HPM weapons: fantasy, or frightening reality?

In the bygone days of cartoons, we followed Flash Gordon wielding imaginary beam weapons. Is there a frightening new reality that overshadows those fantasies? Manuel W. Wik reports.

The following presentation first appeared in the Militär Teknisk Tidskrift *(*Military Technology Magazine*), the quarterly journal of the Swedish Military Technology Society (Militärtekniska Föreningen, No. 3-89) and is reprinted here with the permission of the author. This very concise presentation on high-power microwave (HPM) weapons was made in June 1989 before the conference MILINF 89 (Military Information 89) and reflects the growing interest in the subject on the part of Swedish military circles. The author, Manuel W. Wik, is Coordination Manager at the Defense Materiél Administration in Stockholm, Sweden.*

The development of beam weapons

In the world of cartoons, we encountered space ships and computers before they existed. In the same way, we have been able to follow Flash Gordon and other figures' fights with beam weapons. So far, we have been spared from such weapons in reality. Are those days now over, and do we face a frightening new development?

There is every reason to observe that modern warfare is not only a question of the fight for and the supremacy over territories, seas, air and space. Of fundamental significance in all cases today, is the fight for and the supremacy over the electromagnetic spectrum, from gamma rays, x-rays, and optical frequencies to radio waves and even down to extremely low frequencies. The electromagnetic spectrum, which in former times was mostly used for observations and communications, has gained more importance for the area of arms applications. The electromagnetic radiation from nuclear explosions was contributing to this at the time. This radiation covers a broad spectrum from ionized radiation, x-rays, optical frequencies to radio waves and extremely low frequencies, (nuclear electromagnetic pulse—NEMP).

'Star Wars' and electronic warfare

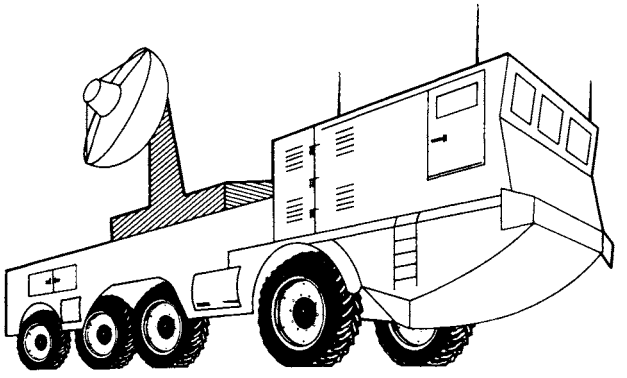
American reports on the SDI program (Strategic Defense Initiative) partly include the development of beam weapons. Those can be subdivided into laser, microwave, and particle beam weapons.

Laser systems so far have attracted most attention. Today tactical laser systems for target acquisition and target tracking, as support functions for weapon systems, in several cases are already so powerful, that there is strong reason to be concerned about their effects on the human eye and on optical or electro-optical systems.

Microwave technology was rapidly developed for radar applications during World War II and at a slower pace thereafter. During the 1970s, however, the development received new impetus with a very powerful jump in generated output from about 1 megawatt to 100-1,000 megawatts. Contributing to this was the combination of microwave technology with plasma physics, particle beam technology, and fusion technology.

The feasibility of very high microwave power has been noted primarily for arms applications. It would, however, be wrong to believe that this is the only possible application. Apart from beam weapons, which are aimed at destroying electronics, one has to pay attention to electronic warfare weapons operating at very high power levels aimed at disturbing electronics from a large distance. Furthermore, short-pulse radars which radiate pulses for no longer than nanoseconds can avoid extinction phenomena upon reflection in targets. High-power communication is an application for "disturbance free" communication links. It should be possible to

FIGURE 1
High-power microwave mobile weapon
(Artist's conception)



make unauthorized tapping of the information difficult.

Isolated use of microwave guns for special purposes began several years ago. The new BTI program (Balanced Technology Initiative) of the U.S.A. includes high-power microwave weapons (HPM). This HPM development is believed to have been initiated many years earlier in the Soviet Union. Several observers believe that the Soviet Union is leading in this field and has developed new means of generating radio frequency (RF) energy. This now can lead to fundamentally new types of weapon systems. Such systems can disturb or damage electronic equipment or possibly be used against human beings. The Soviets' good basic technical knowledge concerning electromagnetic sources already makes prototypes of short-range tactical RF weapons feasible. This could be one of the ways for the East to counter the supremacy of the West concerning sophisticated electronics in military applications. The great dependency upon electronics gains ever more fundamental significance for successful military operations. This calls forth weapons which strike against the electronics as such, and which, therefore, in a way, can be called humane.

Today the efforts to produce tactical beam weapons or basic components are increasing, not only in the Soviet Union and the U.S.A., but also in France, Great Britain, Japan, and Israel. Strategic weapons require greater effort and are therefore more for the future, except for certain applications in space where their enormous range speeds up the development.

HPM types of arms

Energy sources for microwave weapons can be conventional electrical capacitor networks, explosively driven systems, and nuclear charges of the third generation. The arms can be stationary or mobile, ground-based or carried by ships, airplanes, or in space (see **Figure 1**). Even special HPM missiles and gravitational bombs can be imagined. In combination with aiming systems, a very high firing accuracy can be obtained. Because of weight, volume, and self-generated disturbance problems, ground- and ship-based tactical applications will be the first to be realized. Aimed at sabotage, car- or hand-carried HPM weapons might be used already in peacetime, for example near, but outside, sensitive electronic installations which are physically difficult to access.

HPM weapons might become the next generation of electronic warfare weapons, more general, and with a wider range. This is true especially if the weapons prove to be effective without prior detailed information about the capacity of the adversary systems. Instead, the raw power of the beam weapon is being utilized. HPM weapons, however, must be seen as complementary to conventional weapons. They are not replacing them, as they only affect the electronics and as there is a large area of uncertainty between an assured effect on the target and assured survival.

Comparisons with NEMP

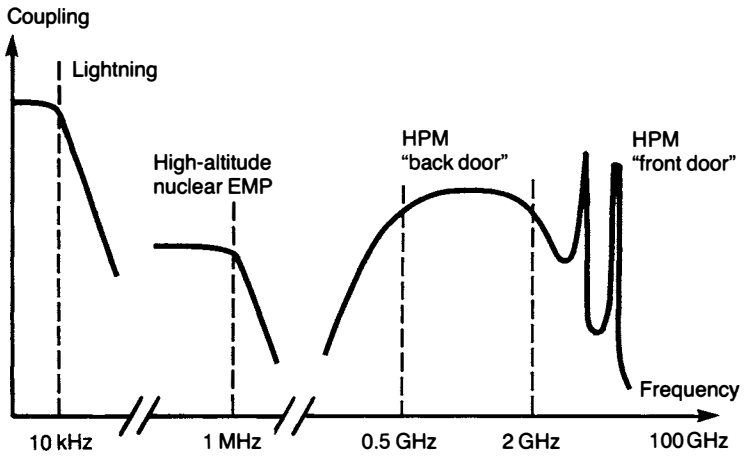
The HPM area has certain similarities with electromagnetic pulse (EMP) from nuclear weapons, but the differences are also significant. The political and military threshold for use of nuclear weapons is high. This threshold in recent years has been increased even more, as a consequence of knowledge about the global environmental effects of nuclear war. On the contrary, there is no real threshold for the use of HPM weapons based upon conventional electrical energy sources. One can imagine their use already in peacetime, covertly and without any later possibility to determine with certainty that HPM weapons were used. This might have consequences for security policy and lead to entirely new threats and scenarios.

The HPM weapons might have greater tactical areas of application than nuclear arms and the effect is considerably more selective. The HPM weapons can illuminate a limited area with a very large number of pulses in the microwave region (1-100 gigaherz) and the pulse effect diminishes with the distance. NEMP from high-altitude explosions exposes entire countries at the same time with one single pulse per nuclear explosion. The NEMP exposure from the present nuclear weapons occurs mainly in the low frequency and radio frequency regions (10 kiloherz-100 megaherz) and with approximately the same field strength over the entire area (see **Figure 2**).

NEMP hardening can have a certain effect against microwave radiation, but can also lack effect depending upon the exposure. High-frequency microwave radiation penetrates much more easily through joints and holes in enclosures, and can result in new types of coupling and effects, among other things, through resonances and signal rectification. The costs of HPM hardening can become high and the uncertainty nonetheless can remain large.

The NEMP effect is attractive for use against electronic

FIGURE 2
Comparison of electromagnetic threats



Electromagnetic threats from lightning, high-altitude nuclear EMP, and high-power microwave coupling as a function of frequency (schematic diagram).

Source: Manuel W. Wik.

and communication functions. It is known that nations with nuclear arms, therefore, already at an early stage, did study the possibility to enhance the EMP effect from, for example, a nuclear explosion at a high altitude (more than 30 kilometers). The propagation of radio waves in space occurs without any significant loss. The energy density required to disturb or damage electronics is lower than that required for other forms of radiation. In space, the strength of a microwave source is not limited by ionization, as in the air, at the Earth's surface. Thus it may be attractive to also study the possibility of utilizing energy from nuclear explosions in space for transformation into directed microwave energy.

Ranges

There is a physically determined upper limit to how much radiation terrestrial weapons can deliver, depending upon the breakdown of the atmosphere. For ground-based systems, it can be shown that small HPM weapons with antennas in the order of magnitude of 1 meter could disturb unprotected computers and other electronic systems at a distance of 10 kilometers (through the so-called "back-door" coupling). The most powerful systems existing today with 10 meter large antennas could disturb computers at a distance of 100 kilometers and cause permanent damage at a distance of up to 10 kilometers. Even stronger sources theoretically are believed to be able to permanently damage electronic systems at a distance of up to several tens of kilometers and disturb at a distance of hundreds of kilometers. One should not forget that a disturbance in an electronic system in turn can lead to catastrophic effects upon primary functions and, thus secondarily, lead to permanent lapse or damage. By comparison, one can mention that in recent years, several airplanes and helicopters have crashed as a consequence of coming too close to existing radio and radar stations. Even weak HPM weapons can, with a good coupling to antennas (so-called "front-end" coupling), burn out microwave diodes in the receiver units at a distance of over 100 kilometers. Human beings can have auditory sensations at a distance of a few kilometers. Theoretically, one can imagine that HPM weapons would be able to disturb nervous systems at a distance of up to 30 kilometers. For space-based systems the ranges in space become enormous.

Advantages

In summary, what advantages and disadvantages can the future HPM weapons then have? To the advantage of the aggressor and the disadvantage of the defender, one could mention the following factors:

The weapon fires with the speed of light.

A large number of shots per unit time can be achieved with certain weapon types.

The threshold for using the weapon is low; it can be used during peacetime and also crises.

The shots can be fired covertly, they are invisible and inaudible, and, in certain cases, it can be very hard to detect that one has been fired at with microwaves.

The weapon strikes directly against the electronics of the adversary, and thereby can blind, silence, and deafen his functions, make them lose their memory, or act in an uncontrolled and wrong way.

The weapon might require less detailed knowledge about the systems of the adversary, and can thereby shorten the time for developing new weapons of electronic warfare.

The weapon might lead to a new generation of electronic

warfare weapons, striking with higher effect and at a longer distance.

The weapon might be more generally applicable than common electronic warfare weapons.

The weapon might be perceived as humane, but it might also affect human beings.

There could be a great development potential in the field of HPM, which could lead to many possible kinds of weapons.

The development can be influenced by progress in several areas of high technology and combinations of them (emerging technologies), for example, new energy sources, fusion and plasma technology, superconductivity, new nuclear arms.

The HPM weapons are less weather-dependent than laser weapons.

Possibilities exist for a very high-output power and an enormous range in space.

There are clearly interesting targets to fight in space.

Warfare in space and on the ground becomes, relatively, less destructive to the environment.

Space-based weapons might be used against targets on the ground.

It might be difficult and expensive to protect oneself with much certainty.

It might be difficult to maintain an intact shield.

It might be difficult to map out the threat.

The high-poweer microwave weapon can be used without forewarning. The element of surprise is part of its deployment tactics.

Disadvantages

To the disadvantage of the aggressor and the advantage of the defender one can mention the following factors:

Use of the weapon could mean taking a chance and running a risk. Uncertainty about the effect remains and the probability of succeeding in using the weapon can vary strongly.

The weapon cannot replace conventional weapons, but can only be a complement to them.

The weapon might require relatively big volumes and weights for its platform to carry, and thus competes with the space for conventional weapons.

Good focusing, targeting, and eventual use of phased array antennas might complicate the weapon system.

The costs of development might become high.

The effective ranges for terrestrial applications might become moderate. The range is limited by the absorption in the atmosphere and the maximal flux is limited by ionization of the air around the generator.

The efficiency is low in relation to chemical explosives.

The leakage of radiation around the weapon (microwave radiation, but also x-ray radiation, etc.) can cause problems on the platform, for both electronics and personnel.

The weapon might cause tactical problems, for example, if other electronic systems have to be protected or shut off when the weapon is being used.

The shots make possible homing in on and localization of the platform or the source.

It might be difficult to achieve both high repetition rates and variable or optimal microwave frequency.

In several cases, the defender in any case, for other reasons, has to have good, basic shielding against damaging effects of strong radio frequency emitters (for example, close to radar stations).

Taken all together, these factors add up to a number of uncertainties which might make it hard for the aggressor to fully judge the usefulness of the weapon type.

Closing remarks

In spite of all dangers which are lurking in the emerging field of beam weapons, it is important not to be seized by some sort of Flash Gordon hysteria. Swedish security and defense policy is best served by treating the matter in a sober and well-informed manner. This can be done through improved knowledge and observations and through awareness and foresight in designing new defense systems as well as reviewing older systems in the framework of balancing all relevant threats. For this, good knowledge, leadership, and collaboration are needed.