of television compared to photography is limited discrimination, although military television could be greatly improved in this respect over commercial equipment. It suffers the same disadvantages of being subject to atmospheric obscuration and of being limited to lighted areas, although moonlight might be adequate with highly developed equipment. It, too, fails to provide exact target location directly. Because of scope distortion, it cannot approach photography in accuracy. Television, however, has four significant advantages. It has no film load limitation, no film recovery problem, it transmits instantly, and is applicable to satellites now. Both the Army and the Air Force have proposed launching television reconnaissance satellites within the coming year.[6] Early satellite television will probably be direct-transmitting, this is, the video signals

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[5] _Aviation Week_, Jan 27, 1958, p 37.

[6] _New York Times_, Feb 4, 1958

will be transmitted as generated by the scanner. This poses obvious problems when the satellite is scanning deep inside unfriendly territory, an area of prime interest. All major U.S. television networks now record programs on magnetic tape for delayed transmission. To them, this technique has the advantage that long delays in processing the movie films formerly used are eliminated. The results are also clearer than filmed programs.[7] This technique, applied to military satellites, would permit data obtained over enemy territory to be stored and played back over friendly stations on demand. The tape is reusable. The process is applicable to any data transmitted on electronic circuits and is scheduled for transmission of limited scientific data in Projects Vanguard and Explorer.

Infra-red:

Infra-red reconnaissance is basically optical reconnaissance but below the visible spectrum. Its primary advantage is its potential of operating in regions of darkness and the detection of such invisible targets as ship wakes and rocket trails by their temperature alone.

Infra-red photography is slightly superior to normal photography in penetrating fog and haze and in detecting certain types of camouflage.

Thermal-electric infra-red reconnaissance is comparable to television in principle. The differences between the two arise from different operating wave length. Different lens material and different detecting cells are required. Cell technology, the limiting factor in the art, is presently based on empirical data and significant improvement in the state of the art will probably come about only by intense

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[7]Popular Photography, Feb 1957, "Will Tape Replace Film?"

basic research.[8] Nevertheless, the crude equipment presently available has been used for such military purposes as sniper rifle sights, anti-aircraft missile guidance and ship wake detection. Massachusetts Institute of Technology scientists and others were even able to track the first Russian satellite on hastily improvised infra-red equipment.[9] This is a significant development but is not comparable to detecting small military targets on the ground against the inherent infra-red "noise" background of the earth's land surface. Large targets such as cities or even blast furnaces and the column of hot exhaust gases from the rocket engines of a ballistic missile should be "visible" from space at the present state of the art. In the case of the missile, cloud cover would be no hindrance to infra-red detection from space since most of the missile's powered flight would be above any cloud cover. Admitting the limited state of the art and the questionable probability of significant improvement, infra-red in a satellite could provide military information not obtainable by other means and will probably supplement other reconnaissance techniques.

Nuclear Radiation Reconnaissance:

Nuclear radiation is easily detected with light-weight equipment now in use. Mounted in a satellite, this equipment would permit continuous monitoring of nuclear explosion test sites and impact areas, radio-active clouds and fall-out, and possibly certain types of power plant and experimental installations. Some types of radiation are subject to atmospheric attenuation and would not be susceptible to satellite detection.

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[8] Scientific Monthly, Jan 1956, p 3 "Recent Developments in the Detection and Measurement of Infra-red".

[9] Aviation Week, Nov 4, 1957, p 31.

Reconnaissance Summary:

Virtually all reconnaissance techniques, except sonar and MAD, applicable to aircraft installation will be adaptable to space satellites. Within a year, attempts will be made to conduct television reconnaissance from satellites. At a minimum, these efforts should yield invaluable information on cloud formations over the earth's surface. At a maximum, early efforts may yield information on the location and approximate nature of major military installations and major ships at sea. Within about ten years, television will become more sophisticated and more effective and will be supplemented by other techniques, probably including photography, radar, passive ECM, infra-red and nuclear radiation detection, and possibly including human observers. This reconnaissance, if not prevented, will probably yield detailed information on military installations, forces, ships and possibly aircraft and missiles on a scale scarcely imagined in the minds of military planners of the past.

COMMUNICATIONS VEHICLE:

A capability for mobile, long-range, secure, tactical communications is an urgent military requirement. Effective, automatic, airborne radio-relay equipment in the UHF band is in wide use. Its effectiveness is limited primarily by the ceiling limitation of the aircraft, aircraft endurance, and weather conditions affecting flight operations. The satellite overcomes all of these limitations. Three evenly spaced satellites placed in an 800 mile orbit and equipped with relatively simple radio relay sets, adapted to the space environment, would provide continuous worldwide UHF communications. The location of the transmitting station need not be revealed by using this system, since the signal could be beamed directly at the satellite and would appear, to any intercepting station, to be generated by the satellite itself. The wide coverage of this system would make it particularly vulnerable to unfriendly jamming. This risk could be reduced by using more satellites in lower orbits, reducing the area covered by each. Another solution would be a single satellite, with the tape recorder previously discussed. With the addition of a coded or programmed control which would energize the receiver and the delayed transmitter only on a predetermined schedule, or on properly coded demand, security from jamming would be enhanced. A number of such countermeasures and counter-countermeasures suggest themselves.

Related to the communications potential is the navigation aid potential of the satellite. Radar capable of missile detection could also establish the position of the radar station by tracking a passive satellite in a known orbit. Such equipment will probably be too large for most ships and aircraft. A satellite equipped with a radar transponder would permit smaller radars to achieve similar results. Shipboard gunfire control radars might serve this purpose. Radio transmission by the satellite would also permit surface navigation by direction finder triangulation or doppler measurement techniques. Under favorable meteorological and light conditions, optical celestial navigation methods, either triangulation or simultaneous azimuth-altitude observations could be used. A high intensity light might enhance the performance of an optical system.

OFFENSIVE VEHICLE:

"Offensive," in this discussion, is used to denote all action taken against an enemy, whether destruction of material and personnel, interference with communications, delivery of propaganda, or whatever.

Destructive Vehicle:

The satellite has been proposed as a missile launching platform. A missile platform satellite in an orbit less than 1000 miles high would have an orbital speed in excess of 15,000 miles per hour. Even if orbitting in a westerly direction, its speed relative to a target on the earth would be in excess of 14,000 miles per hour. Such extreme relative speeds would merely increase the complexity of aiming a ballistic missile from one fixed position on the surface of the earth to another. Compounding this disadvantage of the satellite based missile versus the ground based missile, the cost of placing a launching platform into orbit, together with the missile and its fuel, and maintaining the missile in readiness would be incomparably greater than maintaining a ground based missile and site. Like all satellites, the missile satellite would also be subject to constant surveillance from the earth.

Apparently in recognition of the aiming disadvantage of the satellite based missile, Lieutenant General Clarence S. Irvine, USAF, has proposed a satellite which circles the earth in a westerly direction once each day and hence maintains an apparently stationary position over some point on the equator or, at worst, oscilates slowly in a north-south path. He is reported to have claimed that such a satellite would be ideal for missile launching and that it would be "relatively simple to aim a missile from such a fixed point."[10] This is a surprisingly naive oversimplification and may well be a misquote. The idea, however, bears consideration.

Even a cursory examination of the combined orbits of the earth and the satellite will show that far from being at a fixed point, the satellite is traveling an extremely

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[10] New York Times, March 5, 1958, p C11

complex path similar to that of a spot on a rotating wheel attached to the rim of a larger rotating wheel. The problem is capable of theoretical solution but is scarcely as simple as dropping a rock from a tethered balloon.

The advantage of a missile launching satellite in an orbit 22,000 miles above the surface of the earth, as it would be, is also questionable. True, the area under surveillance would be great and the number of targets to be observed also. Conversely this satellite would be under constant surveillance from numerous sites. A missile so launched would be vulnerable to detection and possible destruction for 22,000 miles compared to 5000 miles or less for an earth based missile launched against the same target. The cost of launching and maintaining such a missile would be even greater than for lower orbits. The arguments so far advanced for using satellites as launching bases for destructive weapons are not convincing.

Deceptive Vehicle:

The satellite could be used as a platform for electronics jamming. Jamming is effective only when the receiver antenna is aimed at or near the jamming source. For instance, a satellite overhead would not be effective in jamming a surface search radar. As it neared the horizon, it could jam the surface search radar in a more or less narrow sector for a relatively short time. It would be more effective against air search and missile search radars while within line-of-sight. A higher orbit would permit a slower transit and prolonged period of effectiveness in a given region but the increased height would require increased power. This potential is less promising than several others and will, at best, be low on any military priority list.

Propaganda Vehicle:

The Russians have already reaped the largest propaganda dividend by launching the first satellite. Later satellites, no matter how sophisticated, can hardly be expected to have such dramatic results, especially with authoritative talk on all sides focusing attention on interplanetary travel. Failing to "keep up with the Joneses", however, would undoubtedly have a significantly adverse effect.

This, by no means, exhausts the propaganda potential of the satellite. The satellite may well redress the balance of power in the present lop-sided battle of words and ideas across the Iron Curtain. Russian leaders need only speak to be heard around the world. Democratic leaders can be heard in Russia only through such stations as the Voice of America, distorted and disrupted by Communist jamming, or through the officially distorted words of the Communist press. Propaganda broadcasts from a satellite, whether voice or television, could not be effectively jammed except by another satellite in the same general position. The frequencies used would permit selection of the satellite signal and rejection of the jamming signal by the simple expedient of reorienting the antenna, a common practice for those television viewers without outside antennas.

CHAPTER III

IMPLICATIONS OF THE SPACE SATELLITE POTENTIALS ON CURRENT WEAPON SYSTEMS CONCEPTS

MISSILES:

As a competitor to missiles, the satellite offers no logical advantage over its shorter lived predecessor. It would be infinitely more costly to fire a missile into orbit and then fire it back to earth than to fire it from one point on the earth to another. The extreme sophistication of a missile system carries with it a concomitant complexity of maintenance. Granting the possibility of manned satellites, it is still inconceivable that such maintenance could not be done better and more efficiently on earth where all of a nation's talent and material resources are immediately available by road, rail, aircraft, or ship, than in space, where, at best, limited talent and resources will be available at extreme cost.

As a countermeasure to missiles, the satellite has greater significance. Conceivably, an anti-missile missile could be fired from a satellite, but the preceding arguments against using satellite missiles against ground targets are equally valid. Its missile countermeasure potential appears greatest in the field of detection and warning. From its great height, it could survey all of an enemy's territory and report each missile launching as it occurs, greatly increasing the warning time obtainable by surface warning nets.

AIRCRAFT:

Since the satellite must be discounted as a missile launching platform, it cannot compete with the aircraft as a deterrent weapon either for mass destruction or precision bombing, nor can it compete with aircraft in the transportation field. It may completely replace aircraft, however, for reconnaissance against surface targets, both land and sea. It cannot perform ASW aircraft functions. It may replace or at least supplement AEW aircraft.

In the anti-aircraft field, the satellite appears to be limited to a detection role. This role may also be limited. Unlike missile exhaust, even jet aircraft would be difficult to detect by infra-red against the heat pattern of the earth. Ground return would probably obscure low flying aircraft on radar although special circuitry can reduce this effect. Aircraft concentrations on airfields, on the other hand, would be readily detected so that the world air order of battle would be an open book.

SURFACE VESSELS:

As in the case of the aircraft, the satellite can perform none of a surface ship's functions except reconnaissance, for which ships have only limited capability. In the sense of competition, then, the satellite cannot replace surface ships. The effect of the satellite on the surface navies of the world may, nevertheless, be revolutionary.

Since the dawn of naval history, navies have drawn much of their importance from their ability to move clandestinely through the vastness of the seas, concentrating overpowering mobile strength against enemy forces, afloat or ashore. With the advent of radio and radar, this advantage was greatly reduced, but not eliminated. Sporadic radar contacts yielded only fragmentary information on a fleet's movements and intentions. The speed of surface units usually prevented significant concentration of opposing submarine or surface strength and even the aircraft was not assured of being able to relocate and attack a reported surface formation or of being able to destroy it.

Radar detection has become sufficiently effective, nevertheless, that, coupled with the destructive power of nuclear weapons, it has forced a revision in naval tactics. A grave defect in radar performance is its inability to identify targets as to type of ship. Progressive thinking is taking advantage of this weakness by breaking up easily identified tactical formations into random groupings, thereby hiding the identity of strength units and, in areas of commercial shipping concentrations, obscuring the very existence of a military force. Great stress has also been laid on the invulnerability of ships to ballistic missiles because of the inherent navigational errors in contact reports and the evasive maneuverability of the ship from the time of its detection and the arrival of the missile. This is sound logic with the present state of weaponry, if the increased submarine threat is accepted, but the reconnaissance satellite may well strip the surface navy of its remaining shreds of invulnerability.

Satellite radar can no more identify its target than can airborne or surface radar. If, however, satellite television or photography has once identified a target, satellite radar reports every few minutes, if not continuously, will permit essentially continuous tracking even at night and in most bad weather. "Shell game" deceptive tactics suggest themselves, but this would involve concentration of units and invite attack. With the exact location and identity of all ships known at all times, an opponent would be in an excellent position to interpose surface, submarine, and air forces in concentrations never before possible, probably in overpowering strength. Even the long-range ballistic missile would be effective against surface ships under these conditions. Granting the surface unit an effective range of 1500 miles with aircraft or missiles, the flight time of a countering missile launched against the ship would be no more than half an hour, scarcely enough time to permit effective evasion of the damage area of a pattern of thermonuclear weapons, even if the missile launching was detected and the aiming point calculated immediately.

SUBMARINES:

Barring a major scientific break-through, the satellite offers neither competition not threat to the true submarine. On the contrary, only the submarine affords any degree of secrecy of movement or safety at sea. This factor, coupled with the increased threat to surface ships will stimulate the development of submarines to an extent at least as significant as the development of nuclear power and the fleet ballistic missile.

GROUND FORCES:

The great variations in ground cover, temperatures, radar reflectivity, and structure of land masses offer opportunity for deception and camouflage of ground forces against satellite reconnaissance not afforded by the relatively homogenous structure of the sea and air. Important military installations, possibly even missile sites, could be detected and identified. Large movements of forces and even large pieces of equipment might also be detected despite countermeasures. Such information would be invaluable, but could not be as comprehensive and exact as information obtained on ships and aircraft concentrations. It might be sufficiently effective, however, to encourage the development of guerrilla-like forces.

CHAPTER IV

SUMMARY

Contrary to the public statements of important public leaders, and the thinking of some conservative military minds, space satellites do have pressing military significance. At an increasing rate within the next decade, Russia and the West will launch satellites of increasing weight and with military capabilities, particularly and most significantly for reconnaissance and communications purposes. The advantage of giving a satellite a destructive capacity is dubious. The nation which recognizes the true significance of these developments on military weapons systems, tactics, and strategy will probably develop an anti-satellite weapon and other countermeasures.

Of all the military elements; land, sea, and air; the sea elements will be most affected by military satellites. The mobility and clandestine movement of surface ships, upon which present naval strategy is based, will wane in significance when countered by continuous surveillance from space and destruction by ballistic missiles. Operations below the surface of the sea, on the other hand, will not be susceptible to space reconnaissance and the present flurry of activity in this long dormant art will appear in retrospect as slothfulness. Air and ballistic missile elements will also be significantly affected by these developments, as will land elements to a lesser degree.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

<u>Conclusion</u>:

Reconnaissance satellites can be developed within a decade. Any nation which has exclusive or pre-eminent use of such devices will have a military advantage over an opponent which may be decisive.

<u>Recommendation</u>:

That the United States proceed with all deliberate speed and considered urgency to develop an effective family of reconnaissance satellites and anti-satellite weapons.

<u>Conclusion</u>:

Surface ships will be rendered highly vulnerable to detection and destruction, but submarines will not be.

<u>Recommendation</u>:

That the Navy's long-range ship construction program be deliberately reviewed for the specific purpose of developing a variety of submarines to carry out the missions of the Navy.

<u>Conclusion</u>:

The communications relay satellite offers a major break-through in communications performance in the immediate future.

<u>Recommendation</u>:

That the communications potential of the satellite be developed concurrently with the reconnaissance satellite.

<u>Conclusion</u>:

The advent of the military satellite will revolutionize naval equipment, strategy, and tactics.

Recommendation:

That the Navy vigorously exploit the position gained by Project Vanguard, publicize the strategic significance of space satellites, and encourage progressive and imaginative thinking regarding naval strategy in the space age.

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