The Fourth Effect

—electromagnetic pulse

By CWO4 James E. Phelps

The Manhattan project delivered the United States the title of Superpower with the development of the nuclear weapon. The brilliant men and women who designed these weapons of mass destruction knew well the blast, thermal, and radiation effects that emanate from the monsters they created.

They had an awareness of the "fourth effect" of electromagnetic pulse (EMP); however, it's true destructive capability did not surface until later. On 8 July 1962, a 1.4 megaton hydrogen bomb detonated approximately 400 kilometers above Johnston Island in the Pacific Ocean.

The EMP effects of the blast reached the Hawaiian island of Oahu, over 800 miles away, instantaneously. Street lights went out, burglar alarms rang, and circuit breakers opened. Scientists determined EMP as the cause of these effects late in 1963.

On today's modern battlefield with its associated high technology weaponry and communications systems, EMP is a definite threat we must analyze. To do this, we must define the problem, understand its effects, and then reduce our vulnerability to those effects.

Overview

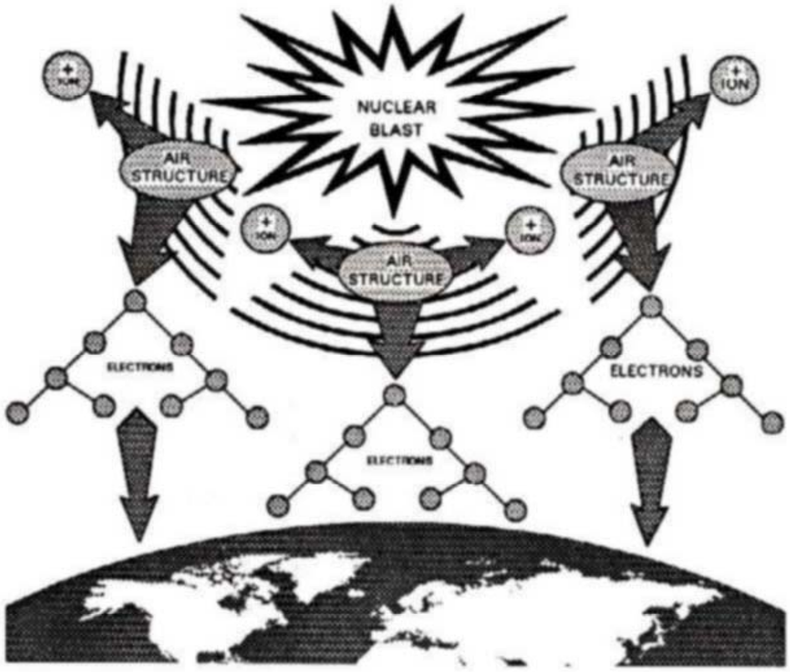
EMP is an extremely complex phenomenon that results from the detonation of a nuclear weapon. Although the explosion of conventional high explosives can generate electromagnetic signals, they have little military significance, and I will not discuss them here. When a nuclear weapon detonation occurs, gamma radiation is a resultant energy emitted by the nuclear reactions that take place. This gamma radiation interacts with the molecular atomic structure of the air surrounding the blast area.

The result of these interactions is the transference of energy from the gamma radiation to electrons within the molecular structure of the air. These "charged" electrons escape their host atomic structures and move outward. The described gamma radiation interactions continue until their energy is attenuated. This entire effect, known as the Compton Scattering Effect, is the primary cause of EMP. The figure on the next page shows a graphic illustration of the Compton Scattering Effect.

The arrows represent gamma radiation emitted from the blast. They interact with the neutral charged atoms within the molecular structure of the surrounding air. The gamma radiation transfers energy to the electrons within the atoms in the air through the Compton Effect. They escape their host atomic structures and travel away from the blast area at the speed of light. The small circles represent electrons.) When the electrons depart the atomic structure of the air that remaining structure is now known as an ion and is positively charged. (The ions are depicted as circles containing a + sign.) The process occurs repeatedly until the energy of the gamma radiation is attenuated. The final result of this process is the instantaneous separation of charges that creates EMP.

As electrons escape from the air's atomic structure, the remaining structure becomes an ion. (An ion is nothing more than a neutral atom or group of atoms that has lost or gained one or more electrons.) These ions are positively charged due to their loss of electrons. As the negatively charged electrons travel outward much faster than the positively charged ions, a separation of charges occurs.

This separation of charges creates an electric field that peaks in approximately 10^{-8}, that is, one hundred millionths of a second or 0.001 microseconds. To say the least, it occurs rather fast. The energy of the field dissipates rather quickly and becomes negligible within a few tenths of a microsecond. The resultant energy produced by this separation in charges



Compton Scattering Effect

is known as EMP. An EMP can create 50,000 volts per meter or more at its peak strength. To bring this to layman's terms, EMP can create an electromagnetic surge up to 100 times more powerful than a lightning bolt and over 100 times faster.

EMP has some crude similarities to radio waves, except EMP has different effects. The electromagnetic waves emitted from a radio transmitter are either frequency or wavelength specific. EMP covers a broad range of frequencies that range from 0 to 100 megahertz. This encompasses a range up to the lower microwave range. The preponderance of EMP is generated in the radio frequency ranges. Additionally, the effective field strength of an EMP can be millions of times greater than ordinary radio waves.

The effects of EMP are determined by the type of burst, yield or size, and burst altitude of the weapon. When a nuclear weapon detonates at the surface, the EMP effects are greatest nearest the point of the blast or ground zero. The most significant effects of EMP from a surface burst, depending on the weapon yield, occurs in an area of approximately 2 to 5 miles.

However, EMP effects are often significant enough to cause damage out to a point where the peak overpressure from the blast attenuates down to 2 pounds per square inch. For example: The surface detonation of a weapon with a yield of 2 megatons has a peak overpressure of 2 pounds per square inch approximately 8 miles from ground zero.

Conversely, a low yield nuclear weapon detonated 200 miles above the center of the United States creates an EMP that would cover most of the country as well as parts of Canada and Mexico. The point to remember here is, the higher the altitude of the blast the greater the coverage and effects of EMP.

Effects

With a basic understanding of how EMP is generated, it is important to understand what and how it affects items of interest. The energy from an EMP does not appear to have any serious effects on human beings, but can produce severe damage in communications equipment, radar systems, satellites, and other types of electronic equipment. Antennas, cables, telephone lines (non- fiber optic), aircraft, power lines, towers, railroad tracks, missiles, gun tubes, and an abundance or other ordinary items collect the energy of EMP.

Items that operate under extreme power levels during normal conditions are much less susceptible to EMP than modern technology lower power level electronics.

There are two types of EMP induced damage that can occur.

Catastrophic damage results in permanent irreparable damage that requires component or system replacement.

Functional upset is a temporary disruption in the system capability with no permanent damage. Functional upset is short term with component or system integrity normally recovered in a matter of seconds or minutes.

EMP damage is a result of the extremely powerful surge of electromagnetic energy entering the system through some type of collector, for example, an antenna, and overloading the system with the unexpected surge. Due to the intense instantaneous surge from the EMP, normal fail-safe devices resident in most electronic components are not responsive enough to contain or attenuate the pulse. The result is either EMP induced catastrophic failure or functional upset. The table on the next page provides a list of EMP susceptible electronic equipment or associated components. List is not all-inclusive. The order of susceptibility is from most to least.

EMP Mitigation Considerations

EMP mitigation techniques on the battlefield are extremely important for command, control, communications, and intelligence (C^3I) equipment. Understanding the drastic effects that EMP can have on C^3I devices, we must know our vulnerabilities and be proactive in attempting to reduce its effects.

Relative Level of Susceptibility

- Digital computer memory circuits (FU)
- Microwave semiconductor diodes (CD)
- Integrated circuits (CD)
- Field-effect transistor (CD)
- Radio frequency transistors (CD)
- Low power silicon-controlled rectifiers (CD)
- Audio transistors (CD)
- Med/high-power rectifier semiconductor diodes (CD)
- Composition and wire-wound resistors (CD)
- Vacuum tubes (CD)
- Low current switches (CD)
- Detonators, pyrotechnic devices, rocket fuels (CD)
- Motors and transformers (CD)

(FU) Functional upset
(CD) Catastrophic damage

There is no one answer to EMP mitigation in air-land operations. Tactical operations require the commander to analyze the mission, enemy, terrain, troops, and time available (METT-T). EMP mitigation techniques require an informed decision by the commander based on his or her analysis of METT-T. The decisions the commander must make relate directly to the employment of mitigation techniques that may result in reduced command and control along with a possible decrease in tactical flexibility. The commander alone makes the decisions on such trade-offs.

There are some basic considerations that provide generic guidelines for the commander in maximizing EMP mitigation that mesh with METT-T analysis. Plan for redundant communication systems during operations whenever feasible. Most commanders do not have the luxury of extra radios; however, land lines, field phones, and messengers provide alternative means of communications should EMP cause catastrophic failure in radio communications.

The use of narrow band instead of broad band radios can reduce the effectiveness of EMP. Broad band radios operate on a wider spectrum and can couple more energy than narrow band. Knowing the preponderance of EMP occurs in the electro-magnetic spectrum below 100 megahertz, microwave communications are an effective form of alternate communications.

Microwave communications work well because they operate in frequency bands above 100 megahertz. Computers are extremely vulnerable to functional upset by EMP. Backup disks of operationally important information are critical to safeguard against information loss if EMP should affect those systems.

Disconnecting antennas and power supplies from all equipment other than mission essential can also reduce the effects of EMP and provide a communications network after the detonation occurs. Finally, operational plans and standing operating procedures should address alternate means of communications if catastrophic equipment failure from EMP should occur.

These guidelines are generic and broad-based. To describe all EMP mitigation techniques available and describe their employment is far beyond the scope of this article. Common sense, initiative, and innovation, coupled with an understanding of EMP and its associated effects are the first step in EMP mitigation in air-land operations. US Army Field Circular 50-16, *Electromagnetic Pulse Mitigation Techniques*, is an excellent source for more in-depth information.

The Bottom Line

EMP can cause severe damage to the vast array of electronic equipment present on the modern battlefield. The need to understand how EMP originates, what it does, and basic mitigation techniques are extremely important. I have attempted to address these issues and stimulate the reader to learn more about the subject. In air-land operations, we must consider EMP an enemy, an enemy with the sole purpose of attacking and destroying C^3I equipment and other electronic devices. The only way you can defeat any enemy is to know him and know him well.

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