RAND | RESEARCH BRIEF

DEFENDING AIRBASES WITH ELECTROMAGNETIC GUNS

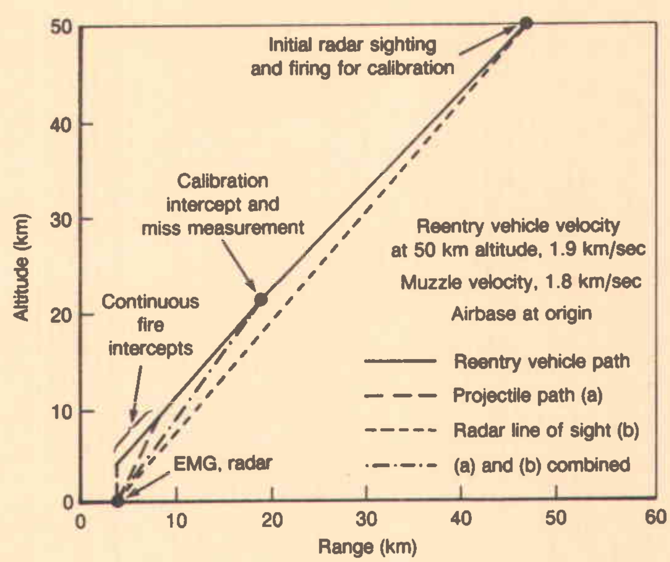
Considerable effort has been devoted in recent years to the development of electromagnetic guns (EMGs), which use electric current to drive projectiles to muzzle velocities considerably higher than those achievable in conventional artillery. A representative conceptual design consists of a rocket turbine, a homopolar generator, an induction coil, and a barrel containing two parallel conducting rails on either side of the bore. Fuel and oxidizer are combined in a combustion chamber, the exhaust from which drives the turbine. The generator converts the turbine's mechanical energy to electric current, which is sent to the induction coil at the base of the barrel. When sufficient energy has been stored in the coil, the current is switched to a circuit running from one rail to the other via the base of the projectile. The current creates a magnetic field behind the projectile. The current and the field interact to force the projectile (the "armature") through the barrel.

The high muzzle velocities achievable with EMGs should result in more time to fire, more accurate prediction of target position, less projectile flight error, and greater impact energy than is attainable with conventional guns. In fact, the impact energy should be great enough to obviate the need for explosives, thus allowing lighter, less expensive projectiles.

Although the EMG concept originated over 60 years ago, only recently has it been possible to generate and switch current pulses large enough to make the concept feasible. A lot of work has to be done before it will be possible to build EMGs that can function in the field. However, enough is now known about the likely design and operating characteristics of EMGs to allow an assessment of their value in various missions. Under the sponsorship of the Defense Advanced Research Projects Agency, The RAND Corporation's National Defense Research Institute has evaluated **the utility of EMGs for defending airbases, especially against nonnuclear tactical ballistic missiles**—potentially a key Soviet threat.

The Rand analysis assumed that airbase defense EMGs would fire 0.25-kg projectiles at muzzle velocities of 2.5 to 4 km/sec—a capability that has already been demonstrated. It was assumed that the first burst of fire from the EMG would be followed by a waiting period to determine by how much the projectiles miss the target. The miss data would be used to correct EMG aim for the remainder of firing. (See the figure.) **The principal findings were as follows:**

- The EMG can be located anywhere within a kilometer or so of the airbase center without significantly degrading its effectiveness.
- If an EMG located 2 km from the airbase center could fire 100 rounds/second at 4 km/sec, it could enforce a keepout altitude of 9 km with a probability of 0.99. At 2.5 km/sec, the keepout altitude would drop to 6 km. (A 3-km keepout range should be sufficient for a conventional warhead or one deploying conventional submunitions.)
- The most critical system error would be the barrel-induced (as opposed to wind-induced) lateral projectile dispersion. For one typical set of engagement characteristics, it was found that doubling that lateral error would cut the keepout altitude by 40 percent.
- With current technology, an EMG able to enforce a reasonable keepout altitude would require about 300 MW of prime power and would weigh about 60 metric tons. Foreseeable technology improvements should halve the power required and the system mass.



Typical EMG-RV engagement

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These findings pertain to an engagement between an EMG and a single reentry vehicle. Of course, an effective airbase defense system would have to be able to destroy **a number of reentry vehicles** arriving in rapid succession. A second analysis took into account the number of tactical ballistic missiles that the Soviets would be likely to commit to a single airbase in an attack against a number of bases in the mid-1990s. The analysis demonstrated that one to four EMGs with rates of fire of 20 to 100 rounds/second would be sufficient to defend the airbase. The number of guns and rate of fire required would depend on the accuracy of the EMG system. Defending against advanced maneuverable reentry vehicles would require much higher rates of fire (or higher accuracies or muzzle velocities).

For defense against conventionally armed low-altitude **cruise missiles,** radar performance would limit keepout range. Because the missile could be approaching at an altitude of 100 m or less, multipath and propagation errors would be large, and radar and EMG siting would be critical. Different EMG systems would thus be required to adequately defend an airbase against tactical ballistic missiles and cruise missiles.

Before an operable full-scale EMG can be built, **several critical issues must be resolved.** These include the design of the barrel and its interface with the projectile, remaining problems with high-current switching devices, lethality criteria, and, for multibarrel guns, intermuzzle shock wave and wake.

The research reported in this brief was carried out in RAND's National Defense Research Institute, Applied Science and Technology Program.
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