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ARMS CONTROL IN OUTER SPACE:

ASATs AND ABMs

by

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IMPLICATIONS OF ORBITING SATELLITES FOR GLOBAL SECURITY

Figure I lists the main roles of satellites related to military applications and indicates:

-whether most of the satellites with the indicated role are orbited on Low Earth Orbits (LEO), Geosynchronous (and therefore very high) orbits (GEO), or at various altitudes;

-whether the overall influence of this type of satellite is

-stabilizing, and\or helpful to defence
-destabilizing and\or helpful to offence
-of significant importance for civilian activities.

Two stars indicates a strong influence, one star a significant but less strong influence.

This assessment suggests that, although satellites can be used for offensive purposes with destabilizing consequences, they can be (and are being) used for many purposes which are stabilizing for security. And, apart from considerations of security and defence, satellites perform so many services for commerce, safety, science, and the effective management of global problems that there will be widespread resistance to any measures likely to restrict their operations.

Although neither of the following judgements are absolute, it can be said that most of the destabilizing activities are carried out from Low Earth Orbit, while the roles effected from Geosynchronous Orbits are primarily stabilizing.

WEAPONIZATION OF SPACE

Except for a few experiments performed some years ago, weapons have not been put into orbit. This may make it easier to negotiate agreements to prohibit it ever being done in the future. However, there is considerable doubt as to the military utility of putting weapons into satellites, especially for space-to-ground attacks, or that prohibition of spaceborne weapons would do very much to enhance the safety of military or civilian assets, whether in space or on the surface of the earth, or to strengthen global stability.

Rather than trying to provide for the safety of military or civilian assets which could be endangered by weapons carried by satellites, WHAT WOULD BE MUCH MORE IMPORTANT (THOUGH ALSO MUCH MORE DIFFICULT) WOULD BE TO PROVIDE FOR THE SAFETY OF ORBITING SATELLITES.

PROTECTING THE INTERNATIONAL USE OF SPACE FOR ALL PURPOSES IS A MORE IMPORTANT (BUT A MORE DIFFICULT) GOAL THAN PREVENTING THE STATIONING OF WEAPONS IN SPACE.

THE VULNERABILITY OF OBJECTS FLYING IN THE ATMOSPHERE

Let us summarize the vulnerabilities of objects flying above the earth.

Although they are hard to hit with stones, arrows, or rifles, birds are vulnerable to men armed with hand-held shotguns. They are also vulnerable to certain birds with high-performance aerodynamics and weapons, such as falcons.

Aircraft fly faster and higher than birds, and are able to take evasive action. But, when flying at low altitude, aircraft are vulnerable to Light Antiaircraft guns with a high rate of fire, and to small agile surface-to-air guided missiles (SAMs). Aircraft flying at higher altitudes can be intercepted and destroyed by larger Surface-to-Air Missiles, able to fly faster than the aircraft, to reach the ceiling of the aircraft, and to manoeuvre in the atmosphere.

Aircraft and cruise missiles are also vulnerable to fast interceptor aircraft armed with rapid-firing guns or cannon, or Air-to-Air guided missiles.

THE VULNERABILITY OF BALLISTIC MISSILES

While artillery shells and ballistic missiles flew too fast to be intercepted by the antiaircraft weapons of the earlier years of the Cold War, in later years the rapidly advancing technologies of rocketry and guidance were used to design Surface-to-Air Missiles (SAMs) with the capability to intercept an ICBM towards the end of its trajectory.

To achieve a range of 10,000 km an ICBM must be accelerated to a velocity of over 7 km/sec. This requires the ICBM to be a large structure with several stages of booster rockets. The "boost phase", occurring over friendly territory, will last for several minutes, during which the booster rockets are used and discarded, and which is completed with the reentry vehicle above the atmosphere.

Once boosted to the "burnout velocity" of over 7 km/sec the reentry vehicle proceeds on its "mid-course" phase through empty space for about 25 minutes, rising to an altitude as high as 1200 km, travelling with a velocity only slightly less than it was at burnout of the booster rockets, until it reenters the atmosphere in a region roughly 500 km from the intended impact point.

A rocket-propelled interceptor missile of feasible size and cost will not be able to achieve a burnout velocity even close to the 7 km/sec of an ICBM, and it cannot expect to be launched until the approach of the ICBM has been detected and its trajectory at least roughly determined. If the site of interceptor missile battery and its surface-based fire-control radar are located near the intended impact point of the ICBM, its opportunity to acquire the target begins about 11 minutes prior to impact.

The difficult task of the ABM system is to project an interceptor into the path of the oncoming ICBM, timed so that the two pass close enough for the kill mechanism of the interceptor to destroy the ICBM. The entire process must be completed in a time-span of a few minutes.

The limited ranges of detection and tracking, and the limited burnout velocities of the interceptor missiles of the first anti-ballistic missile (ABM) systems confined them to interception in the final stages of the ICBM trajectories, when the ICBMs were close to or already in the upper atmosphere. But more recent developments in rocket and guidance technologies, many of which have been directed towards interception of missiles with shorter as well as intercontinental ranges, have opened up the prospect of interceptions occurring above the atmosphere.

THE VULNERABILITY OF ORBITING SATELLITES

While ballistic missiles spend no more than a few minutes in empty space in the mid-course of their trajectory, satellites continue to operate in orbit for extended periods, some as long as many years. Most of the orbits are measured, logged, and reported internationally.

While some satellites can be manoeuvred into slightly altered orbits, most continue in paths that can be accurately predicted for long periods in the future.

Satellites in Low Earth Orbit (favoured for high resolution photography) will circle the earth about 16 times per day, occasionally passing fairly close to every location on the earth whose latitude (North or South) is less than the angle of inclination of the orbit.

Although satellites in Low Earth Orbit will be moving with velocities slightly faster than that of ICBMs (7.4 to 7.8 km/sec), an ASAT interceptor missile only needs enough burnout velocity to reach up to the altitude of the satellite at points in a circle with a radius of a few hundred km centred above the location of the ASAT launcher. Sample burnout velocities required to reach altitudes of 300 and 500 km are 2.4 and 3.0 km/sec respectively.

The booster rockets designed for surface-to-surface missiles of medium and intercontinental ranges could propel ASAT warheads (which are likely to be lighter than Surface-to-Surface Missile (SSM) warheads up to much higher altitudes. To illustrate their capabilities, Figures II, III, and IV show possible trajectories of SSMs which have been designed to achieve maximum ranges of 1000, 2000, and 10,000 km respectively. Each figure shows five trajectories, the lowest of which is the one necessary to achieve the maximum range that can be attained for the relevant burnout velocity (3.0, 4.1, and 7.2 km/sec). But it would be easy to project the same missile at a higher angle than that producing the maximum range, in which case the trajectory would rise to a higher altitude but return to earth at a lesser range from the launch point. It would also be easy to use the same booster to project a lighter payload to a higher trajectory.

LEO satellites orbit at altitudes of between 150 and 1000 km, most of them below 500 km. Figure II shows that a booster capable of accelerating an ASAT payload up to 3 km/sec could cover the altitude band up to 500 km, out to horizontal ranges of several hundred km from the ASAT launcher. Figure III demonstrates that a burnout velocity of 4 km/sec would allow extensive ASAT coverage up to 1000 km altitude, and very long range indeed below 500 km. It would appear that the boosters suitable for many of the Short-Range Ballistic Missiles (SRBMs) may be convertible into ASAT boosters against satellites in LEO.

The other types of booster rocket deployed today (although in smaller numbers and in fewer and more responsible hands than is the case for SRBMs) are those designed for ballistic missiles of intercontinental range (ICBMs) and for launching of space vehicles into orbits.

Figure IV shows the region of outer space that is accessible to a booster capable of projecting an ICBM warhead to a range of 10,000 km. It reaches up as high as 4000 km altitude, but is far short of the altitudes necessary to reach GEO (i.e. around 35,000 km). But, obviously, a booster able to launch a satellite into GEO could also put an ASAT payload there too, provided that it weighed no more than the satellite.

Assuming that some delay (perhaps as long as a few days) is acceptable before the satellite is attacked, all the ASAT battery has to do is to wait for the satellite to come into its reachable zone, and then launch at the appropriate moment

PROVIDED THAT IT HAS ENOUGH BURNOUT VELOCITY TO REACH THE NECESSARY ALTITUDE, AND THAT A DELAY CAN BE TOLERATED, IT IS EASIER FOR A MISSILE TO INTERCEPT A SATELLITE THAN TO INTERCEPT A BALLISTIC MISSILE

An ASAT weapon has been developed for launch from an aircraft (an American F-15 fighter). The mobility of the aircraft gives great flexibility to the choice of time and place from which to launch the interception. The speed and altitude of the aircraft provides some of the velocity that would have to be provided by the first booster stage of a surface-based ASAT missile.

As far as kill mechanisms are concerned, a satellite is likely to be more vulnerable than a ballistic missile. A ballistic missile must have the heat shield necessary to allow its payload to survive reentry into the atmosphere. A satellite is likely to have sensitive instruments exposed on its exterior.

Since the interception will occur above the atmosphere, blast will not be transmitted. But the high velocity of the lightly constructed satellite makes its destruction possible by direct collision with any small dense object.

Just as aircraft are vulnerable to attack by both weapons launched from the surface and from other aircraft, satellites can be attacked by other satellites, as well as from the surface. The Soviet Union experimented with an ASAT satellite which was to be sent into the same orbit as its satellite target, approach it closely, and explode when commanded from the ground.

Thus, satellites are very vulnerable to destruction by mechanisms which already exist in great numbers, not limited by any arms control treaties. Surface-based launchers could use booster rockets built for ballistic missiles to project ASAT warheads into the highly predictable paths of satellites. Satellites can be provided with ASAT weapons and directed into close proximity to target satellites.

A third ASAT threat is developing in the form of high-powered laser beams, able to focus energy on small lightly constructed targets at great distances, especially if not required to first penetrate the atmosphere. These could be generated in a ground installation, preferably located high on a mountain, or in a large aircraft.

Satellites in high earth orbits, or especially in Geosynchronous orbits, are less vulnerable than those in Low Earth Orbits (i.e. no more than a few hundred km). The booster rockets designed for shorter range ballistic missiles could not propel an ASAT warhead above the altitudes of Low Earth Orbits. However, as already mentioned, most of the satellites with destabilizing military roles fly in Low Earth Orbits.

THE POSSIBILITIES FOR ARMS CONTROL IN SPACE

Let us review the threats to orbiting satellites. See Figure V.

An orbiting satellite can be threatened with:

- an ASAT payload projected into the satellite's trajectory by a rocket which may have been originally designed for a ballistic missile or an ABM missile
  - the control of the antisatellite missile may be aided by information collected from an enemy satellite
- an ASAT payload carried into space by a satellite
- perhaps, in the future, a laser beam projected from the ground, a ship, or another satellite.

Thus, any agreement which would provide comprehensive protection for satellites must limit (or prohibit) the existence (or use) of both surface-based and space-based ASAT systems.

The problem is compounded by the widespread ownership of booster rockets designed for ballistic missiles, which can also boost into the path of satellites ASAT payloads designed for their destruction. New ABM systems, currently under development, will also possess powerful booster rockets able to accelerate ASAT payloads to high burnout velocities.

Prohibition of weapons in orbit (i.e. "weaponization of space") would only address part of the threat. Powerful lasers being developed for ABM use, may also pose a threat to orbiting satellites. Even if they are unable to concentrate enough energy on the satellite to physically damage its structure, they may be able to interfere with the operation of its sensors and other instruments.

Successful prohibition of weapons in space would be a contribution towards arms control and a partial step towards the protection of satellites. But the more important goal of complete effective protection of satellites poses many more complicated problems and would be far more difficult to accomplish.

ROLES OF SATELLITES

FUNCTION	ORBITS	STABILIZING	DESTABILIZING	CIVILIAN
SURVEILLANCE	LEO	**	*	**
SIGINT	HI or LO	**		
ELINT	HI or LO		*	
TRACKING OF MOVING OBJECTS	LEO	*	**	*
COMMUNICATIONS	HI or LO	**	*	**
MISSILE WARNING	GEO	**		
DETECTION OF NUCLEAR EXPLOSIONS	GEO	**		
NAVIGATION	LEO		**	**
METEOROLOGICAL	GEO		*	**
SEARCH & RESCUE	HI or LO			*

Figure I

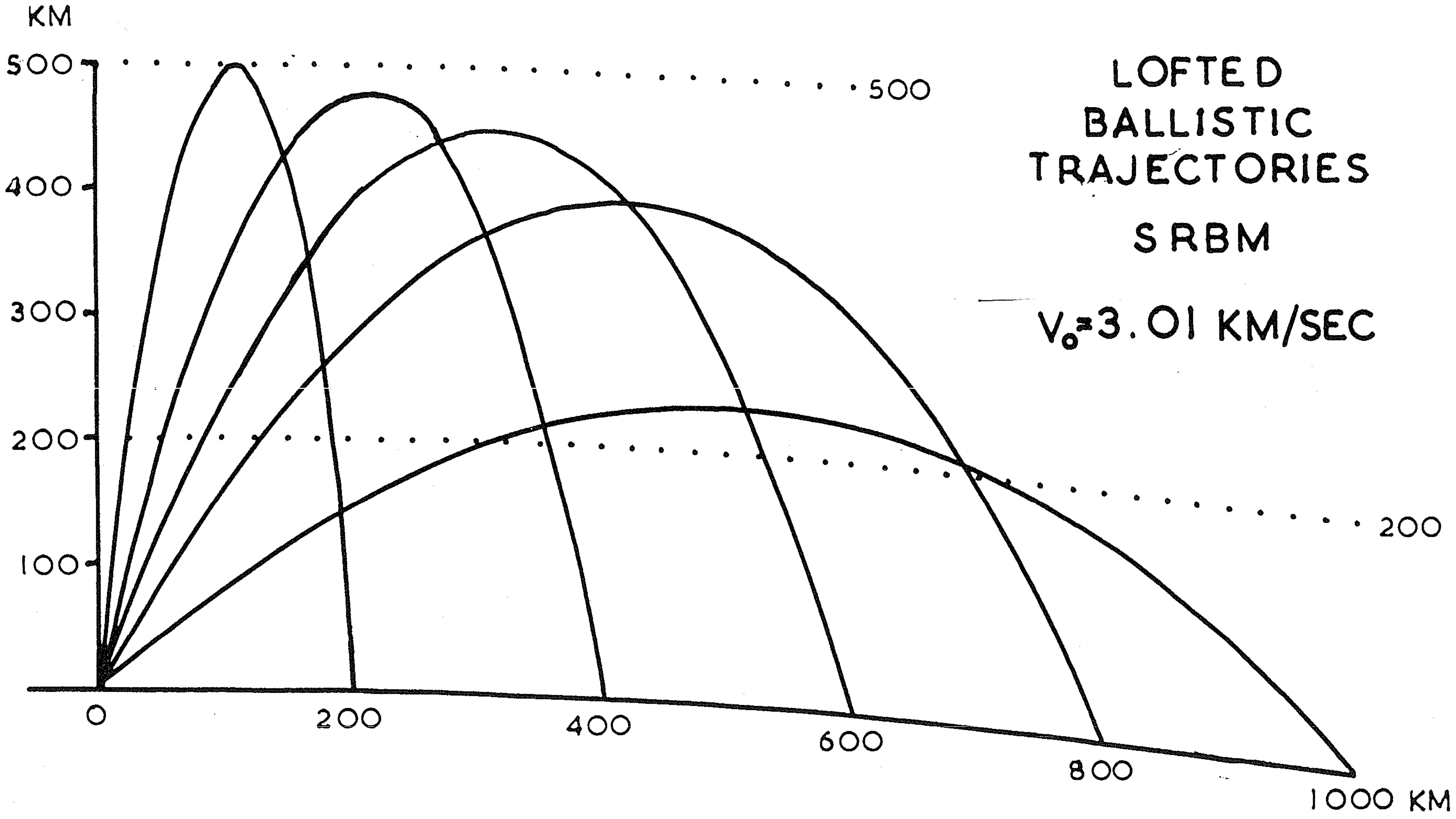

LOFTED
BALLISTIC
TRAJECTORIES
SRBM
$V_o = 3.01$ KM/SEC
KM
500
400
300
200
100
0
200
400
600
800
1000 KM
500
200

Figure II

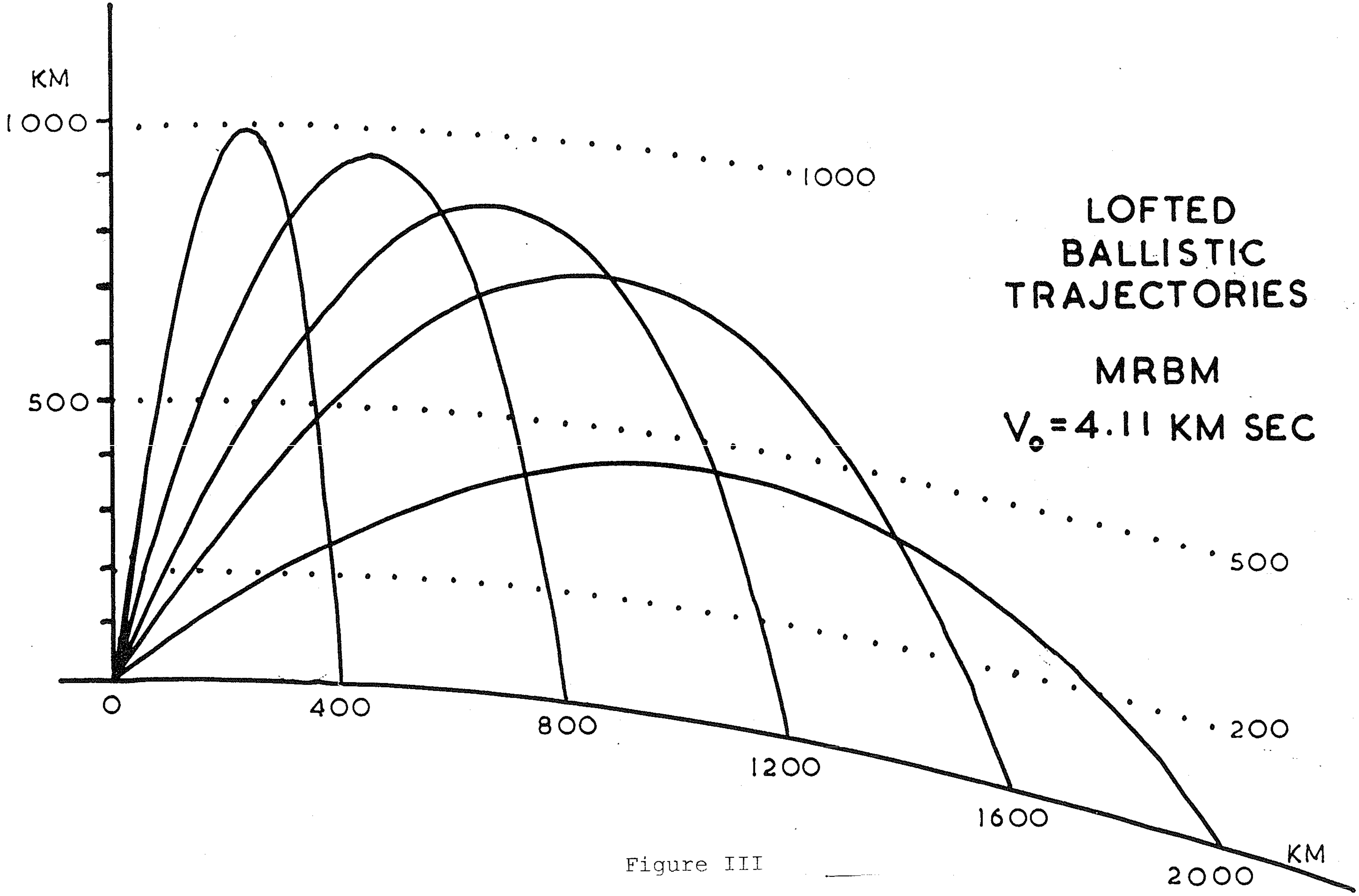
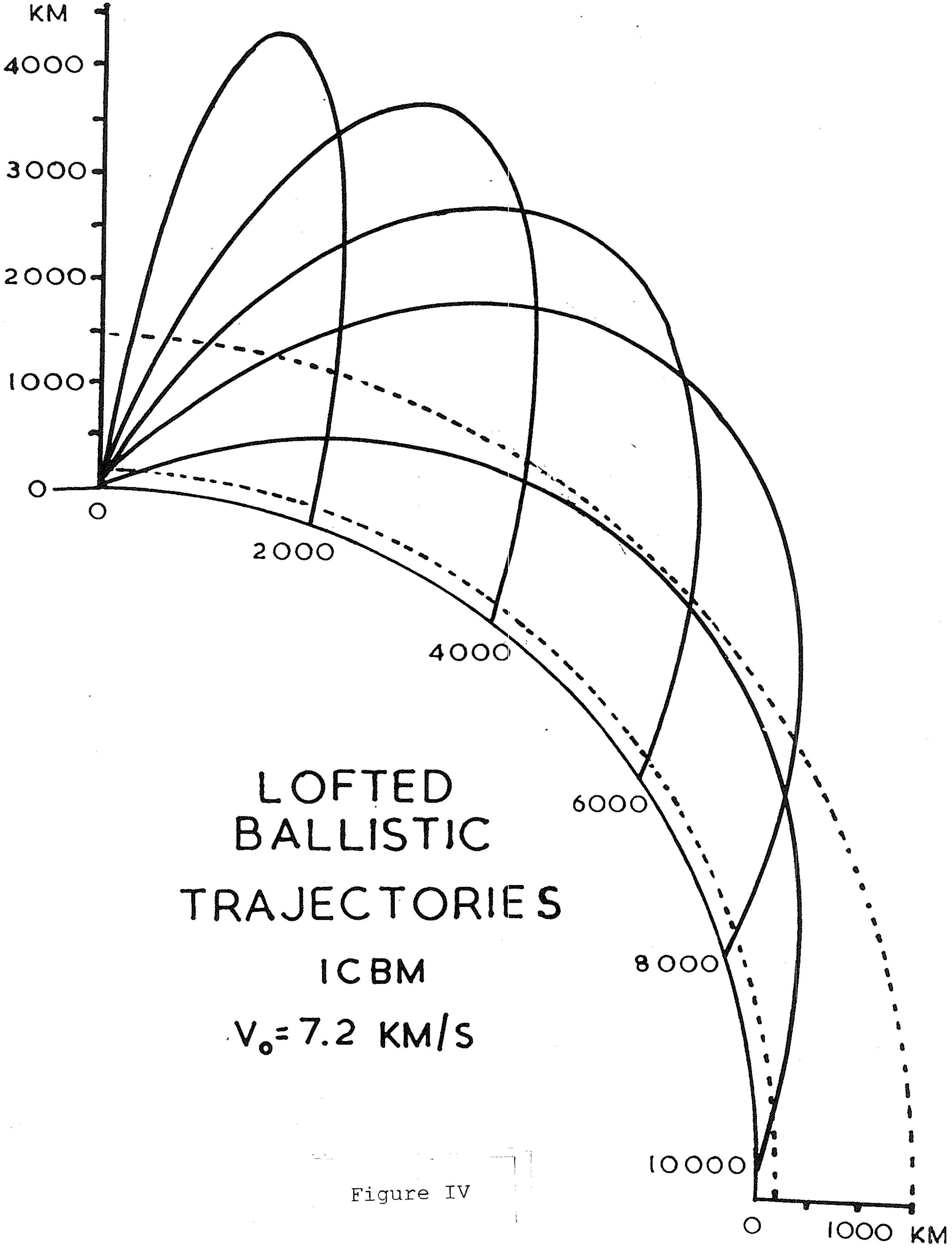

KM
1000
500
0
400
800
1200
1600
2000
KM
1000
500
200
LOFTED
BALLISTIC
TRAJECTORIES
MRBM
V_0=4.11 KM SEC

Figure III



KM
4000
3000
2000
1000
0
0
2000
4000
6000
8000
10000
0
1000 KM
LOFTED BALLISTIC TRAJECTORIES
ICBM
$V_0 = 7.2$ KM/S

Figure IV

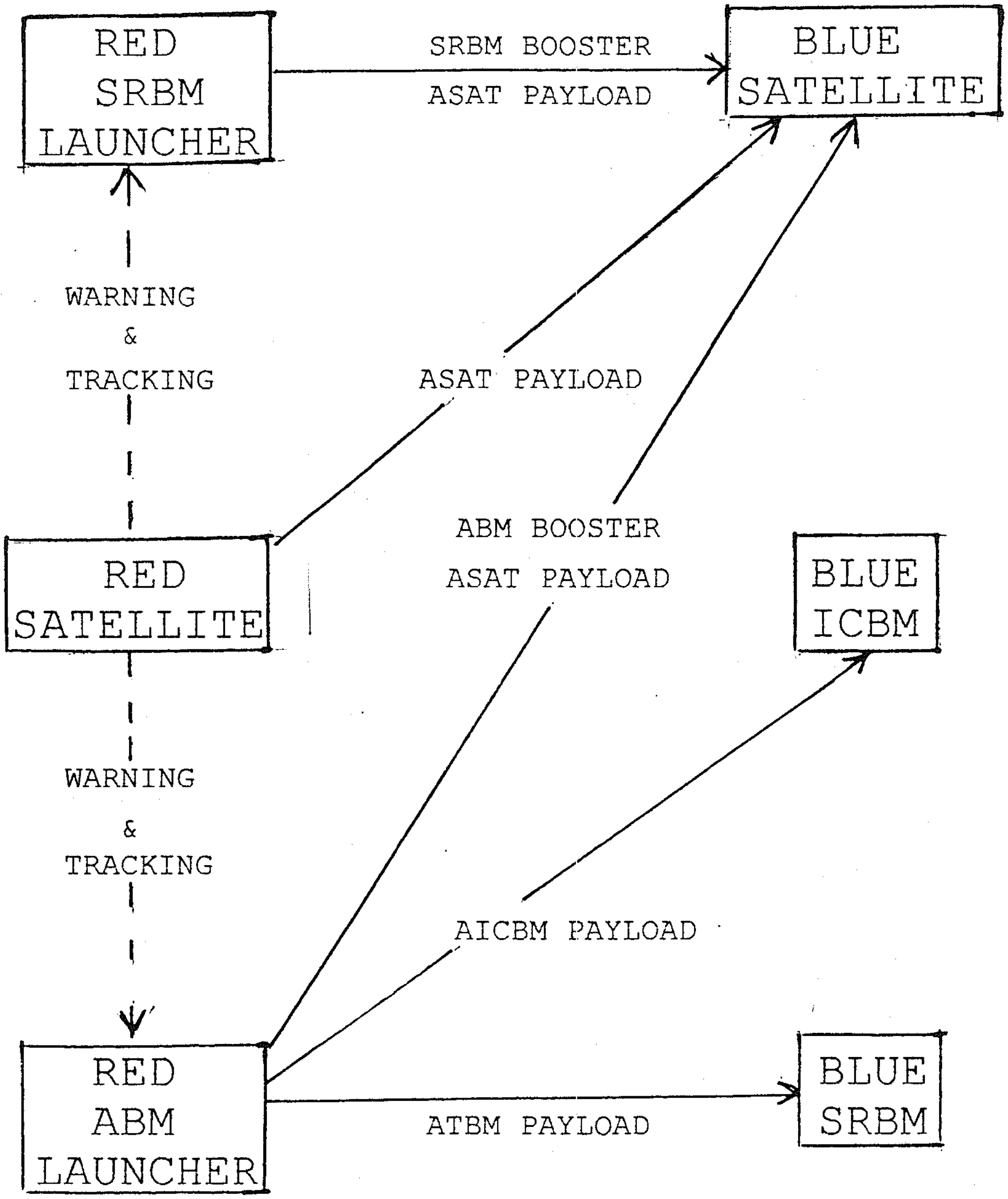

RED SRBM LAUNCHER
SRBM BOOSTER
ASAT PAYLOAD
BLUE SATELLITE
WARNING & TRACKING
ASAT PAYLOAD
RED SATELLITE
ABM BOOSTER
ASAT PAYLOAD
BLUE ICBM
WARNING & TRACKING
AICBM PAYLOAD
RED ABM LAUNCHER
ATBM PAYLOAD
BLUE SRBM

Figure V