Mastering EMP for offense and defense

by Charles B. Stevens

Since June Dr. Edward Teller of Lawrence Livermore National Laboratory has emphasized in several national interviews the need to educate industry and the public about large electromagnetic pulses (EMP) generated by space-based nuclear explosions. One large, space-based nuclear explosion is capable of generating an EM pulse sufficient to destroy most unshielded electrical and electronic devices and systems throughout the United States without necessarily causing any other type of direct bomb damage. But as Dr. Teller's recent testimony before Congress strongly indicates, his concern about EMP effects may not be limited to that generated by offensive Soviet nuclear explosions. EMP effects could be used as part of a layered defense against nuclear-tipped missiles. This particular defense could be generated with part of the U.S. arsenal of offensive nuclear warheads.

This possibility of using nuclear explosions in space to interdict ICBMs was noted by Marshal V. D. Sokolovskiy in his famous book *Soviet Military Strategy*: "and the use of electromagnetic energy to destroy the rocket charge in the descent phase of the trajectory or to deflect it from its target."

All nuclear explosions generate extremely short bursts of intense radio waves—EMP. These EM pulses are created when the initial radiation (x-rays and gamma rays) of the nuclear fireball ionize and accelerate electrons in the air and thereby produce large electrical currents. In exoatmospheric (space-based) detonations, EM pulses were found to be both more intense and extensive than in air bursts. The United States discovered this empirically in 1962 when a space-based nuclear test over Johnson Island generated an EMP signal which "turned off" the lights in Hawaii thousands of miles away. At the same time, the Soviets exploded a 60 megaton monster H-bomb in a high altitude test. The Atmospheric Nuclear Test Ban Treaty was signed shortly after this test series. In retrospect, U.S. scientists realized that the Soviet Union was aware of a dramatic increase in EMP associated with high altitude detonations long before 1962. The U.S.S.R. had completed an extensive program of high altitude nuclear explosions to empirically map out the potential of EMP effects. In several recent speeches, Dr. Teller has noted this and the Soviets' publication of an explanation for intense high altitude EMP in the 1950s' open scientific literature.

EM pulses dramatically increase in amplitude and extent in exoatmospheric, as compared with atmospheric, detonations for two basic reasons. EMP is primarily due to bomb-generated gamma rays. The electrical current that they create through the ionization and acceleration of atmospheric electrons is called a Compton current. It is this short-lived current which generates the EM pulse. In the atmosphere burst case the Compton current propagates symmetrically outward from the point of detonation. Thus, if we drew lines representing each radial direction along which a Compton current is found, it would define a sphere with the detonation point being the center. This simply reflects that the gamma rays are deposited into the atmosphere in a spherical shell.

In the exoatmospheric case, though, only a portion of this spherical shell of gamma rays intersects the earth's atmosphere. As a result, the Compton current generated is no longer spherically symmetrical. Therefore, the interaction between the Compton current and the earth's magnetic field is greatly enhanced. And this interaction leads to the generation of a Compton current perpendicular to the radial direction. This new, transverse component of the Compton current generates out-going and in-going fields of the magnetic dipole type. The out-going magnetic dipole EMP is a short pulse of high amplitude, because the Compton current pulse moves outward in synchronism with this part of the EMP.

The earth is surrounded by a thin plasma (the ionosphere) whose properties determine conditions for shortwave radio communication. EMP and the Compton currents which generate it interact with the ionosphere, causing long-lived disturbances which interrupt and distort radio communication.

It has been long recognized that EM pulses can directly disrupt the functioning of ICBMs. If an ICBM warhead is not shielded against EMP, EM pulses can be absorbed into the electrical circuitry of the missile's guidance and detonating system, causing short bursts of intense electrical current which either destroy or permanently disrupt the circuits. And the effectiveness of electromagnetic shielding can always be overcome through increasing the intensity of the EM pulse. This has spurred great emphasis on the development of optical fiber circuits for military systems, since these non-electrical circuits are not affected by EMP.

EMP may have a number of possibilities for indirectly disrupting an ICBM. The huge amounts of energy contained in the ionosphere are normally so diffuse that the ionosphere is harmlessly traversed by an ICBM; but it may be possible to use EMP as a sophisticated kind of "ionospheric modification," and so replicate the self-generated beams, streamers, and density changes that are seen in other ionospheric modification experiments. Some combination of bomb-pumped plasma instabilities in the ionosphere, scientists have speculated, may be usable for large-area defense against ballistic missiles. In such an application, a high-altitude burst of a nuclear weapon or deposition of energy from an x-ray laser would be used to energize the ionosphere and to act as a "seed crystal" for organizing ionospheric plasma energy. The resultant plasma instabilities may be capable of generating missile-destroying electron beams, electric field changes, or plasma density variations.