Snatches of Elint, together with a few facts and a lot of logic, silhouette an embryo antimissile system.

FORETESTING A SOVIET ABM SYSTEM

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The summary presentation of this particular case history in inductive analysis will show how a slim amount of data may give a basis for determining the general characteristics and net capabilities of a new Soviet system before the Soviets themselves have a firm prototype of it. Such an accomplishment would not be noteworthy when U.S. R&D has already broken trail along the line of development in question, but when it is the USSR that is doing the pioneering it is much more controversial and difficult to foresee the outcome. The advantages of doing so, of course, are that it gives the U.S. developers a critical lead time in which to take countermeasures and a basis for objective planning—no small matters in the race toward Armageddon.

Apparent Soviet Anomalies

At first the theory of ICBM interception called for destruction of the incoming missile as far away as possible, while it was still outside the atmosphere. Then the development of chaff and decoys in increasing numbers and complexity led to a need for waiting until the atmospheric drag on reentry provided a way to distinguish the real warhead from the false images. Endo-atmospheric interception thus became firm U.S. doctrine, absorbing an enormous investment in the development of terminal defense radars, exotic computers, new high-performance missiles, and solutions for the complex problems of reentry physics. For it was natural to assume that the Soviet defense system would be based on similar endo-atmospheric reasoning, in fact would be a mirror image of our own. In consequence, U.S. ICBMs were designed to reenter and penetrate the

[1] The author, who suffered a fatal heart attack a few weeks after submitting this manuscript, had devoted most of his last years to the work therein described. His thesis has aroused considerable dissent in the intelligence community, and reasoned counterargument is invited.

atmosphere as rapidly as possible, leaving a minimum of time after target discrimination for the enemy's anti-ballistic-missiles to reach them.

In the fall of 1961 and 1962, however, the Soviets performed *exo*-atmospheric nuclear experiments at their ABM research center near Sary Shagan. There were never any atmospheric tests there. U.S. intelligence had been aware of two new research radars, code-named Hen House and Hen Roost, at Sary Shagan, but the first signals from either were intercepted only when some Hen House pulses were reflected from the ionized cloud generated by a nuclear explosion during these tests.

The intercepted Hen House signals had peculiar characteristics. Most notably, their carrier frequencies were in the VHF range, a very *low* frequency relative to the L and S bands normally used for U.S. long-range radars. The Soviets had other VHF radars, for example the newly deployed Tall Kings for early antiaircraft warning; but the Hen House signals turned out to have much more information content than is needed for mere early warning. For ABM use the low frequency should have serious disadvantages, not only in tracking ICBMs but even in their early detection. Theoretically, uncertainties in propagation, both in the lower troposphere near the earth and in penetrating the ionosphere to the target vehicle, might create such errors in measurement as were thought to render VHF quite unsuitable for U.S. tracking applications. Furthermore, it might be presumed that any nuclear explosion in the radar path would blind a VHF system.

The longer wavelength does have its own virtues, however. It is harder to jam or deceive with decoys, and it makes for a cheaper system. It would maximize the radar cross-section of target U.S. ICBMs. Such a system would be a natural extrapolation from previous Soviet radar technology. The logical interpretation of the Sary Shagan tests was that the Soviets were in fact exploring the feasibility of a new exo-atmospheric intercept system, using VHF radar, in defiance of our endo-atmospheric doctrine.

Postulated Soviet System

In 1963 the U.S. Army's missile electronic warfare organization at White Sands, under the stimulation of inductive argument from a CIA liaison officer (this reporter), became convinced that Soviet researchers had found, or were finding, ways to get around the difficulties both of exo-atmospheric target discrimination and of VHF radar in ABM systems. Late that year, at about the same time that a "probable Hen House" signal from Sary Shagan was first intercepted via moon bounce,[2] an Army contract was signed with Data Dynamics, Inc., to study the potential of a broadly-postulated exo-atmospheric-kill ABM system based on such a radar. The contractor was given intelligence support from both White Sands and CIA.

The Hen House proved to be a large planar array of emitting elements scanning electronically and having extremely high transmitted power. Not only its peak power but also its average power was extraordinarily high, with a capability for a very high data rate. Such a radar may be called range-dominant, in that it measures range more accurately than azimuth or altitude. It had to be assumed that the Soviets were not trying to develop it for continuous tracking of ICBMs from the point of detection on the horizon to the point of interdiction; at high look angles in a wartime nuclear environment a VHF blackout would be virtually certain. The Hen House would have to get its position-prediction data quickly at long range, near the horizon, and that would be the reason for its high power and data rate.

At maximum range, however, it was calculated that no single range-dominant radar could determine target positions with sufficient accuracy. Measurements of altitude, in particular, circumscribed by the limited vertical dimension of the planar array, could not be made fine enough. To make the postulated system credible one had to assume a Soviet solution for this inadequacy, and one solution might be the operation of several radars from different locations against the same targets to pinpoint them by the intersection of their fixes, a sort of continuous triangulation. This would require reliable instantaneous communication among the several locations, along with computers to correlate in real time the multiple reception of target-reflected signals; and the Soviets had in fact installed microwave facilities at Sary Shagan as though possibly in fulfillment of this need.

A modificaton of the multiple-radar system so conceived would avoid the obviously inordinate expense of a large number of high-performance instruments like Hen House: several distant receivers could be grouped with each Hen House transmitter, all interlocked by real-time communications. (For experimental purposes the Soviets

[2] See Frank Eliot's "Moon Bounce Elint" in *Studies* XI 2, p. 59 ff.

could use the deployed Tall Kings as receiving sites in order to check out the feasibility of this idea.) Such a multistatic radar system would have distinct advantages against the enemy's electronic countermeasures because of the difficulty of targeting the widely dispersed receivers. This model of an ABM radar system requires a reasonably high level of sophistication in processing data for long-range prediction, but one not inconsonant with known Soviet capabilities. The important thing was that the range-dominant system model could be simulated and legitimately exercised to investigate its potentials and general vulnerabilities, even if the Soviets would not in the final analysis construct it to operate in quite this manner.

Evaluation

From these basic postulates the contractor, who had earlier done work for the Air Force on the prediction of future positions for orbital vehicles, developed the technical details and worked out the complex equations for the multistatic system. The mathematical simulations showed that such a system could have an accuracy in average target location within one nautical mile. Maximum effective range from the transmitter could be increased, say from 600 n.m. to more than 1,000 n.m., by forward location of the receivers. Though not invulnerable, the VHF radar was in many ways not so vulnerable as conventional systems. The enemy would have difficulty in horizon-to-horizon electronic jamming of a dispersed-receiver system, and requirements for high jammer power in the VHF frequency region would exact weight and size penalties. VHF chaff dipoles, to be effective, would have to be more than 40 inches in length and relatively heavy. The radar might not even register small objects, greatly easing the problem of target discrimination.

Blackout from nuclear explosions in the radar path could be to some degree avoided by locating at least the receivers well to the side of likely ICBM targets. Enemy interference with the radar by a nuclear detonation at a conjugate point on the earth's magnetic lines of force would not be possible across the Arctic horizon. The prognosticated degradation of the beam from low-angle anomalies turned out not to be prohibitive at long range. The powerful VHF beam may even have the advantage of a "knife edge" effect, curving over the horizon for useful increases in unambiguous range. The USSR seemed to be about ten years ahead of the United States in developing such a VHF-oriented system, and it was reasonable to assume that their optimization of it through experimental development might be even better than any model we could conceptually imagine.

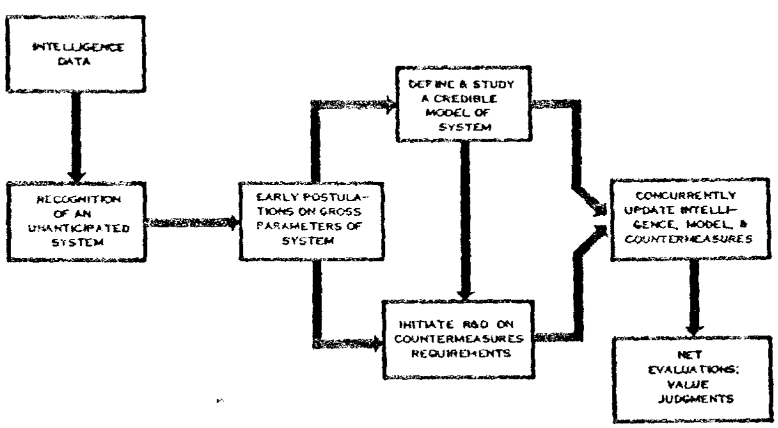
A partial answer to the problem of discriminating between warheads and decoys before reentry could be to design the ABM warhead to be effective, exo-atmospherically, against whole swarms of incoming targets, say by making its yield large enough to kill ICBMs at great distances. Was it the Soviet premise that the problem of decoys is not a serious one if the ABM warhead has a large enough lethal radius? The intelligence-based postulate of a Soviet system which encompassed this possibility appeared to have been vindicated on 7 November 1964 by the revelation of the large Soviet Galosh missile, which appeared capable of carrying a megaton-range warhead to fire at exo-atmospheric altitudes.

Prospects

Even if the Soviets had withheld the parading of the Galosh, it had been possible as early as the spring of 1964 to have, in the contracted study, a basis for ignoring the implications of their display, on 7 November 1963, of the aerodynamically-designed Griffon missile which did not fit the requirement for a long-range, high-altitude ABM. By that spring it had been possible to formulate computer subroutines by which the contractor could continuously update simulated long-range Soviet ABM systems on the basis of the latest intelligence data. In mid-1964 operational and planned U.S. attack models were "flown" (by the same contractor under different sponsorship) against the defensive model in mathematical simulation for purposes of net evaluation.

Such very early postulation and analysis on the basis of scant data, something of a rarity in the intelligence community, may be viewed as a likely necessity now, at least in the electronic warfare field, to provide objective grounds for developmental decisions. In this case, recognition of the feasibility of an ABM system using VHF radars established a need for electronic countermeasures in the VHF region and was followed by formal military requirements for new chaff and decoys, for high-powered jamming tubes with new long-term fuel and power supplies, and for horizon-to-horizon antenna pattern developments. It led the White Sands missile electronic warfare organization to build the first VHF measurements radar in the United States. And the projection of a possible exo-atmospheric, area-kill ABM system which the Soviets could deploy in conjunction with their deployment of a "finite deterrent" ICBM system aided in advance recognition of a potential strategic threat against the United States.

The U.S.-USSR R&D contest, hopefully, will get beyond the ABM-ICBM confrontation. The posture of all military, naval, air, and space forces will feel the impact of new strategic modes in which electronic warfare and net evaluations are controlling factors. The moral of this case history is that countermeasures and counter-countermeasures must keep pace in real time with the development of the opponent's threat. In order to achieve this, the intelligence community must commit itself, as indicated in the accompanying diagram, to designating the broad parameters of a threat at the earliest possible time. Research and Development must then use these broad parameters to initiate immediately the development of generally necessary counter-components and so at least move in the direction of readiness for the future threat. It is not necessary to foresee just how the enemy will optimize his developmental designs, to flesh out our model in ultimate detail, or to obtain community agreement on all the refinements in order to institute these timely measures.



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