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ANTIRADAR CAMOUFLAGE

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13. ABSTRACT

An analysis is presented of antiradar techniques which can be used over various portions of the trajectory of an ICBM. Techniques include emission of false targets, low reflective paint and coatings for warheads, and the usage of warhead shapes designed to reduce reflection.

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7. Antiradar Camouflaging of Ballistic Missiles

In connection with the continuous improvement of systems of detection and interception of air and space assault weapons, which have wide operating range and tremendous destructive force, a great deal of work is being performed abroad directed toward the creation of means facilitating the penetration of ballistic missiles through the antimissile defense (AMD) system. For this reason, the USA is performing intensive development of various means of counteracting AMD systems, designed to be placed on the "Atlas," "Titan," and "Minuteman" ICBM's, the "Polaris" long range ballistic missile and the "Pershing" medium range ballistic missile. According to data from the American press, approximately one billion dollars has already been spent on the creation of AMD countermeasures. A significant portion of this money has been expended on the creation of means for antiradar camouflage.

Let us briefly analyze how antiradar camouflage makes the interception of ICBM's more difficult over various sectors of the trajectory (Figure 5.38).

The problem of intercepting the ballistic missile in general form consists of preventing explosion of its warhead in the region of the object being defended. In the case of a nuclear warhead, interception must be performed at sufficiently high altitude and long range from the object being protected to prevent destruction on the defended territory by explosion of the warhead.

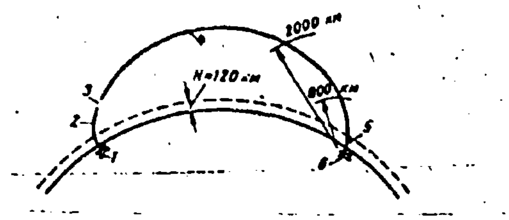

Figure 5.38. Typical Trajectory of a Ballistic Missile: 1, Launch position; 2, Active sector; 3, Area of jettison of rocket engine; 4, Middle portion of trajectory; 5, Area of maximum deceleration (50 g) at 10-20 km altitude; 6, Target.

Calculations performed in the USA indicate that the interceptor must be launched approximately 15 seconds after the command for interception is received. The characteristics of existing engines and power supplies, as well as the comparatively long time required for start-up of gyroscopes greatly hinder fulfillment of this requirement [24]. It follows from this that timely interception of intercontinental ballistic missiles requires that they be detected at the greatest possible range.

The usage of devices which decrease the power of the radar signals reflected from the ICBM allow the range to be decreased sharply, along with the probability of detection of a missile by radar. If low reflecting forms and antiradar coatings can be used to decrease the effective reflecting surface of the warhead of a ballistic missile by 20 times, as follows from formula (2.1), the radar range for detection is cut to less than half. The probability of detection of the target is decreased by at least the same factor.

In this case, very little time is left for interception of the ICBM. Reliable interception of the target can be achieved only if the speed of the interceptor is sharply increased.

Figure 5.39 shows the relationship between the velocity of the interceptor v_{max} and the range of detection of the target D with a protected area of 185 km radius. We can see from the graph that as the limiting detection range of the ICBM is halved (decrease in effective reflecting surface of 16 times), successful interception of the missile can be performed only if the speed of the interceptor is increased by approximately 1.5 times. If this condition is not fulfilled, explosion of the nuclear warhead will occur over the territory being protected.

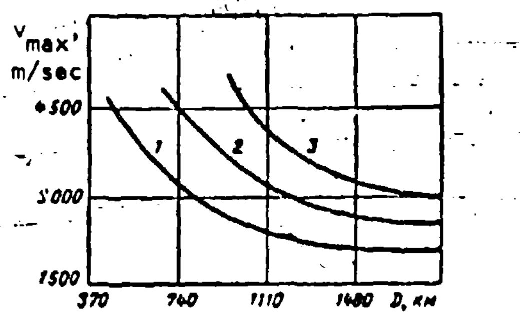

Figure 5.39. Velocity of Interceptor as a Function of Detection Range of the Target: 1, Target velocity v_t = 6,000 m/sec; 2, v_t = 9,000 m/sec; 3, v_t = 12,000 m/sec.

Obviously, a decrease in effective reflecting area of a ballistic missile should be achieved over all sectors of its trajectory. However, it should be kept in mind here that in spite of relatively simple geometric forms used in the design of missile element components, the effective reflecting area may change over various flight sectors. This results from the gradual separation of rocket stages and the continuous change of the radius of the last stage (warhead) relative to the radar station. Furthermore, the effective reflecting area may change due to scattering of the radiowaves by the flame of the engine, and also as a result of heterogeneities in the ionosphere which is perturbed by the operating engine. In spite of the fact that during the active sector of the trajectory the missile is most vulnerable, detection in this sector by ground based radars is not probable, since in this case the operating range of the radars is limited by the curvature of the Earth. Placement of detection and tracking radars for ballistic missiles on aircraft or satellites involves considerable technical difficulties at the present time.

After achieving the required trajectory for parameters, the missile begins flight in the middle sector beyond the limits of the atmosphere with the engine turned off. During this flight sector, the warhead may be separated from the body of the rocket. The range and probability of detection of a warhead during the middle trajectory sector can be considerably decreased by special measures to decrease its effective reflecting surface, which consists of selecting the optimal form of the nose cone of the missile and using radar absorbing materials. In order for the sharp nose cone to be always directed toward the radar of the AMD system in order to retain the minimum effective reflecting area, the nose portion of the missile must be stabilized on the track of its flight. The necessity of stabilizing apparatus arose in connection with the fact that nose cones not oriented toward the radar (for example the 'Mark 4" on the "Atlas 8," "Atlas F" and "Titan I") rotate in the middle flight sector and represent large targets for radar operators in the enemy defense forces.

After the nose portion of the missile has been detected, various false targets may be used to help camouflage it, i.e., disorient the enemy or completely saturate the throughput capacity of the AMD detection and tracking system.

During the middle flight sector, the effectiveness of antiradar camouflage of ICBM's using false targets may be very high. Since in this flight sector, the influence of the atmosphere is completely excluded, light objects such as dipole reflectors or inflated balloons having the form of a warhead or a sphere can be used as false targets in this sector.

For example, it has been reported in print that a combination of such false targets emitted by the "Titan" long range ballistic missile has been tested successfully in the USA. A missile equipped with a model of a nuclear charge flew 8,000 km and landed in the region of the southern Atlantic Ocean.

After separation of the spent stages, the warhead of the rocket emitted six false targets. All the false targets carried balloons in their nose portions, which created large blips on the radar screens, masking the true size and position of the target and making radar observation more difficult [7].

After false targets are emitted by a warhead, the position of its center of gravity, which has been displaced by the launching of the false targets, must be adjusted.

The disorienting false targets can also be placed on the last stage of the rocket; in this case, after the false targets have been emitted and the last stage has been separated, it must be moved away from the warhead by a breaking rocket or destroyed, in order that the flight trajectory of the last stage cannot be used to determine the trajectory of the warhead.

In spite of the fact that destruction of ICBM's in the middle portion of the trajectory seems at first glance to be most suitable, since it can be performed at great range from the defended object, the problem of guiding an interceptor when false targets are used is so complex that, in the opinion of foreign specialists, interception in this case is improbable and can be looked upon as only a secondary means of defense.

The use of antiradar camouflage methods decreasing the effective scattering surface of an ICBM is of particular significance in the final flight sector of the missile. In this sector, the usage of false radar targets may be less effective than in other flight sectors, since due to the difference of the dynamic mode of re-entry of the warhead and false targets into the atmosphere, the probability of differentiation between warhead and false targets is increased. The warhead, with great weight and load drag, begins to lose speed at comparatively low altitudes, whereas the false targets such as metallized strips or inflated balloons begin to lose velocity noticeably at high altitude.

The recognition of warheads upon re-entry to the atmosphere may be made significantly more difficult if heavy objects are used as false targets, the ballistic coefficients of which are equal to or near to the ballistic coefficients of the true warhead.

The workers developing false targets have been forced to cope with improvements in AMD radars, for which the volume of information concerning airborne targets (dimensions, fluctuations of reflected signal, tumbling of objects in space, etc) which can be attained have been increased by new methods of analysis of the fine structure of the reflected signal. This in turn has required increased complication of the design of false targets, which leads to an increase in their size and weight. However, as the weight of false targets increases, one must consider the fact that each kilogram of payload costs the same to deliver, regardless of the destructive capacity of the charge. In other words, increasing the weight of false targets requires a decrease in the weight of the warhead of the missile.

The warhead of a missile, as it enters the dense layers of the atmosphere on its descending trajectory at supersonic speed, forms a strongly ionized or plasma envelope and plasma wake of considerable length. Plasma has the ability to reflect radar signals and therefore the effective scattering surface of the warhead increases due to ionization. Since the time for decay of the plasma wake is about 2 sec, its length for a warhead traveling at 6,000 m/sec is approximately 12 km.

A decrease in the ionized envelope and plasma wake can be achieved by changing the geometric form of the nose portion, or by using special ablation materials. For example, with a thin cone shape of the nose portion of the missile, a less intensive plasma envelope is created, while a rounded nose cone base helps to suppress the turbulent, strongly ionized (plasma) wake.

Special low temperature coatings such as teflon are recommended, as they are capable of absorbing the heat radiation of the nose portion as it re-enters the dense layers of the atmosphere; the plasma may also be neutralized by oppositely charged gas particles. Foreign investigators are studying such methods of decreasing the ionized envelope by injecting special materials through apertures in the nose portion of the rocket.

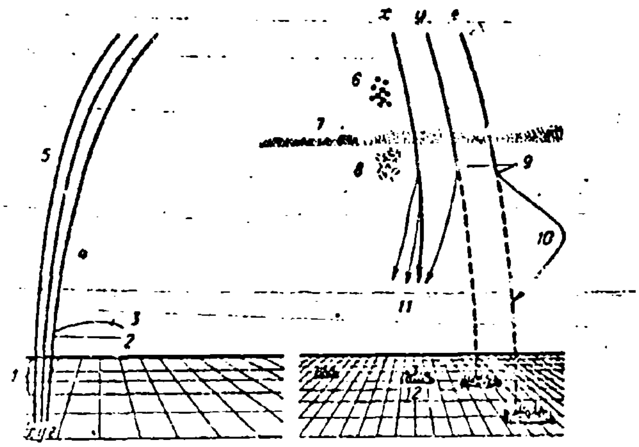

Figure 5.40. Usage of Radar Camouflage Methods during Various Sectors of the Trajectory (x, y, z) of a Ballistic Missile: 1, Active sector of trajectory; 2, Moment of separation of last stage; 3, Destruction of spent stage or change of its trajectory; 4, Passive interference or false targets; 5, Middle sector of trajectory; 6, False targets in the form of air filled balloons; 7, Re-entry zone into dense layers of atmosphere; 8, Heavy reflectors (false targets); 9, Moment of change of trajectory; 10, Maneuvering warhead; 11, Rockets aimed at radars; 12, Target.

The combination of antiradar camouflage measures just mentioned allows a considerable increase in the reliability of penetration of AMD systems by ballistic missiles, and consequently allows an increase in the effectiveness of these missiles in the performance of their combat assignment (Figure 5.40).

Naturally, measures of antiradar camouflage of ballistic missiles must be used in the complete combination of AMD countermeasures. In order to estimate the effectiveness of this combination, games modeling of operations in the area of overcoming enemy AMD can be used. The solution of such a problem represents great difficulty, since, in the opinion of the American military specialists, there are about 20 critical parameters of an AMD system and hundreds of less critical parameters. By individual and successive variations of these parameters during the course of a repeated games process with a fixed ballistic missile warhead power and given combination of AMD countermeasures, an estimate can be produced of the probability of successful penetration of an enemy AMD system.

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