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OUTLINE

TECHNICAL ISSUES IN THEATER MISSILE DEFENSE

by

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ABSTRACT

This note discusses technical issues in theater missile defenses in the terminal, midcourse, and boost phases. The first two are familiar and developed, but face fundamental countermeasures. Boost phase intercepts engage missiles when they are most vulnerable, but have been studied less for theater defense because the engagement times are short. Overall, theater missile defenses resemble strategic defenses, complicated by the tenfold shorter boost phase.

I. INTRODUCTION

This note discusses some technical issues that face the development of theater missile defenses--the political decision to deploy having been made. It does not represent the assessment of the Strategic Defense Initiative Organization (SDIO) or that of Los Alamos; it is just a discussion of technical problems. How current defensive concepts are intended to work is described in an earlier report;[1] this one concentrates on problems. Together the two give a balanced view.

In the Gulf War it became clear that missile defenses were wanted. In the proliferation environment of its aftermath it is likely that they will be needed. The question here is whether meaningful defenses will be attainable. In the Gulf War, Patriot missiles provided psychological support that was important to alliance stability. In the next war, defenses will be evaluated on their ability to actually defend, so they will need to perform better.

II. TERMINAL DEFENSES

Terminal defenses like Patriots are most familiar. In some ways they are the simplest. They involve the shortest ranges and the smallest sensors and interceptors, and they can be commanded by local radars. Moreover, terminal engagements occur after the weapons have started to slow down, which strips out many decoys. The Patriot is radar command guided for most of its flight, then its on-board receiver takes over and maneuvers as close as possible and detonates its explosive charge. Guidance is complicated by the deceleration of the missile by the air during pursuit, but that can be predicted and incorporated into augmented navigation.

In the Gulf War extended-range SCUDs re-entered flat, which caused them to break up and produce many targets that were credible to radars. That was partially compensated for by aiming at the leading object, because the weapon should be the most dense, slow down the least, and hence be in front.

The fragments containing the weapons were often asymmetrical, which caused them to accelerate transversely. Longitudinal decelerations were on the order of 100 g's, so transverse accelerations could be 10-20 g's, which stressed the acceleration capabilities of the Patriots and caused miss distances to grow. In some cases the weapons flew helical trajectories that approximated optimal evasive maneuvers, causing large miss distances.[2]

In the Gulf War such trajectories were flown by accident. In the next war, missiles could be equipped and programmed to fly them intentionally with minor modifications. Not only would that require high interceptor accelerations, it would also negate the augmented navigation needed to predict ahead. The resulting large miss distances could be serious for Patriots; they would be much more serious for interceptors like ERINT that must directly hit the weapon to kill it. Predicting ahead against random disturbances could increase miss distances. Break up and transverse acceleration would be particularly effective against simple, proliferated interceptors.[3] Thus, the future of intercepts in the terminal phase is quite uncertain.

Incidentally, this problem was studied in the early days of SDIO. Then it was argued that intentionally maneuvering re-entry vehicles (RVs) could outmaneuver terminal interceptors, so the terminal phase was viewed as only a back-up. In breaking up, SCUDs approximated the performance assumed for maneuvering RVs. This limit is fundamental; thus it is necessary to look further back up the trajectory for confident intercepts.

III. MIDCOURSE

Midcourse is next. It was studied relatively well in SDIO. Ideally, the interceptor would accelerate leisurely to exo-atmospheric altitudes, where the weapon would have no drag to maneuver. Such altitudes are relatively high. If the interceptor accelerates all the way to contact, intercepts occur at about a third of the altitude where the weapon is detected. To stay above the altitudes where drag is significant requires that intercepts be above 30-40 km. That means detection and launch must occur when the weapon is at 90-120 km. Weapons only get that high for ranges of ≈ 360-500 km, so shorter range missiles do not have distinct midcourses.

The main problem in midcourse for theater defense, as in strategic defense, is the large number of objects possible. In strategic defense the concern is decoys; in the theater just the normal number of nuts and bolts can be a problem, because they multiply the requirements on the radars, infrared sensors, and interceptors. If there were ≈ 10 objects per missile, that could require ≈ 2 x 10 x 500 missiles ≈ 10,000 interceptors, which is large for what is meant to be a local theater defense.

With good sensors it should be possible to discriminate most small objects. But there are ways to generate many larger ones. One is to fragment the spent fuel tanks with explosives, which was tested a few decades ago. It was not useful for strategic attacks, in which missile buses pushed the RVs out ahead of and away from the debris cloud. But for unitary warheads a cloud of weapon-sized fragments could be made to surround the weapon, again multiplying the number of interceptors.

There is another approach to defeating midcourse defenses: breaking the payload up into many small weapons before the interceptors can arrive. Theater missiles burn out in 60-80 s. As soon as they finish powered flight, their payloads could be dispensed as 10-100 munitions of 10-100 kg each which would separate on the way to target. Dispersal velocities of a few m/s, which are available with commercial dispensers, could give impact patterns of 100-1,000 m.[4] It is generally assumed that midcourse theater threats will be simpler than strategic ones. Given the technology now in commerce, that is not clear.

For cluster, chemical, and biological units, dispersal can increase effectiveness, particularly when their targets are a cities. Dispensing munitions has much the same effect as using multiple RVs in strategic engagements. But because accuracy is less of a concern, dispensing can be done much faster and sooner. It runs up the number of interceptors and lowers the value of targets in an unacceptable way. Thus, it is necessary to look to intercepts during powered flight.

IV. BOOST PHASE

Boost phase gives the interceptors an opportunity to engage missiles when they are most vulnerable. It has been studied less for theater defenses than strategic, in part because theater engagement times are so short. Conventional interceptors with average velocities of $\approx$ 3 km/s could only cover out to about 3 km/s x 50 s $\approx$ 150 km; SCUDs could be deployed deeper than that. There are several concepts for generating longer ranges.

Airborne lasers are speed-of-light weapons. But current powers and apertures would only reach out to a few tens of kilometers, which would force the aircraft to intrude and leave them vulnerable. The combinations required for ranges of hundreds of kilometers could take a decade of development.[5] Space lasers with the range to avoid threats could take another decade, but would provide continual presence over the whole globe.[6] Ground-based pulsed lasers could protect specific countries from local threats.

Mounting interceptors on remotely piloted vehicles flying over threatening countries could reduce interceptor range to the missiles. But they would be intrusive and would still require average velocities of $\approx$ 100 km/50 s $\approx$ 2 km/s, or peak velocities of $\approx$ 4 km/s, which would require development. Interceptors with average velocities of $\approx$ 500 km/50 s $\approx$ 10 km/s are an option for theater coverage. They need not be intrusive; they could be ground, air, or ship based. But high velocity and acceleration interceptors would require development.[7]

Space-based interceptors (SBIs) could provide presence with reasonable constellations. Contrary to early estimates, it is not practical for the attacker to underfly such constellations.[8] Arms control stability issues appear to have been satisfactorily addressed;[9] SBIs face political opposition primarily due to concerns about crisis stability. But deployment inclination, autonomy, and survivability could be used to ameliorate most concerns.[10] SBIs could be jointly deployed with some simple level of technology.[11] If so, that might be done faster than some non-space concepts discussed above.

V. PREBOOST

It is desirable to interdict launchers before they launch their missiles, but it is hard to do so. Launchers have only modest signatures, which are not readily detected by current sensor suites. It is not clear that preboost intercept was achieved in the Gulf War. Improvements in this capability rest primarily on improvements in sensors, not interceptors.

VI. SUMMARY AND CONCLUSION

This note has discussed technical issues facing the development of theater missile defenses. In the next war, defenses will be evaluated on their ability to defend. Terminal defenses are the simplest and most familiar. But the breakup of missiles and the irregular trajectories of those carrying the weapons make terminal defense problematical.

Midcourse was studied extensively in strategic defense. In theaters the main problem is the large number of objects possible. Nuts and bolts can be a problem, because they multiply requirements for radars, infrared sensors, and interceptors, but with good sensors it should be possible to discriminate most of them. There are, however, ways to generate many large ones. One is to fragment spent fuel tanks. Another is to break the payload into many small weapons before the interceptors arrive, which can be done with dispensers in commerce. Because accuracy is less of a concern, dispersal can be done much faster and sooner than in strategic engagements.

Boost phase intercepts engage missiles when they are most vulnerable, but they have been studied less for theater defense because the engagement times are so short. Conventional interceptors could not reach SCUDs. Airborne lasers would need development for the hundreds of kilometer ranges needed to keep them safe. Space lasers would give global presence but could take a decade of development. Current interceptors on RPVs would be capable but intrusive. Higher velocity interceptors would be less intrusive but would require more development. Preboost is desirable, though intrusive, but hard to achieve.

SBIs could provide presence with reasonable constellations. They primarily face political opposition due to concerns about crisis stability. They could be made strategically transparent through proper design, basing, and control. It appears that terminal and midcourse concepts could be defeated by fundamental measures, leaving pressure on the boost phase. There, short ranges make possible a set of ground-, air-, and sea-based laser and interceptor options, but they have range and intrusion limits. Space-based concepts are opposed for political and stability reasons.

Thus, theater missile defense appears as strategic defense writ small, but complicated by the tenfold shorter boost phase.[12] Developing a viable set of defenses appears difficult; there appear to be several steps. The first is relying on the kindness of strangers, i.e., assuming that maneuvers, decoys, and cluster munitions will not be faced in early threats. Since all are already feasible, this in part amounts to assuming some restraint on the part of arms suppliers to the third world. The second is to try all boost-phase concepts and hope that one will evolve faster than expected. The third is to work toward joint development, deployment, and control of SBIs. The latter is appropriate because the goal of theater defense is protection for all, which makes participation by all countries of good will appropriate.

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