4-G, 8
93/23

~~SECRET~~

This document consists of ____pages
No.____of_____copies, Series ______

TO: ACDA/ST - Dr. Long August 14, 1962

FROM: ACDA/ST - F. Dyson

SUBJECT: Report on "Implications of New Weapons Systems for Strategic Policy and Disarmament"

This paper is an attempt to identify problems and issues which ought to be of concern to ACDA. In no case have I made more than a preliminary study of the problem. But I have tried to get down to solid details so far as I could in the time available. On each issue I have stated my own conclusions for what they are worth.

I hope you will follow this up by picking out some of the questions which seem specially urgent or interesting and giving them a much more thorough treatment. This could be done partly here and partly outside. Perhaps the Hudson Institute might get involved.

I myself would consider the following an appropriate order of priority for further investigations:

(1) The gigaton mine problem
(2) The Soviet AICBM system
(3) Fission-free nuclear weapons
(4) Supersonic low-altitude missiles

In each of these four areas there is need both for an intensive technical study of the facts and for an imaginative grasping of the political opportunities which the new technical developments may offer. The political opportunities will mostly be lost if they are not foreseen and prepared for.

Enclosure

Report - subject as above

ARMS CONTROL AND DISARMAMENT AGENCY
(✓) Release ( ) Excise ( ) Deny
(✓) Declassify ( ) Declassify in part
FOIA, PA, E.O. Exemptions ______
Downgrade TS to ( )S or ( )C, OADR
Classify ________, OADR
Class/Declass Auth F. Smith Date 12.13.93

~~SECRET~~

4-G,8

SECRET

This document consists of___pages
No.____of____copies, Series______

PROGRAM FOR A STUDY

By: Freeman J. Dyson
ACDA/ST

Date: August 14, 1962

Implications of New Weapons Systems for Strategic Policy and Disarmament

"The unimaginable touch of Time."

W. Wordsworth, Sonnet on Mutability

SECRET

i

TABLE OF CONTENTS

I. Outline of Study

We consider eight possible weapon systems which are likely to be seriously considered for deployment during the next ten years (1962-1972).

(a) AICBM system of conventional type using interceptor missiles.

(b) AICBM system using high-energy beam, either of charged particles, radio waves, or light.

(c) Mines with explosive power in the range of 10 GT (gigatons), carried in ships or in submarines. Note: 1 gigaton = 1000 megatons.

(d) Fission-free nuclear weapons with explosive yield in the range of 100 pounds of TNT.

(e) Backyard ballistic missiles; i.e., missiles with intercontinental range, warheads in the range of 100 kt, sufficient accuracy to hit small targets, and sufficiently small size to be easily moved by road.

(f) Supersonic low-altitude missiles based on the PLUTO nuclear ram-jet propulsion system.

(g) Massive and effective systems for the tracking and hunting of submarines.

(h) Manned space forces, capable of surveillance and bombardment either with or without control from the ground.

We call these systems for short:

(a) Conventional anti-ballistic missile, CABM

(b) Unconventional anti-ballistic missile, UABM.

(c) Gigaton mines, GM.

(d) Fission-free weapons, FFW.

(e) Backyard ballistic missiles, BYBM.

(f) Supersonic low-altitude missiles, SLAM.

(g) Massive anti-submarine warfare, MASW.

(h) Manned space forces, MSF.

In Section II we summarize the technical facts relevant to each of these systems in turn. In Section III we present a preliminary analysis of their strategic implications.

II. Technical Status

Before studying the strategic implications of these systems, it is useful to collect as much information as possible concerning their present technical status. The following remarks need to be supported with documents, corrected and brought up-to-date where necessary.

A. Conventional Anti-Ballistic Missile

CABM is under active development both in the USSR and the US. There is evidence that the USSR is taking this development more seriously than the U.S. One may expect some kind of operational CABM system to exist in the USSR during the next ten years. Whether the U.S. will build an operational system is undecided.

The effectiveness of CABM systems is hotly debated. The uncertainty arises primarily from the unpredictable effects of the attack environment upon the reliability of a very complex system. The following qualitative statements are generally accepted:

(1) In the present state-of-the-art a CABM system could be built which would intercept and destroy a single ICBM arriving in a peace-time environment.

(2) The effectiveness of CABM against a large ICBM attack would depend strongly on the quality of intelligence available to each side. If the attacking side knew precisely the technical diagnostic methods of the defense, the attack could certainly penetrate by using suitable countermeasures (decoys, etc.). If the defending side knew precisely the technical penetration aids employed by the attackers, the defenders would be able to add to their system suitable discrimination diagnostics to counter the penetration aids, and the defense would then have a fighting chance of beating off even a heavy attack.

(3) CABM systems can protect small hard targets with much greater assurance than cities.

(4) The deterrent value of a CABM system may be considerable, even if its actual effectiveness in combat would be negligible. The deterrent value depends on the attacking side's estimate of how good the CABM system might be. Thus it may be said that the most important requirement for a CABM system is that it should look better than it is.

B. <u>Unconventional Anti-Ballistic Missile</u>

UABM systems have been studied extensively in the U.S. and the conclusion has usually been that they are not feasible. However, these ideas die hard, and new variants are always being hopefully brought up. At the present time the optimists are placing their main hopes in optical systems using mammoth-size LASER beams, but the fashions change from year to year.

The radio-frequency beam system has been rather conclusively proved unfeasible because the beam ionizes the atmosphere and the resulting plasma absorbs the energy of the beam.

The particle beam systems suffer all kinds of difficulties with hydromagnetic instabilities. Most experts have concluded that the instabilities are insuperable, but no complete proof of this has been given.

The optical beam system has the basic disadvantage that it will not penetrate clouds. It is either a fine-weather-only system, or it must be deployed in high-flying airplanes.

In summary, one may say that the probability of a UABM system becoming feasible during the next ten years is low, but that a technical surprise may occur at any time. The possibility of UABM ought therefore to be kept in mind in strategic planning.

The basic difference between UABM and CABM is that UABM is not ammunition limited and is hardly even rate limited. If UABM can work at all, it will be able to fire and kill so rapidly that it can deal with a large number of ICBM and decoys arriving simultaneously. Thus it is conceivable that a fixed number of UABM installations could defend a country reliably against a massive ICBM attack with sophisticated penetration aids. It is hardly conceivable that CABM could do this reliably.

C. Gigaton Mines

GM are undoubtedly feasible in the present state of the nuclear weapons art. A weapon with 10 GT yield can be built at a cost of about 200 million dollars. The weapon would weigh about 1000 tons and could be built into the hull of a ship or submarine, or towed behind a ship or submarine in a separate underwater container. The weapon could be built so as to produce either tremendous radioactivity or very little, according to taste.

There are two possible ways of using GM, based on radiological and hydrodynamical effects respectively. If it is used radiologically, it will be detonated in shallow water (a few hundred or thousand feet deep) off the coast to the windward side of the target country. The purpose is to spread radioactive fallout as widely as possible over the target area. The effectiveness of such an attack is highly unpredictable, since the distribution of fallout depends mainly on meteorology. Even if the radioactivity drifts in the desired direction, the area covered might be only a rather narrow strip. It is clear that a radiological attack with GM would be a major catastrophe for the country attacked, but it is not clear that the consequences would be as severe as those resulting from an ICBM attack of moderate size. Some more careful estimate of the radiological effects of GM is obviously required.

The hydrodynamic use of GM is probably more destructive and certainly more predictable. The GM in this case is to be sunk in deep ocean water (depth 15 to 25 thousand feet) off the edge of the continental shelf, some hundreds of miles away from the coastal region which it is desired to destroy. The effect of the explosion is to create enormous oceanic waves which will steepen and finally break as they travel into shallow water and onto the land. Quantitative study of the destructive effects has not been made. Rough estimates indicate that the inundation would reach to a height of 200 - 300 feet above sea level, or to a distance of 200 - 300 miles inland, whichever limit is reached first. The speed of flow of the water, being of the order of 50 miles per hour, would be sufficient to remove all top soil, vegetation and buildings from the inundated area. The destruction in this area would probably be more complete, thorough and permanent than that resulting from ordinary nuclear attack. The vulnerable region of the U.S. may contain about half of the population, although it is much less than half of the area. One or two GM would be enough to destroy any one of the three coastal regions of the U.S. (Atlantic, Pacific, or Gulf). Severe damage to other maritime countries would of course be unavoidable.

Whether GM are used radiologically or hydrodynamically, they must be detonated on the ocean floor either by a time fuse or upon receipt of a prearranged hydroacoustic signal.

The techniques for assembling the bomb, installing it in its ship or submarine, carrying it to the desired place, sinking it, and detonating it on the ocean bottom, could be developed and made reliable by tests with dummy weapons carrying only small H.E. charges. This part of the enterprise would not be expensive and would not require a high level of technological sophistication. Moreover, the installation and testing program could rather easily be camouflaged and kept secret.

Western Europe, Australia and Japan are even more vulnerable than the U.S. to GM attack. China is rather less vulnerable than the U.S. and the USSR is much less vulnerable. It is this geographical asymmetry which makes GM a very serious threat to the strategic interests of the U.S.

The problem of active defense against GM is technically very difficult. It is certainly more difficult than defense against POLARIS type submarines. An effective active defense would require not only tracking, but seizure and search in peace time of all ships passing through an enormous area of international waters. Passive defense of population against GM could perhaps be provided by a large-scale deployment of Noah's arks. Technical studies of the operational problems, where the arks should be stored, how the population could be embarked in them at short notice, and how the arks could be launched when the flood arrived, remain to be made.

Perhaps the most disagreeable aspect of the GM problem is that the delivery of GM does not require a high level of technology. GM would therefore be a logical choice of strategic weapon for a country which had learned how to make nuclear weapons but was too poor or technically undeveloped to build a modern ICBM force. The design of the GM itself would not be more difficult than the design of an ICBM warhead. The only features of a GM which would present novel problems to a weapon designer are its size, and the fact that it must withstand a hydrostatic pressure of up to 1000 atmospheres on the ocean bottom and still work reliably. The great size makes the design in most respects easier rather than more difficult. The problem of hydrostatic pressure may be a little tricky. Obviously the design should allow some liquid at ambient pressure to flow inside the device and relieve stresses due to unequal compressibilities of the solid parts of the structure. This problem seems to be of a kind which any competent team of engineers should be able to master.

The materials needed for building a GM are approximately the same as for a single megaton weapon, plus a thousand tons of heavy water and other cheaper materials. The production technology of heavy water is widely known. Thus the entire technological effort required for creating a GM force, which would be a major international threat, is only about equal to the effort of building a dozen thermonuclear weapons without delivery vehicles. Roughly speaking, the total cost of a GM force would be a few billion dollars, or about one-tenth of the cost of an ICBM force of comparable destructiveness.

Another disagreeable feature of GM is that they might be delivered anonymously by a poor country anxious for reasons of pique or jealousy to ruin the rich countries and make a big splash in the world. The poor country might reasonably hope to escape retribution in the resulting confusion. Thus the existing ICBM forces of the rich countries do not constitute an effective deterrent against attack by poor countries armed with GM.

Within the next ten years the main danger of GM production presumably lies in the CPR (Chinese People's Republic) However, the possibility that the USSR might also adopt this type of strategic weapon ought not to be ignored.

D. Fission-Free Weapons

FFW are not now known to be feasible. The problem of designing a FFW is more similar to the problem of designing a controlled thermonuclear reactor than to the problem of designing a fission weapon. It is likely that in the long run FFW will be feasible if, and only if, controlled thermonuclear reactors are feasible. FFW are perhaps easier to design since the required containment times are much shorter. Thus it is always possible that a practical FFW will be invented "by mistake" as a by-product of the research in controlled thermonuclear reactions, rather than as a result of weapons development programs. The chance that FFW will exist in the next ten years is anybody's guess.

A FFW with a yield of 100 pounds of TNT, the energy appearing mainly in the form of 14 Mev neutrons, will kill people out to a distance of about 500 feet. Foxholes will provide little protection against the neutrons; steel tanks will provide even less. The amount of nuclear material needed for such a weapon would be about one milligram of tritium and would cost about ten dollars. The cost of the weapon would certainly be greater than this, since some engineering of watchmaker's precision would be involved. However, it is likely that the cost of a FFW, if feasible at all, would be comparable with the cost of sophisticated conventional ammunition, such as an H.E. shell with proximity fuze. The lethality of the FFW would exceed that of H.E. ammunition by a factor of 100 to 1000.

The military importance of FFW is a subject of much debate. It seems difficult to argue that FFW with yields in the range of 100 - 1000 tons would be important. Such weapons would be comparable in effects to existing tactical fission weapons with yields in the kiloton range, and they would also be comparable in cost. It is only in the very low yields, say in the range 100 - 1000 pounds, that the FFW might become a hundred or a thousand times cheaper than a fission weapon, while retaining a high degree of nuclear lethality. It is possible to imagine FFW in the 100 pound class being produced and used in quantities comparable with conventional H.E. ammunition. A country possessing such armaments would certainly have a great advantage in tactical nuclear warfare.

Whether tactical nuclear warfare is probable or possible in the real world is a political question. We shall discuss this and other political questions connected with FFW later in the study.

The thermonuclear reaction rates make it highly unlikely that FFW can ever be designed without using tritium as fuel. Thus the danger that countries without isotope separation plants and production reactors could build nuclear weapons burning pure deuterium seems to be non-existent.

E. Backyard Ballistic Missiles

BYBM are not yet in existence but they are likely to become feasible during the next ten years. The necessary warhead development is now in progress. The main problem remaining is refinement and miniaturization of guidance equipment.

The military advantage of BYBM lies in their high mobility and consequent invulnerability. The warhead yield of 100 kt is quite adequate if the accuracy is correspondingly high. The obvious technical disadvantages of BYBM are that command and control of firing is uncertain and the possibility of accidents is greater than in a static system.

A BYBM of intermediate instead of intercontinental range is of course much easier to design and build. Such a missile, under the name MMRBM (mobile medium range ballistic missile) has been proposed as a basic offensive armament for the European NATO powers. It could be produced and deployed in a few years if the decision were made to do so. The strategic study of BYBM should include both the intercontinental and medium range versions.

F. Supersonic Low Altitude Missile

SLAM is technically feasible and a prototype vehicle will probably fly in about five years. Decision to build an operational system has not been made.

The technical specification of SLAM is roughly as follows: Speed - Mach 3; Altitude - 500 feet above ground; Payload - one multimegaton bomb or perhaps several; Range - global; Maneuverability - enough to make accurate prediction of its track impossible; Accuracy - comparable to ICBM or better; Launch site - comparable to ICBM in cost and in vulnerability; Crew - none.

In most respects the addition of SLAM would not greatly change the capabilities of the ICBM systems which are likely to exist during the next ten years. However, SLAM would make the problems of defense even more complicated. A defense system to deal with SLAM would require a huge and expensive organization entirely separate from any AICBM system which might also be built. The kinds of radar, tracking systems and interceptors which could engage SLAM could not engage ICBM's and conversely.

Advocates of SLAM claim that it will provide a natural replacement for the manned bomber force when manned aircraft become obsolete through increased vulnerability to interception. Insofar as the function of the manned bomber force is to divide the attention of the defense, this claim is correct. However, SLAM will lack three important advantages of manned aircraft; namely, the ability to fly on air alert, the ability to respond to command in flight, and the ability to reconnoiter. For the purpose of strategic discussions, it is more nearly correct to think of SLAM as a peculiar kind of ICBM than as a peculiar kind of airplane.

G. Massive Anti-submarine Warfare

There are two possible ways in which a MASW system might come into existence. One is the way of brute force; namely, a decision to spend the necessary number of billions of dollars to cover the oceans with sonar detection systems of conventional type. The other is a technological break-through, a new invention which enables the tracking and monitoring of submarines all over the oceans to be done at a more reasonable cost. The CLINKER effect might conceivably form the basis for such a breakthrough but it is not altogether clear that this effect even exists.

The present technical status of these two types of MASW is very similar to the status of CABM and UABM, respectively. Conventional MASW is extremely expensive, its possible effectiveness is uncertain, and it can undoubtedly be defeated by countermeasures and clever tactics if the submarines know the characteristics of the defensive system. Unconventional MASW has a rather small chance of becoming a reality during the next ten years, but it might conceivably be much more effective than conventional MASW in the long run.

The strategic effects of MASW would be of two kinds. First, the effect of MASW on POLARIS systems. This would be similar to the effects of CABM or UABM on land-based ICBM systems. Soviet MASW might destroy the confidence of U.S. planners in the invulnerability of the U.S. POLARIS force, even if the Soviet MASW system were itself imperfect or fragmentary. U.S. MASW would probably have a smaller effect on Soviet submarine missile planners, because the characteristics of U.S. MASW systems would be better known to the other side. Second, there are important effects of MASW on the balance of naval forces which might be used in non-nuclear or geographically limited war. For the U.S. it is the necessity of defending surface ships against Soviet submarine attack in limited war rather than the threat of bombardment by Soviet submarine missile forces, which provides the main incentive for developing MASW.

One special feature of MASW, which is not shared by anti-ICBM systems, needs to be studied. This is the possibility that MASW might be used, secretly or openly, to destroy POLARIS submarines on patrol in peace time. If U.S. POLARIS submarines in international waters close to the Soviet Union should occasionally disappear without trace, the effectiveness of the POLARIS force would be considerably reduced. POLARIS is clearly more vulnerable to this kind of attrition than a land-based ICBM system. If the USSR had deployed a MASW system, it could probably destroy a large number of U.S. submarines over a period of time without serious risk of precipitating a major war.

H. Manned Space Forces

MSF are likely to come into existence, unless their deployment can be stopped by international agreement, towards the end of the decade 1962-72. It is not clear whether it is meaningful to make a sharp distinction between MSF and unmanned military space vehicles. Unmanned space reconnaissance vehicles already exist, and unmanned space bombardment vehicles could be deployed within a few years if either the U.S. or the USSR desired to do so. There are two reasons for emphasizing manned systems in this study. (1) The space program of the Soviet Union has been heavily and consistently oriented towards manned operations. (2) By studying manned systems one is led to consider the effects of possible big jumps in tactics or in technology, whereas unmanned systems are usually pictured as being only modest extrapolations of existing MIDAS, SAMOS, and ICBM capabilities.

The technical limit of what might exist by 1972 in the way of reconnaissance MSF is roughly as follows. Permanently manned stations equipped with a variety of large telescopes and other sensors can keep the surface of the earth under observation with a ground resolution of the order of one foot wherever the weather and natural illumination are favorable. The crews of the stations can carry out prompt interpretation of data, and can examine on a minute-by-minute basis any areas where interesting things seem to be happening. It is of some importance, in planning for international agreements concerning MSF, to bear in mind that even a peacefully oriented program of manned exploration of space cannot avoid having many of the same capabilities as a military MSF reconnaissance system.

The order of magnitude of possible reconnaissance MSF by 1972 will be determined mainly by the unit cost of placing mass in orbit. This cost will depend mainly on success in standardizing and simplifying space launch and recovery operations. Very large reductions in unit cost are possible, if vehicles can be mass-produced without continual modifications, and if the operating routines can become as standardized as normal airline operations.

The technical possibilities of MSF for bombardment purposes have never been as impressive as their possibilities for reconnaissance. Roughly speaking, bombardment MSF can do only the same things that ICBM forces of equal size could do at much lower cost. Extreme advocates of bombardment MSF (i.e. certain Air Force officers) make the following arguments in support of their position: (1) The Task of anti-ICBM systems is made easier by the fact that ICBM's travel from known bases along known trajectories; MSF bombardment may come from any direction and so is much more difficult to intercept. (2) Land-based ICBM systems may be completely disorganized and their command and control destroyed by a massive attack; bombardment MSF can wait calmly while their home country is devastated and then retaliate at leisure. (3) If both sides abandon land-based ICBM's and transfer all their offensive forces to space, it becomes possible to conduct a pure "counterforce war" in the classical military tradition without hurting any civilians. These arguments must be considered seriously, but they probably will not stand up to detailed analysis. Incidentally, the same three arguments are sometimes made by extreme advocates of POLARIS systems.

If we are correct in deciding that the primary function of MSF will be reconnaissance, it is possible that their next most important function will not be the bombardment of ground targets but the interception and destruction of enemy reconnaissance space vehicles. There is no doubt that boarding or destruction of enemy space vehicles will become technically possible during the next decade.

The foregoing remarks about the technology of MSF assume a continuation of present developments based on chemical propulsion. It is possible that by 1972 the introduction of a more efficient propulsion system such as ORION might significantly extend the range of technical possibilities. However, even the most optimistic view of advanced propulsion systems does not greatly affect the nature of military operations in the neighborhood of the earth. Advanced systems like ORION would make possible rapid trips to Mars, an objective which may be desirable but which cannot be considered to be militarily important at the present time.

III. Strategic Analysis

The strategic analysis of a new weapons system must address itself to the following questions.

(a) What will be the effect on the overall military balance if the new system is adopted by both major powers without political restraints?

(b) What will be the effect if the new system is adopted by one power only?

(c) What will be the effect of a political agreement to limit or prohibit the deployment of the new systems?

(d) What are the problems in enforcing or verifying such a political agreement?

(e) Will the existence of the new system have strong effects on the feasibility or political acceptability of measures of disarmament involving other types of weapons?

All these questions may be important, but in general the most important are (a) and (e). Usually (a) is more important than (b), because the adoption of any new weapon system by one major power forces the other to follow suit almost automatically. Usually (e) is more important than (c) or (d), because the effects of a new weapons system in altering the political climate in which disarmament policy is made are more far-reaching than the effects of an agreement to prohibit that particular weapons system alone. As an example of this last statement, consider the case of satellite reconnaissance vehicles; the existence of these vehicles may radically improve the chances of agreement on overall disarmament by reducing the need for ground inspection, whereas an agreement to prohibit satellite reconnaissance vehicles would in itself be a rather minor step towards disarmament.

A. Conventional Anti-Ballistic Missile

A very detailed study of the strategic implications of CABM systems has been made by Thornton Read in an unpublished book, "Strategy for Active Defence." The following remarks are mainly based on Read's analysis.

The most important characteristic of a CABM system is that it does not save the targets which are attacked, but it does save the targets which are not attacked. The CABM system should be designed to give important targets a high price, in the sense that an attacking force must use many ICBM's upon a single target in order to be sure of destroying it. The best strategy for the attack is to use enough ICBM's upon each attacked target so that these targets are almost certainly destroyed. The effectiveness of the defence is measured by the reduction in the number of targets that can be attacked with this optimum strategy.

This operational feature of a CABM system reinforces the technical feature of CABM weapons mentioned in Section IIA (3). Technically, CABM weapons defend small hard missile launch-sites more easily than large cities, because the interception can be delayed to a lower altitude in the case of small hard targets, and the problem of decoy discrimination is thereby greatly diminished. Operationally, cities are harder to defend than missile sites, because one wishes unconditionally to save the ten largest cities, whereas a defence of missile sites which resulted in only ten of them being destroyed would be considered highly successful. Reducing the number of targets that can be attacked is a good enough defence for missile sites, but it is not good enough for cities.

It follows that there is little reason for the fears which have sometimes been expressed that CABM would have a destabilizing effect on strategic balance. The fears are based on the idea that CABM might encourage a country to adopt a "First Strike" policy, relying on CABM to protect its cities against retaliation. However, it is highly unlikely that CABM can ever be an effective defence for cities. If CABM systems are deployed on a large scale, their immediate and preponderant effect will be to decrease the vulnerability of the second-strike ICBM forces. The probable answer to question (a) is that installation of CABM systems on both sides will make the present strategic balance more stable.

Read in his analysis assumed that the attack has good information about the general capabilities and deployment of the defence. It is important to carry through the same kind of analysis for the case in which the attack does not have this information. This has not been done. In practice it is to be expected that the good-information analysis would apply fairly well to a U. S. CABM system defending against Soviet attack, whereas a poor-information analysis would be more realistic for a Soviet CABM system defending against U. S. attack.

The poor-information situation will considerably improve the effectiveness of the defence, both for technical and operational reasons. Technically, the defence enjoys the benefits described in Section IIA (2). Operationally, the defence benefits by forcing the attack to waste ICBM's in excessive numbers on undefended targets. However, the operational advantage to the defence will again be much greater when defending missile sites, than when defending cities. Consider the following over-simplified example. Suppose that the USSR has 100 missile sites of which only 10 are defended by CABM installations. Suppose that 10 ICBM's are required to destroy a defended site, while one ICBM is sufficient for an undefended site. The number of ICBM's required to eliminate all the 100 sites is then 190 if the attack has good information about the defensive deployment. If the attack does not know which sites are defended, the number of ICBM's required is 1000. The undefended sites might be supplied with cheap dummy CABM installations which satellite reconnaissance could not distinguish from real ones. Thus a poor-information attack on the 100 missile bases could well be made prohibitively expensive and uncertain. On the other hand, even in a poor-information situation, the defence of the city of Moscow against retaliatory ICBM attack will not be much improved by the addition of dummy CABM installations.

The probable conclusion to be expected from this kind of analysis is that a reassuring answer can be given to question (b). Because of the asymmetry in the quality of information available to each side, a CABM system will always be more valuable to the USSR than to the U. S., and it is therefore possible that the U. S. would decide against deploying an operational system even after the USSR had built one. This is one of the few cases in which question (b) is as important as question (a). The kind of answer that one may expect to question (b) is that, within certain limits which must be carefully specified, a unilateral deployment of CABM by the USSR will tend to stabilize the strategic balance and will be in accordance with the strategic interests of the U. S. The favorable effect on U. S. security will arise, of course, not from the existence of the Soviet CABM system itself but from the non-existence of additional Soviet offensive missile forces which might have been built with the economic resources devoted to CABM. There are two other bonus effects of a serious Soviet investment in CABM: (i) a CABM system is not prone to start war by accident, and (ii) a CABM system might have a good chance of stopping an accidental war, for example, if a single missile were accidentally launched from the U.S. against Moscow.

Provisionally we may answer questions (c) and (d) by saying that an agreement to limit CABM systems is strategically undesirable and that any attempt to verify such an agreement would be destabilizing. In addition, there is a clear political disadvantage, from the point of view of world public opinion, in trying to limit the "peaceful and defensive" CABM systems, while continuing to build up offensive systems. These answers must be further studied and elaborated.

The answer to question (e) would require a lengthy analysis. There is no doubt that the existence of CABM will have major effects on almost all aspects of disarmament. The effects arise in two distinct ways, one concerned with intelligence and one concerned with strategy.

The intelligence effect of CABM is the following. We have seen that the effectiveness of Soviet CABM, and the confidence of the Soviet leaders in the protection which CABM gives them, depend heavily on keeping the details of the system secret. Furthermore, the CABM installations are big, immobile, and take many years to develop or to modify, so that their secrecy can only be preserved by a rigorous security system. It is almost impossible to protect the secrecy of the system if even one installation is included in a territory subject to thorough ground inspection. Consequently, the USSR cannot adopt a strategy in which CABM plays a vital part, and at the same time agree to any kind of disarmament treaty in which the USSR does not retain the right to keep inspectors out of some large areas of Soviet territory. Reliance on CABM will strongly reinforce the unwillingness of the USSR to agree to schemes of zonal inspection in which the choice of areas to be inspected is left to chance or to other countries.

The U. S. will be able to bargain for rights of thorough inspection of Soviet territory only if the area subject to inspection is specified at the time of negotiation or is subject to some degree of Soviet veto. Thus the existence of CABM will make agreements on verification of any kind of disarmament more difficult to reach. On the other hand, it is likely that even without CABM these particular difficulties would be almost equally great.

The strategic effect of CABM on the feasibility of general disarmament becomes important in the later stages when ICBM forces are supposed to be reduced to low levels or to zero. Existence of CABM on both sides would then be very helpful. First, the force-level at which second-strike retaliatory forces remain effectively invulnerable is lower when these forces are protected by CABM; thus a "minimum deterrent" policy could be stabilized at lower force-levels. Second, if we finally come to the point of reducing ICBM forces to zero, the CABM system could give fairly good protection even to cities against a possible small-scale attack by clandestine ICBM forces. During all the later stages of disarmament the existence of CABM systems would reduce the importance of small concealed ICBM forces and so make both sides less nervous.

The overall answer to question (e) is thus that CABM systems will make the negotiation of any kind of disarmament agreement more difficult in the early stages but easier in the later stages. This is a sweeping generalization which must be subjected to detailed scrutiny.

B. Unconventional Anti-Ballistic Missile

It is not worth-while to analyze UABM in the same kind of searching detail that is appropriate for CABM, since we lack even the roughest information on the tactical and operational limitations which a UABM system might possess. It is just the tactical and operational limitations of a weapons system which often make all the difference to its strategic effects.

Probably the most useful exercise in analyzing UABM is to assume (no doubt quite unrealistically) that UABM will spring into existence suddenly and that it will be a perfect defence against ICBM's. These assumptions present the problem of UABM in its most dangerous form.

Suppose then UABM to be 100% effective. The answer to question (a) is rather simple. It may be assumed that if UABM can destroy ICBM's it can also destroy manned bombers, POLARIS missiles, SLAM, etc. The two-sided introduction of UABM means that all strategic weapons are useless and will be discarded. The strategic balance will be determined by the strength of armies as in World War II days, with the addition of nuclear artillery and various other refinements. It would appear that if the U.S. were prepared to divert effort in good time from strategic weapons to ground forces, the resulting military balance could well be a stable one, and the security of the U. S. would be greater than it is now.

The answer to question (b) is equally simple. If the USSR developed a perfect UABM system and installed it on a massive scale before the U. S. could duplicate it, then the strategic balance would be totally upset and the USSR would have the world temporarily at its mercy. It may be assumed that this situation would be disastrous to the U. S. interests, although it is not completely clear that the USSR would in practice be able to exploit its military superiority any more effectively than the U. S. did when enjoying a comparable superiority during the years 1945-9. Speaking broadly, we may say that the advent of UABM would be beneficial if it were two-sided but highly dangerous if it were in the hands of the USSR alone.

Coming next to questions (c) and (d), it follows that the interests of the U.S. lie not in halting technological developments which might lead to UABM, but in keeping informed about what the other side might be doing in this direction. A negotiated agreement to refrain from building UABM is neither desirable nor easily verifiable. The effect of UABM on U.S. disarmament policy is that it increases the desirability of good intelligence about all kinds of scientific activity in the USSR, both open and secret. The U. S. should put more stress in its negotiations on increasing the scope of official visits and exchanges between Russian and foreign scientists and engineers, who are in the best position to give warning if unexpected discoveries having military application are made. Such open contacts may be more effective in protecting the U. S. against technological surprise than a whole army of inspectors searching for hidden weapons.

The answer to question (e) for UABM is rather more favorable than for CABM. Assuming that both sides have a highly effective UABM system, it should be possible to negotiate an agreement to destroy ICBM forces without stringent inspection. The reduction of land forces would of course be beset with the same kinds of political difficulties as we are now facing in the same area. On balance, the existence of UABM should make general disarmament substantially easier.

C. Gigaton Mines

For GM the questions (a) and (b) can be answered very decisively. The building of GM by any country in the world would be a major threat to the U. S., and the threat would not be significantly reduced if the U.S. decided to build GM too.

Coming to question (c), two things are clear. First, the prevention of GM ought to be one of the urgent and consistent objectives of U.S. policy. Second, the prevention of GM cannot be achieved by military means but only by political agreement. This is a case par excellence in which the conclusion of some sort of reliable international arms-control agreement is essential to the long-term security of the U. S. Furthermore, such an agreement would be useless without the participation of the CPR.

It is a delicate question, whether it would ever be wise to bring up the subject of GM explicitly in international negotiations. Discussion of GM might have the effect of starting people thinking, and the result might be to precipitate the very development we wish to avoid. In such a situation, "let sleeping dogs lie" may be a safer policy; this is in fact the policy that those who think about GM have hitherto followed.

What is needed is a political agreement which makes it in practice impossible for any country to build GM, without revealing that this is the purpose of the agreement. Here is a task for a devious diplomat!

An agreement which would be highly desirable from this point of view is a nuclear test-ban agreement including the CPR. A gigaton bomb would not require testing at full scale, but it could hardly be developed by the CPR without tests of a size that can be easily detected. The security of the U.S. would benefit far more from a test-ban agreement including the CPR than from an agreement among the existing nuclear powers. It would be militarily worthwhile to make substantial concessions in order to buy such an agreement, if it is at all possible.

Another type of agreement covertly directed against GM would be an agreement to limit production of heavy water. This might arouse suspicion if proposed by itself, but it could be inserted inconspicuously into an agreement to limit production of other more glamorous materials such as tritium and plutonium. The treaty could be negotiated in such a way that the controls of tritium and plutonium production were full of loop-holes and so would be acceptable to the USSR and CPR, while the controls on heavy water production (in which nobody would appear to be particularly interested) would be stringent enough to prevent any illicit production of thousand-ton quantities. The negotiators could, if necessary, justify the inclusion of a control of heavy-water production with some vague remarks about the importance of tritium and plutonium production in heavy-water reactors of the Savannah River type.

A treaty controlling heavy-water production would have the advantage that it would prevent the production of GM in the USSR as well as in other countries. A test ban would be effective in other countries but not in the USSR, since the USSR already has the necessary experience to design a GM without further tests.

The answer to question (d) for the case of a test-ban agreement has been discussed at tremendous length by many people. So far as tests relevant to GM are concerned, verification is not a serious problem. The answer to question (d) for an agreement on heavy-water production cannot be given without a detailed technical study. It seems likely that verification of production of heavy water in quantities sufficient for GM could be achieved by an occasional expert examination of declared facilities, provided that unilateral intelligence could detect the construction of very large undeclared facilities.

Question (e) is not particularly relevant to the problem of GM. The main effect of GM on other types of disarmament is the following. The possibility of GM greatly increases the urgency of all measures designed to halt the spread of nuclear weapons to more and more countries.

D. Fission-Free Weapons

The strategic effects of FFW become important only if the number of FFW produced and deployed is substantially greater than the existing stockpiles of tactical fission weapons. The following analysis will therefore be based on the assumption that FFW, if feasible at all, will be produced in hundreds of thousands or in millions. This means that it becomes economic to use FFW to destroy a single tank, a small group of soldiers, or even a single soldier.

The main effect of tactical fission weapons is usually supposed to be to prevent troops or vehicles from attacking in concentrated formations. Dense troop concentrations are the kind of target on which fission weapons can be used effectively. It is usually supposed that dispersed mobile warfare would still be possible in a war fought with tactical fission weapons.

With FFW available to both sides in really large numbers, it seems impossible that any kind of mobile warfare could be fought. Even a highly dispersed force moving over the surface of the earth would be too vulnerable to FFW to survive. With all due allowance for technical uncertainties, it may be expected that the effects of FFW on tactical warfare may be similar to the effects of machineguns in World War I. Tactical FFW war would probably degenerate into trench warfare in the World War I style, only the trenches would be deeper and a smaller number of soldiers would be required to man them. The defensive would be heavily favored over the offensive, and a tactical stalemate would be reached very rapidly.

In a ground war with FFW available to only one side, it is probable that the side with FFW would quickly win, if the war remained limited to tactical operations. In this case the side with FFW would conduct dispersed mobile operations and annihilate the opposing forces in detail, without presenting many targets suitable for attack by tactical fission weapons.

The questions (a) and (b) can then be provisionally answered for FFW. The effect of both sides having FFW would be to make offensive military operations on land prohibitively expensive, so that all frontiers could be effectively defended by fixed fortified lines. The effect of one side only having FFW would be to give that side a decisive advantage; the other side could not defend itself effectively with tactical fission weapons alone.

These answers apply to the hypothetical situation of a tactical nuclear war in which both sides "obey the rules" and refrain from escalating the war by making strategic attacks upon each other. To give realistic answers, the all-important factor of escalation must be explicitly included.

The effects of escalation on the existing strategic balance in Western Europe and elsewhere have been analyzed very thoroughly in report WSEG 62 (Top Secret). The effects of adding FFW to the existing situation will now be discussed within the framework of the WSEG 62 analysis. At present there are four distinguishable levels of escalation of a war for the defence of Western Europe, (1) non-nuclear war, (2) tactical nuclear war, (3) strategic exchange with continental weapons, (4) strategic exchange with intercontinental weapons. Supposing that the war begins with a Soviet attack on level (1), the possibility of a successful defense on this level is doubtful. The defence would be favored by immediate escalation to level (2), if level (2) could be maintained. However, the USSR would almost certainly escalate from level (2) to level (3), which again strongly favors the attack. The U.S. is then more or less committed to escalate to level (4), which theoretically favors the defence but does not leave much that is worth defending. The conclusion of the WSEG 62 analysis is that the best chance for the West is to plan to fight the war on level (2), using the threat of level (4) to deter the USSR from escalating to level (3). Many of the detailed recommendations of WSEG 62 are concerned with the problem of making the distinction between levels (2) and (3) as sharp and unambiguous as possible. This is to be done, for example, by separating geographically the tactical and strategic nuclear forces of NATO.

After one has gone through this very logical and persuasive argument of WSEG 62, one may still have serious doubts whether any Soviet strategist would be impressed by it. Considerable evidence exists that Soviet plans do not recognize any distinction between levels (2) and (3). One may therefore decide that these recommendations of WSEG 62 are illusory, and that the preferred strategy for the West should be to fight as long as possible on level (1), relying on the threat of direct escalation to level (4) to discourage the USSR from pressing its advantage on level (1) too far. Either the WSEG 62 strategy of emphasizing level (2), or the alternative "non-nuclear strategy" of emphasizing level (1), has a good chance of becoming official NATO policy at some time during the next 10 years.

Now consider the effect of introducing FFW into these arguments. Instead of level (2), one now has a new level (2'), tactical war with FFW only. Suppose first that FFW are available in quantity to both sides. From the point of view of the West, level (2') has two great advantages over level (2). These are: (i) the defence is favored more strongly by FFW than by tactical fission weapons, and (ii) the distinction between levels (2') and (3) is much clearer than the distinction between levels (2) and (3). The chance of a successful defence being maintained at level (2') without further escalation seems considerably greater than the chance at level (2). This is an abstract statement. Restated in concrete terms, the statement would perhaps be more convincing. The defence of a frontier with FFW could be strictly confined to a zone extending a few miles from the firing line, whereas a defence with tactical fission weapons requires attacks on lines of communication and troop concentrations far behind the front; hence the FFW defence has a much better chance of not degenerating into an all-out nuclear exchange.

The answer to question (a) for FFW including escalation is then the following. The introduction of FFW on both sides will make the WSEG 62 strategy of tactical nuclear war much more likely to succeed. However, this strategy may still fail, and a strategy of relying on non-nuclear defence of Western Europe may still be preferable.

The answer to question (b) is similar. Suppose the USSR has FFW and the U.S. does not. Then the USSR would be favored in a European war at level (2') as well as at levels (1) and (3). In this case the WSEG 62 strategy would be completely useless, and the only chance for the West would be to adopt a non-nuclear strategy.

If one relies on the WSEG 62 strategy, then the situation of question (a) seems very good and the situation of question (b) seems very bad. If one rejects the WSEG 62 strategy and relies on a non-nuclear defence backed by threat of possible escalation to level (4), then the answer to both questions (a) and (b) is that FFW have no important effect on the strategic balance.

After all this long discussion, we are left with the following simple conclusions. If one believes that tactical nuclear war is possible, then FFW are very important. If one believes that tactical nuclear war is impossible, then FFW are unimportant. Whether tactical nuclear war is possible or not is a political question, the answer depending on Soviet political decisions of which we can have no certain knowledge. If FFW are available on both sides, the chance of stabilizing a war at the tactical nuclear level is considerably improved. If FFW are available to the Soviet side only, the chance of stabilization at this level becomes zero.

The answers to questions (c) and (d) for FFW are essentially the same as for UABM. It is neither desirable nor feasible to stop FFW from being invented, if the invention arises out of general progress in the study of plasma physics and controlled thermonuclear reactions. What is important is to maintain a vigorous U. S. program of research in controlled thermonuclear reactions, and to push for as much contact and exchange of information as possible with the Russian program.

A comprehensive test-ban treaty would make the testing of FFW illegal, and the abstention from testing of devices with 100-pound yield could not be reliably verified by any detection system. A comprehensive test-ban therefore will involve a certain risk that the other side may obtain a lead in FFW development. There are three reasons for not taking this risk very seriously. (i) The U.S. could probably keep more-or-less abreast of Soviet developments by means of legal non-explosive experiments. (ii) The danger from FFW arises not when the USSR has tested a prototype but when the USSR has produced a few hundred thousand weapons and distributed them to infantry units; the processes of mass-production, troop-training and deployment would take a long time and would probably become known to the U.S. in time for counter-measures to be possible. (iii) The strategic effects of FFW in Soviet hands may not be overwhelming.

The answer to question (e) for FFW is the following. The possible existence of FFW has the effect of making a comprehensive test-ban treaty somewhat more risky and therefore more difficult to negotiate. The increased risk arising from FFW must be weighed against much greater risks which arise from weapons development in the absence of a test-ban. Apart from this negative effect on the test-ban problem, there seems to be no important reaction of FFW upon other forms of disarmament.

E. Backyard Ballistic Missiles

The fight between fixed and mobile Minuteman systems has been fought and won by the fixed system. The decision against the mobile system was based on many considerations, the most important single factor being probably the greater uncertainty of command and control in the mobile system.

An intercontinental BYBM system would have precisely the same advantages and disadvantages as the mobile Minuteman system, in somewhat accentuated form. There is no need to repeat all the arguments that have been used against the mobile Minuteman. We may simply state the general conclusion, that an intercontinental BYBM system would not have a significant effect on the strategic balance between the major powers. The effects of BYBM on the prospects for general disarmament are clearly adverse, since BYBM could be easily concealed and so would make an agreement to limit numbers of strategic delivery vehicles much harder to reach. It is therefore in the interest of the U.S. not to deploy, and not to encourage other countries to deploy, intercontinental BYBM systems.

The rest of this section will deal with the problem of medium-range BYBM systems, commonly called MMRBM, as strategic weapons for the European part of NATO.

The arguments for and against MMRBM are frankly political rather than military. The question is whether the Western European countries need an "independent retaliatory force" to deter a Soviet attack, or whether they can rely on the U. S. retaliatory forces alone. The U. S. is formally pledged to respond to a Soviet attack on Western Europe as if it were an attack on the U.S., but the reliability and permanence of this pledge are inevitably subject to some degree of doubt.

If one assumes that the independent retaliatory force is a political necessity for the European NATO powers, then the MMRBM is probably the best system to adopt. It is the only land-based system which would have a chance of surviving a massive first strike by the superior Soviet force of accurate short-range and medium range missiles.

If one believes that the NATO alliance is one and indivisible, and that the U. S. retaliatory forces are sufficient to protect all the NATO countries, then the arguments against MMRBM become very strong. First, MMRBM are likely to be difficult to control, vulnerable to sabotage, and prone to accident. Second, MMRBM would make the verification of disarmament more difficult. Third, MMRBM widely distributed in Western Europe would increase Soviet fears of encirclement and would probably stimulate a general intensification of Soviet military efforts.

It is our judgment that the political advantages within NATO of a European MMRBM system are decisively outweighed by the political disadvantages produced by probable Soviet reactions to such a system. The USSR must inevitably regard a European MMRBM system as a direct and serious threat to its security. To establish such a system would mean to abandon all efforts toward a relaxation of tensions and toward a political stabilization of the existing situation in Europe.

F. Supersonic Low-Altitude Missiles

Since SLAM, even in the eyes of its most optimistic proponents, is only an adjunct to existing ICBM forces, it cannot have any important effects on the strategic balance. If an AICBM system should be developed with efficiency high enough to nullify the ICBM forces, it is likely that with some additional effort the SLAM forces could be nullified too. The answer to questions (a) and (b) is that in any foreseeable circumstances SLAM will not be of major strategic importance.

In view of its basic unimportance, SLAM might be a good candidate for a generous political gesture, designed to limit the arms-race and improve the atmosphere for other more serious steps toward disarmament. The gesture might take the form of a unilateral renunciation of SLAM by the U.S., following the tactic of "Graduated Reciprocation in Tension Reduction" advocated by the psychologist Charles Osgood. Alternatively the U.S. might propose a treaty for the world-wide prohibition of SLAM without any special machinery of verification. Either move would be a good "first step" in a serious effort to negotiate a general disarmament agreement, and would not endanger the security of the U.S.

The political impact of either form of renunciation of SLAM would be very great if the renunciation immediately followed the first successful flight-test of a SLAM vehicle. A SLAM vehicle flying at Mach 3 and at 500 feet altitude, its tail white-hot and spewing out radioactive exhaust, will be an impressive and terrifying spectacle; it will create a shock-wave strong enough to demolish light buildings anywhere within half a mile of its track. A publicly staged demonstration of a SLAM vehicle flying around the world over an oceanic route would create a sensation out of all proportion to its real military importance. After such a demonstration, a U.S. announcement to the effect that "in view of the unlimited powers of destruction offered by this formidable new weapon, the U.S. has decided to spare humanity the horrors of its further development..." would fall upon ready ears. The demonstration followed by renunciation would be a superb propaganda stunt. Moreover, it would be not merely a propaganda stunt but a genuine move in the direction of international sanity, to which the Soviet leaders might perhaps be responsive.

If a decision is made to use SLAM for a political move of this kind, it is important to make the decision soon enough so that the technical and operational problems of the demonstration flight can be foreseen and overcome. The vehicle required for a demonstration flight may be quite different in detail from a normal prototype vehicle. The provisional flight-test date is five years away, but the decision to turn this flight-test into a public political demonstration ought if possible to be made within the next two years.

G. <u>Massive Anti-Submarine Warfare</u>

A successful development of MASW by the U.S., with or without a parallel Soviet development, would enormously increase the ability of the U.S. to fight a prolonged non-nuclear war, for which regular sea-borne supplies of men and materials are a primary requirement. Such a development would be highly desirable for two reasons. First, the balance of military strength in many peripheral areas of the world would be shifted in favor of the U.S. Second, the ability to fight a prolonged non-nuclear war is the most essential factor in trying to establish a defense of Western Europe which does not automatically escalate into general nuclear annihilation as soon as it is challenged.

Compared with this effect of MASW in making non-nuclear war more feasible, the effect of MASW in degrading the capabilities of

POLARIS forces is probably of lesser importance. The installation of MASW would be gradual and could not be altogether concealed even by the tightest Soviet secrecy. Thus the U. S. would know that the POLARIS force was becoming vulnerable, long before its vulnerability would become complete. While the Soviet MASW system was being built and improved, the U. S. would have time to cut back on the building of POLARIS forces and build an equivalent number of MINUTEMAN sites instead.

Although the effect of MASW on the strategic balance, through increasing the vulnerability of the second-strike POLARIS forces, is destabilizing, it seems that the destabilizing effect is neither severe nor sudden enough to be dangerous. On balance this unfavorable effect is greatly outweighed by the effect of MASW in decreasing the vulnerability of U. S. land forces overseas to submarine blockade during prolonged non-nuclear war. So the answer to questions (a) and (b) is that development of MASW by the U. S. would have generally beneficial and stabilizing effects on the strategic balance, whether or not the USSR installed a similar system. The question of a Soviet system not balanced by a U. S. system does not need to be considered.

A political limitation on MASW systems is undesirable and should not be attempted. It might in some circumstances be desirable to combine national MASW systems into an international system for monitoring submarine movements. This would be helpful, for example, if many countries had come into possession of nuclear weapons, and if the major powers were primarily concerned with protecting themselves against anonymous POLARIS or GM attack by poorer countries. Likewise, an international MASW system would be helpful in reducing uncertainties during the late stages of any plan for complete and general disarmament.

The answer to question (e) is that the existence of MASW systems, either national or international, would help considerably in negotiating any agreement on disarmament of naval forces. An efficient MASW system would be able to monitor the activities of retained forces accurately enough, so that the problem of verification of the agreement would not be severe. The requirements for detailed inspection of naval bases and port facilities could be correspondingly relaxed.

H. Manned Space Forces

We must first consider the question whether there is any merit in the "extreme Air Force view" which regards bombardment MSF as a decisive strategic weapon of the future. Since nobody maintains that bombardment MSF would be cheaper or more accurate than an ICBM force with the same destructive power, the argument must hinge on the question of vulnerability. Is it possible that a land-based ICBM force could be disorganized and made ineffective by a massive attack? Is it possible that a bombardment MSF force, built at the same total cost as the ICBM force, could be less vulnerable?

The vulnerability of land-based ICBM forces has been intensively studied. Roughly speaking, the conclusion is that a hardened and dispersed ICBM force is sufficiently invulnerable for purposes of retaliation, provided that the opposing force is of approximately equal or inferior strength. The problems of command and control of the force after a heavy attack are worrying, but strenuous measures have been taken to make the control system rugged. It is likely that the ruggedness and reliability of the control system will improve in future years to a point at which failure of retaliation through disorganization of the control system is highly improbable.

The vulnerability of bombardment MSF has hardly been studied at all in quantitative way. One thing is very clear: the bewitching picture of MSF sailing the seas of space in silent and secret majesty, like the grey ships of the British fleet which Napoleon never saw but which defeated his dreams of empire, is an illusion. Space is an environment in which it is extremely difficult to hide. Any substantial MSF must frequently be serviced and supplied from the ground, and the location of the MSF orbits will soon be precisely known to the other side. A passive space-vehicle can be located by radar from distances of thousands of miles, and a vehicle emitting radio signals can be located from much greater distances.

It is inevitable that, as soon as one side establishes a large bombardment MSF, the other side will establish a counter-MSF which will continuously reconnoiter, track and watch the activities of the bombardment MSF. The counter-MSF will then be in an excellent position to disable the bombardment MSF by a concerted surprise attack. Each counter-MSF vehicle could probably destroy 5 or 10 bombardment MSF vehicles by means of small interceptor rockets carrying nuclear warheads with a weight of 50 pounds each. The tactics of this kind of space warfare need to be examined in detail. But it can already be said with some confidence that, in a fight between two MSF of approximately equal strength, the advantage to be gained by surprise attack is very great. A bombardment MSF will in the long run become highly vulnerable and therefore unreliable as a retaliatory force.

The basic reason why bombardment MSF are more vulnerable than ICBM forces is that a space vehicle cannot be adequately hardened against nuclear weapons. It takes an ICBM to destroy an ICBM, but a 50-pound warhead would be enough to destroy any space vehicle.

The conclusion of this discussion of bombardment MSF is that they would be strategically destabilizing and that it is in the interest of the U. S. to stop them from being deployed by either side. Unfortunately, it seems impossible to conclude and monitor a political agreement prohibiting bombardment MSF without becoming deeply involved in the problem of reconnaissance MSF, where the interest of the U. S. works in the opposite direction.

The strategic issues involved in reconnaissance MSF are very simple. So long as Soviet society is less open than U. S. society reconnaissance MSF will be strongly advantageous to U.S. security. Furthermore, reconnaissance MSF make all kinds of disarmament agreements easier to reach by reducing the need for comprehensive ground inspection.

Only in one respect are reconnaissance MSF harmful. They increase Soviet fears of a successful U. S. first strike, and thus help to push the USSR in the direction of increased armaments. However, it is not reconnaissance MSF alone, but reconnaissance MSF in conjunction with a superior U. S. striking force, which makes the Soviet leaders so acutely nervous. So long as the U.S. is determined to maintain a superiority of force, there is not much chance that Soviet leaders will agree to substantial measures of disarmament, whether or not reconnaissance MSF exist. Conversely, if the U.S. would settle for some kind of strategic parity, the Soviet leaders would probably consider their security adequately protected even in the presence of reconnaissance MSF. Thus the decisive factor in destabilizing the arms race is probably the U.S. policy of strategic superiority rather than the U.S. use of space reconnaissance vehicles.

It would be strongly in the interest of the U.S. to come to some political agreement with the USSR in which the use of reconnaissance MSV is officially legalized. We should be prepared to make substantial concessions to achieve such an agreement. If such an agreement is not made, there is always a danger that the USSR will begin destroying U.S. vehicles. Destruction of vehicles would probably not be able to stop effective reconnaissance of the USSR by the U.S., but the resulting situation would be politically embarrassing, explosive, and dangerous. The interest of the U.S. in legalizing reconnaissance MSV seems to be much more acute than our interest in prohibiting bombardment MSV.

It is in any case clear that a U.S. acceptance of strategic parity would be a minimum concession which the USSR would require in return for a legalization of reconnaissance MSV.

IV. Summary and Recommendations

The main conclusions of the strategic analysis can be conveniently presented in tabular form.

QUESTIONS	CABM	UABM	GM	FFW	BYBM	SLAM	MASW	MSF
	WEAPON SYSTEMS							
(a) Effect of bilat-use of system.	F	F	U	F	U	I	F	F
(b) Effect of unilat-eral use of system.	F	U	U	U	U	I	F	F
(c) Effect of politi-cal agreement to limit use.	U	U	F	U	F	F	U	U
(d) Feasibility of political agree-ment.	D	O	T	O	G	T	D	D
(e) Effect of system on other forms of disarmament.	UF	F	I	U	U	I	F	F

The meaning of the letters i$ as follows:

F - favorable to U.S. security and to the stability of the strategic balance.
U - unfavorable to U.S. security or to general stability.
UF - initially unfavorable and later favorable.
I - question irrelevant
D - doubtful
G - good
O - political agreement to increase scope of open contacts with Soviet scientific establishment is the best safe-guard.
T - benefits of a political agreement can only be realized by clever tricks with careful preparation.

All these conclusions are of course tentative, pending further study.

The most striking general conclusion which emerges from a survey of the table is that the present strategic balance is on the whole stable against the perturbations introduced by new weapons. The stability arises from the fact that no new weapon, with the possible exception of GM, seriously competes in effectiveness and reliability with a large dispersed ICBM system. The chief dangers to stability and to U.S. security which are seen as likely to arise from new weapons during the decade 1962-72 are two; namely: (1) Deployment of GM by the CPR or by other emerging nuclear powers. (2) Sudden unilateral deployment of large-scale UABM or FFW by the USSR, as a result of a well-concealed technological breakthrough.

The following is a brief summary of specific recommendations arising from the study of the various weapon systems.

(1) Political measures to discourage the CPR from building GM should be attempted on high priority. Necessary diplomatic and military concessions should be offered in order to make either (a) a test ban agreement, or (b) an agreement limiting production of heavy water, or both, attractive to the CPR. The connection between these agreements and GM should be carefully concealed during the negotiations.

(2) Political agreements to keep contacts with the Soviet scientific community as wide open as possible should be sought in preference to agreements on inspection for specific weapons.

(3) A program for the public demonstration of SLAM followed by a dramatic act of renunciation should be used as a curtain raiser to more serious disarmament negotiations.

(4) Medium-range BYBM should be denied to the European NATO powers.

(5) The Soviet development of CABM should not be discouraged, and disarmament proposals made to the USSR should not insist on a degree of inspection which would compromise the Soviet CABM system.

(6) Political agreements should be sought by which the USSR recognizes the legality of reconnaissance satellites and reconnaissance MSF, in return for the U.S. acceptance of a position of strategic nuclear parity.

V. References

Since I have not attempted to track down the important documents on each of the subjects discussed, I give a list of names of people from whom I have obtained the bulk of the information on which the study was based.

(a) CABM, technical. CIA briefings to JASON Division of IDA on the Soviet CABM development.

(b) Briefings to JASON on NIKE-ZEUS by people from Western Electric.

(c) CABM, strategy. Thornton Read, Woodrow Wilson School of International Relations, Princeton University.

(d) UABM. N. Christofilos, LRL, Livermore; K. M. Watson, University of California, Berkeley; M. Rosenbluth, General Atomic, San Diego.

(e) GM. Occasional discussions at Los Alamos; T. Taylor, General Atomic, San Diego.

(f) FFW. Ray Kidder, LRL, Livermore.

(g) BYBM. John Foster, LRL, Livermore.

(h) SLAM. T. Merkle, LRL, Livermore.

(i) MASW. Walter Munk, University of California, La Jolla; N. Christofilos, LRL, Livermore.

(i) MSF. "Extreme Air Force View," Capt Mixon, AFSWC, Albuquerque, N.M. Studies of possible military use of MSF made by Project ORION, General Atomic, San Diego.

The overall strategic analysis owes much to George Pugh of ACDA, though he is not responsible for the conclusions.