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ARMS CONTROL AND OUTER SPACE

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ARMS CONTROL AND OUTER SPACE

INTRODUCTION

The scientific exploration of space, beginning with probes by radio transmissions, balloons and sounding rockets, and followed by satellites orbiting the earth and then space vehicles reaching the moon and planets, was soon succeeded by practical exploitation for commercial and military ends. Satellite relay of radio and television broadcasts are now commonplace, as are weather reports including photographs from meteorological satellites. As will be described in this paper, a number of important military functions are now carried out by satellites(1). These military functions have been related to surveillance or navigation, rather than carriage of weapons, and have not caused serious unease or demands for control. However, some programs for anti-satellite systems are under development, and increasing interest is being shown in the use of Directed Energy Beams for defence against ballistic missiles (2). As will be explained, beam weapons may prove most effective if mounted in space vehicles, and are likely to be more of a threat to earth satellites than to ballistic missiles.

Such success as has been achieved in arms control has been in large part associated with the limitation or proscription of weapons not yet developed, or of the banning of weapons from parts of the universe where they have not yet been deployed. Examples would be the ABM Treaty, the Outer Space Treaty, the Seabed Arms Control Treaty, the Antarctic Treaty, and the Treaty for the Prohibition of Nuclear Weapons in Latin America.

With this background in mind, it is likely that attention will soon be focussed on the extension of arms control in space, perhaps in time to forestall a competition involving heavy expenditures on anti-satellite or space-based ABM weapons.[3] However, in formulating sensible objectives for arms control in space it will be necessary to take into account those activities, military as well as commercial, which are beneficial and should be encouraged to continue.

In a search for policies in arms control that promise to be useful and practical, it is important to identify criteria which are objective and logical. The thrust of this paper is to suggest as a prime criterion for arms control that a measure should contribute to the stability of international relations, and in particular to the stability of the strategic deterrence of aggression and war. Unfortunately, as will be shown, when this criterion is applied to military space systems, it appears that very few systems can be categorized as either completely stabilizing or completely destabilizing. This is disappointing for those who seek simple answers. But in arms control, as in so many other arenas, close objective study shows that few aspects are in truth simple.

STABLE AND UNSTABLE DETERRENCE

The concept of stability and its application to the analysis of strategic weapon systems was discussed in an earlier issue of this journal.[4] The essence of the idea is that a stable system is able to react to stresses in such a way as to preserve its equilibrium. In the case of a strategic weapon system, two types of stability need to be distinguished.

To be stable in a crisis, a system must not provide any rational incentive for either opponent to attack first. Neither should it motivate either to set his responses on a "hair-trigger", which might be activated on a false alarm, or produce a disproportionately large response to a comparatively minor provocation. Crisis stability operates over a short time period, possibly minutes, hours, or a few days.

The other type of stability has to do with the arms competition, and operates over a longer time scale, probably years. If the introduction of a new strategic system provides a rational motive for the opponent to build another new system to counter or offset it, then the new system is destabilizing from the point of view of arms control.

Crisis stability is improved by steps such as reliable early warning, and arrangements for communication in emergencies. It is adversely affected by the introduction of weapons well suited for a surprise first strike. Arms control stability can be improved by good agreements with adequate verification, and damaged by the introduction of a weapon representing a new type of threat.

THE PRESENT STATE OF ARMS CONTROL IN SPACE

The Limited Test Ban Treaty, signed in 1963 and subsequently ratified or acceded to by 108 countries, prohibits nuclear test explosions (or any other nuclear explosion) in the atmosphere or beyond its limits, including outer space.

The Outer Space Treaty, signed in 1967 and subsequently ratified or acceded to by 76 countries, prohibits the placing of nuclear weapons or other weapons of mass destruction in orbit around the Earth. It also specifies that objects projected into space remain the property of the launching state.

Neither these nor any other agreement forbid the many uses of space being made today for military purposes, nor do they prevent the development or deployment of antisatellite weapons, as long as these do not carry nuclear explosives.

The ABM Treaty of 1972, operating between the USA and USSR, permits each party to have one limited ABM system, and allows the developing and testing of fixed land-based ABM systems at agreed test ranges. It forbids the development of space-based ABM systems, and agreement has been established that the introduction of a system employing "other physical principles" capable of substituting for ABM launchers or missiles would be the subject of discussion.

THE STABILIZING AND DESTABILIZING CHARACTERISTICS OF SATELLITE SYSTEMS

To the extent possible, the various types of satellite systems will now be categorized as stabilizing or destabilizing, from the points of view of crises and of arms control. In most cases it would be misleading to label a system as "categorically stabilizing" or "categorically destabilizing". There may be aspects that are clearly stabilizing or destabilizing, but the overall effect will depend on a host of factors such as the nature of the military balance between the nations in question, the international setting, and the military strategies of the opposing nations.

Photo-Reconnaissance

Whether for verifying arms control agreements or simply monitoring the weapons deployed by adversaries, photographic reconnaissance satellities must surely be listed as highly stabilizing for arms control. If the other side is keeping within agreed limits, and not deploying destabilizing weapons, photo-recce satellites can confirm the fact. If they are contemplating a buildup (whether or not in defiance of agreement) the probability of early detection would be a deterrent.

It is not so clear where to list reconnaissance satellites for crisis stability. They could warn of movements of surface ships, aircraft, and ground forces. They certainly would be useful for an aggressor planning a surprise attack, whether at the strategic or tactical level.

Radar Reconnaissance

While photographic images can provide the resolution needed for identification of the details of missiles, warships, and radar installations, and for estimating the size of deployed military formations, the right conditions of visibility may not present themselves when the information is desired. For certain purposes, such as surveillance of the surface of large areas of ocean, radar is a better instrument than the camera, being able to sweep a huge area without depending on daylight or weather.

In a time of crisis it could be important for both contestants to know whether the other's surface fleet was at sea, and where it was. The knowledge would help an aggressor to plan a surprise attack on his opponent's ships, or warn the prospective victim of a developing threat from surface ships, although not from submarines or aircraft. In general, it is probable that increased mutual knowledge of the opponents' activities is stabilizing in a crisis.

In a few years it may be possible to detect aircraft in flight by a satellite, dependent on infrared or radar signatures. Such a system would be free of many of the limitations of ground radar.

Radar satellites would be of minor value for verifying arms control agreements. They very well could provide the motivation for an antisatellite system to be built by a nation critically dependent on the safety of its surface fleet.

Electronic Intelligence

ELINT satellites are very similar to photo-recce satellites from the point of view of stability. They are particularly valuable for monitoring the characteristics of radars and for observing missile tests, and certainly contribute to arms control stability. In a crisis they might give warning of preparations for attack, but would also be of considerable value to the side planning a surprise attack. Analysis of radar transmission could, for example, provide information regarding strengths and weaknessess of radar cover, the identification of stations off the air, and vulnerability to electronic countermeasures. Analysis of communications traffic can reveal something of the state of activity and readiness of large military formations.

Communication

During a crisis, stable behaviour is likely to be encouraged by good communications. False alarms, or the absence of information can lead to dangerous reactions, possibly without central authorization. Rational assessment of the significance of apparently threatening activity in one part of the world requires up-to-the-minute reliable knowledge of what is (or is not) happening elsewhere. Communications satellites contribute to crisis stability. For arms control stability, which operates on a longer time scale, they do not appear to be either stabilizing or destabilizing, although the heavy dependence on communications satellites by one side could provide a motive for development of ASAT by the other.

Missile Detection

Although it is possible to detect the flight of ballistic missiles by large ground-based radars, a more reliable system with worldwide coverage has been achieved by the use of infrared detectors in high altitude satellites. Three of these can cover nearly all of the earth's area, including the detection of sea-launched missiles and missiles fired on test ranges.

A system able to detect the launching of missiles from distant territory should be stabilizing in a crisis, since it makes an attack less likely to achieve complete surprise. A reliable warning system with worldwide coverage should provide crisis stability in the event of an accidental launch of a missile, or explosion of a nuclear weapon, since it would be realized that no more missiles were on the way. In such a situation, crisis stability would also be enhanced by reliable worldwide communication between adversaries.

A missile detection system can also have a part to play in stabilizing arms control, especially in conjunction with ELINT and photo recce satellites and suitably located ground radars, as a means of monitoring missile tests.

Detection of Nuclear Explosions

Although the capability to report nuclear explosions on a worldwide basis would aid in the assessment of the success of an attack and in the efficient assignment of follow-up weapons, on balance it would seem to be a stabilizing factor in a crisis and also for arms control. Awareness that an attack was under way would be heightened, making retaliation more probable. International control of a conflict not involving NATO or the WP, but in which nuclear weapons were employed, could be expedited. Above-ground testing of nuclear weapons by any country would be detected.

Navigation

Navigation satellites enable submarines to fix their positions well enough to correct errors accumulating in the inertial navigation systems on board the submarine. The resulting accuracy with which SLBMs can be delivered would seem to be quite adequate to provide a stabilizing retaliatory capability against population targets. However, the potential accuracy of future cruise or ballistic missiles which correct their in-flight navigation errors by use of a satellite navigation system may be so high as to give them a counterforce capability against hardened point targets. It could be concluded that navigation satellites can be stabilizing or destabilizing, depending on the accuracy which they can provide for strategic weapons.

Highly accurate navigational satellites could also be considered destabilizing for arms control, since their contribution to a counterforce capability could provide a rational motivation for an opponent to defend his retaliatory weapons by BMD, make them mobile, increase their numbers, or build a system to destroy the navigation satellites. On the other hand, aids to the navigation of civil aircraft and ships in peacetime can prevent accidents and save time, thus encouraging international cooperation.

Meteorological

Meteorological satellites could be of use for the planning of offensive air and naval operations, and are therefore likely to be of more help to an attacker than a defender. They would be an aid for the avoidance of detection. It would seem that they should be listed as destabilizing in a crisis. From the point of view of arms control they are also mildly destabilizing, since if A can forecast cloud cover and use it to conceal the movements of his ships or other activities from B's photographic satellites, B has an incentive to equip himself with other surveillance systems able to operate in spite of clouds. On the other hand, the worldwide exchange of meteorological data in peacetime has a positive effect for international cooperation.

Scientific, Geodetic, Earth Resources

Many types of satellites are used to make observations and measurements of various features of the earth and of space. The information so obtained may be employed for all sorts of purposes, some of which may be military. In particular, geodetic data regarding the precise shape of the earth, the position of geographic features on the surface, and the gravitational field which controls the trajectories of ballistic missiles are needed for accurate delivery of missiles to distant targets. Likewise, the guidance of terrain-following cruise missiles will be dependent on accurate maps of surface contours, probably best obtained by satellite observations.However, no one can foretell the use which may be made of knowledge not yet acquired, and it does not seem possible to categorize these types of satellites as either stabilizing or destabilizing.

Manned Satellites

For most of the roles already described, the instruments in unmanned satellites perform the functions better than could men. The presence of men in a satellite poses restrictions on its operations, in addition to demanding a major part of the payload, to say nothing about the cost, in order to sustain life with a very high degree of reliability. However, there are certain functions that can be only, or best, performed by human astronauts. One of these is the assembly of large structures in space, something that may be required for several purposes. Another is the inspection of satellites already in orbit, diagnosis of faults, and repair.

It does not seem profitable to try to categorize manned satellites as either stabilizing or destabilizing. But the potential value of the space shuttle for launching, assembly, and maintenance of a wide variety of space vehicles, both commercial and military, is so great that no agreement to abstain from its use could be acceptable.

Antisatellite Systems

From the foregoing analysis it can be seen that it is not possible to categorize all satellites as either stabilizing or as destabilizing, whether for crisis or for arms control. However, on balance it would seem that they are more stabilizing than destabilizing, especially for arms control.

As a consequence, antisatellite systems can be described as, on balance, destabilizing, especially for arms control. Antisatellite measures are sure to generate counter counter-measures to protect the threatened satellites, a classic feature of arms competition.

ANTISATELLITE DESTRUCTION MECHANISMS

Some potential antisatellite systems depend on satellites, some are ground based, and some may be carried by aircraft. A system designed to destroy ballistic missiles in flight is very likely to have an antisatellite capability. Our discussion of antisatellite systems should encompass all systems that could have the potential to destroy space systems.

Satellites can be attacked by at least five types of destruction mechanisms. It is instructive to discuss the destruction mechanisms one by one, and to consider their possible effectiveness against missiles as well as satellite systems.

Nuclear Warhead

A nuclear explosion radiates a large amount of energy, which can damage a satellite by thermal shock, and by interaction of electromagnetic fields, X-or gamma radiation, or neutrons with electrical components. The vacuum of outer space, which prevents the transport of energy in the form of blast, allows unimpeded transmission of radiation.

The nuclear kill mechanism capable of the most widespread damage to space systems is the electromagnetic pulse (EMP).[5] This is a form of radiation extremely destructive for electrical equipment. A large nuclear explosion at high altitude can generate an EMP likely to incapacitate electronic components at ranges of thousands of kilometres, whether in space vehicles or on the ground. It would be indiscriminate, threatening all satellites, ground readout stations, and other electrical systems except those provided with special protective shielding, bypass circuits, fuses, or backup units.

Nuclear warheads constitute one of the kill mechanisms for ballistic missile defence. Because they contain a nuclear weapon themselves, the reentry vehicles are vulnerable to damage by neutrons (which are able to penetrate the heat shield and initiate an incomplete nuclear reaction). They are also vulnerable to the soft X-rays from a nuclear explosion outside the atmosphere, as would be a satellite. Both of the interception missiles for the American Safeguard ABM system used nuclear warheads.

High Explosive Warhead

Because blast cannot be transmitted through a vacuum, a high explosive warhead would need to damage an orbiting satellite by driving metal fragments into its structure.

The vulnerability of ballistic missiles to high explosive is reduced by the presence of the heat shield needed for survival during reentry into the atmosphere.

Mechanical Collision

When a collision occurs between two objects, the damage done depends on the kinetic energy represented by their masses and relative velocity. Since an orbiting satellite is moving at high speed relative to the earth, (roughly 17000 statute miles per hour in the case of a low circular orbit), the presence of quite small fragments of metal in its path can represent a serious hazard. Thus, a small interceptor, distributing many small hard fragments in the path of the satellite, would use the high velocity of the satellite to wreck itself when it collided with some of the fragments. Alternatively, a small homing vehicle could destroy the satellite by a head-on collision.

The same principles apply to destruction of a ballistic missile, although its reentry shield will make it a tougher target than a satellite and it will not be moving as fast.

Laser Beam (6)

A laser beam delivers its energy in the form of electromagnetic radiation. This could be absorbed in the outer surface of the target and converted into heat, with consequent structural damage if sufficient energy were delivered. However, some satellites with sensitive components such as infrared detectors or solar cells could be incapacitated by comparatively low intensities of laser energy.

The heat shield on a ballistic missile should afford considerable protection against laser energy, and there will be no sensitive mechanisms exposed. Because the laser beam would lose energy in the atmosphere, there is an important advantage if the source can be located in space.

Particle Beam (7)

The effects of a particle beam on a satellite will be to deposit energy more deeply and more uniformly than would a laser. The intensity would need to be quite high in order to inflict significant damage unless particularly sensitive components were exposed. A ballistic missile will be a tougher target than a satellite, except that its nuclear warhead could be incapacitated by neutrons.

THE RELATIONSHIP FOR ARMS CONTROL OF ANTISATELLITE SYSTEMS TO BMD

All of the mechanisms described above which are capable of destroying ballistic missiles in flight are also able to attack satellites. It is also true that the systems designed to detect ICBMs in mid-course will probably be able to detect satellites in low earth orbit.

The technical problems faced by exoatmospheric ABM systems are more difficult than those for interception of a low orbit satellite. The ICBM is a tougher target to damage, it arrives with far less warning time or opportunity to predict its trajectory, and it offers no later opportunities on subsequent orbital passages.

Should laser or particle beam weapons, whether ground-based or space-based, attain the capability to destroy ballistic missiles in mid-course, there is little doubt that they would find low-orbit satellites an easier target.

Satellites in very high orbits, or following very elliptical orbits, are more difficult targets, both to detect and to intercept. The problems of interception will be eased if it is deemed acceptable to wait for a few hours or a few days until the motion of the earth and of the satellite brings the target into favourable position.

SUMMARY

It would be unrealistic to label all military uses of space as uniformly either stabilizing or destabilizing. On balance, there seems to be more that are stabilizing than destabilizing, especially from the point of view of arms control. Because of this, antisatellite systems are considered to be destabilizing.

These judgements regarding the stabilizing or destabilizing influence of various types of satellites are indicated in the Table. They are by no means categorical, and represent tendencies rather than absolute characterizations.

It would appear that abrogation of the ABM Treaty would put an end to any prospect of control of antisatellite weapons.

In summary, and speaking only in principle, prevention of antisatellite measures would seem desirable for the preservation of stable deterrence, but complications and difficulties in the way of a workable agreement are formidable. Should the ABM Treaty be abrogated, the prospects for arms control in space will be greatly reduced.

SATELLITE SYSTEM	STABILIZING TENDENCIES		DESTABILIZING TENDENCIES	
	CRISIS	ARMS CONTROL	CRISIS	ARMS CONTROL
Photo-Recce		X	?	
Radar Recce	?			X
ELINT		X	?	
Communication	X			
Missile Detection	X	X		
Nuclear Explosion Detection	X	X		
Navigation			X	X
Meteorological			X	?
Earth Resources				
Scientific, Geodetic				
Manned				
ASAT			X	X

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