

E –BOMB

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ABSTRACT

The contemporary military rivalry is driven mostly by the ongoing military technical revolution. In particular, the weapons used on the future battlefield will play an important role in military affairs. Electromagnetic weapons seem to involve key elements for the future battlefield; they offer advantages over conventional weaponry by providing non-lethality, the advantage of attack at the speed of light, fast engagement of multiple targets, potentially low operational cost, and wide-area coverage for offensive and defensive purposes. This paper proposes hypothetical electromagnetic bombs (e-bomb). The next step in this paper is to define the importance of the hypothetical e-bomb in military rivalry. The military rivalry mostly depends on military technical revolution.

Keywords- E-bomb, military, electromagnets.

I. INTRODUCTION

The electromagnetic bomb, or e-bomb, is a new class of weapon based on high-power surges, and it can render impotent even the most advanced digital weapons. The first electromagnetic pulse effect was observed during a high altitude airburst nuclear weapons testing (In July 1962, a 1.44 megaton United States nuclear test in space, 400 kilometres above the mid-Pacific Ocean, called the Starfish Prime test Starfish Prime also made those effects known to the public by causing electrical damage in Hawaii, about 1,445 kilometres away from the detonation point, knocking out about 300 streetlights, setting off numerous burglar alarms and damaging a telephone company microwave link). In 1962, the Soviet Union also performed a series of three EMP-producing nuclear tests in space over Kazakhstan, which were the last in the series called "The K Project".

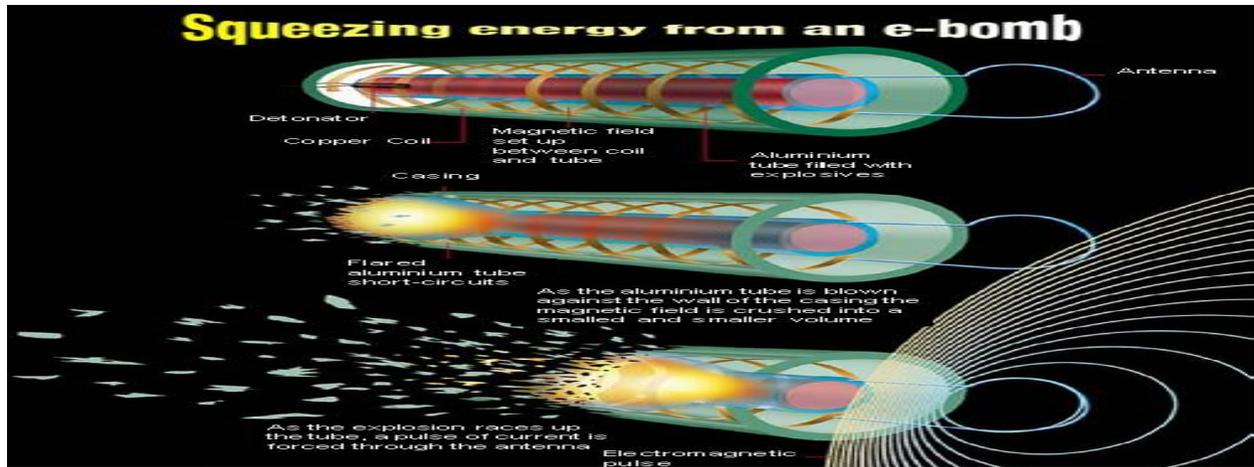
The Electromagnetic Pulse is in effect an electromagnetic shock wave. This pulse of energy produces a powerful electromagnetic field, particularly within the vicinity of the weapon burst. The field can be sufficiently strong to produce short lived transient voltages of thousands of Volts (i.e. kilovolts) on exposed electrical conductors, such as wires, or conductive tracks on printed circuit boards, where exposed. It is this aspect of the EMP effect which is of military significance, as it can result in irreversible damage to a wide range of electrical and electronic equipment, particularly computers and radio or radar receivers.

II. THE TECHNOLOGY BASE FOR CONVENTIONAL ELECTROMAGNETIC BOMBS

Key technologies which are extant in the area are explosively pumped Flux Compression Generators (FCG), explosive or propellant driven Magneto-Hydrodynamic (MHD) generators and a range of HPM devices, the foremost of which is the Virtual Cathode Oscillator or Vircator. This paper will review the basic principles and attributes of these technologies, in relation to bomb and warhead applications.

A. Explosively Pumped Flux Compression Generators

An explosively pumped flux compression generator (EPFCG) is a device used to generate a high-power electromagnetic pulse by compressing magnetic flux using high explosive. The central idea behind the construction of FCGs is that of using a fast explosive to rapidly compress a magnetic field, transferring much energy from the explosive into the magnetic field. An EPFCG can be used only once as a pulsed power supply since the device is physically destroyed during operation. An EPFCG package that could be easily carried by a person can produce pulses in the millions of amperes and tens of terawatts, exceeding the power of a lightning strike by orders of magnitude. They require a starting current pulse to operate, usually supplied by capacitors.



In a typical coaxial FCG, a cylindrical copper tube forms the armature. This tube is filled with a fast high energy explosive. A number of explosive types have been used, ranging from B and C-type compositions to machined blocks of PBX-9501. The armature is surrounded by a helical coil of heavy wire, typically copper, which forms the FCG stator. The stator winding is in some designs split into segments, with wires bifurcating at the boundaries of the segments, to optimise the electromagnetic inductance of the armature coil. It is typical that the explosive is initiated when the start current peaks. This is usually accomplished with an explosive lens plane wave generator which produces a uniform plane wave burn (or detonation) front in the explosive. Once initiated, the front propagates through the explosive in the armature, distorting it into a conical shape (typically 12 to 14 degrees of arc). Where the armature has expanded to the full diameter of the stator, it forms a short circuit between the ends of the stator coil, shorting and thus isolating the start current source and trapping the current within the device. The propagating short has the effect of compressing the magnetic field, whilst reducing the inductance of the stator winding. The result is that such generators will producing a ramping current pulse, which peaks before the final disintegration of the device.

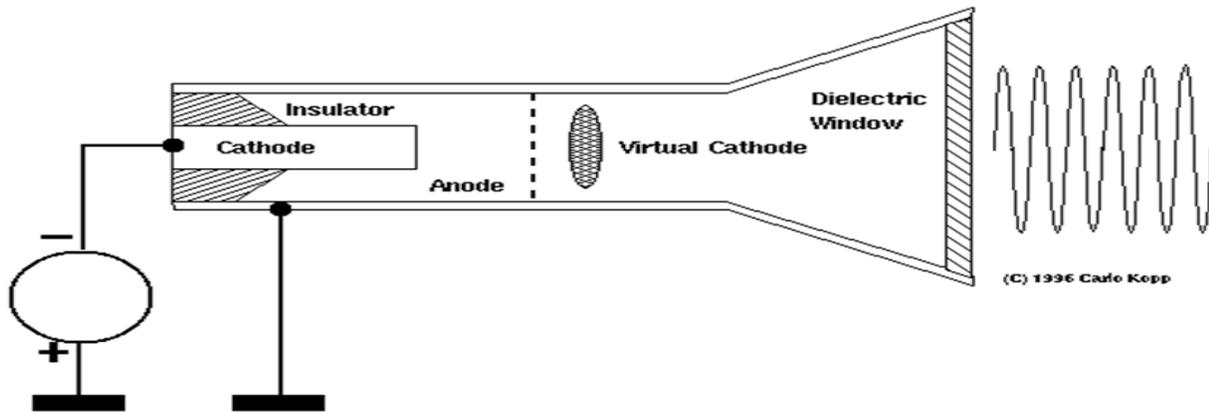
B. Explosive And Propellant Driven MHD Generators

The design of explosive and propellant driven Magneto-Hydrodynamic generators is a much less mature art than that of FCG design. Technical issues such as the size and weight of magnetic field generating devices required for the operation of MHD generators suggest that MHD devices will play a minor role in the near term. In the context of this paper, their potential lies in areas such as start current generation for FCG devices. The fundamental principle behind the design of MHD devices is that a conductor moving through a magnetic field will produce an electrical current transverse to the direction of the field and the conductor motion. In an explosive or propellant driven MHD device, the conductor is a plasma of ionised explosive or propellant gas, which travels through the magnetic field. Current is collected by electrodes which are in contact with the plasma jet.

C. High Power Microwave Sources – The Vircator

The various microwave sources are : Klystron , Magnetrons, Gyrotrons, Vircators, Ubitron/Free-Electron Lasers, Klystronlike Intense Relativistic Electron Beam Devices . The **Vircator** is of interest because it is a one shot device capable of producing a very powerful single pulse of radiation, yet it is mechanically simple, small and robust, and can operate over a relatively broad band of microwave frequencies.

The fundamental idea behind the Vircator is that of accelerating a high current electron beam against a mesh (or foil) anode. Many electrons will pass through the anode, forming a bubble of space charge behind the anode. Under the proper conditions, this space charge region will oscillate at microwave frequencies. If the space charge region is placed into a resonant cavity which is appropriately tuned, very high peak powers may be achieved. Conventional microwave engineering techniques may then be used to extract microwave power from the resonant cavity. Because the frequency of oscillation is dependent upon the electron beam parameters, Vircators may be tuned or chirped in frequency, where the microwave cavity will support appropriate modes. Power levels achieved in Vircator experiments range from 170 kiloWatts to 40 GigaWatts



III. THE LETHALITY OF ELECTROMAGNETIC WARHEADS

The issue of electromagnetic weapon lethality is complex. While the calculation of electromagnetic field strengths achievable at a given radius for a given device design is a straightforward task, determining a kill probability for a given class of target under such conditions is not. This is for good reasons. The first is that target types are very diverse in their electromagnetic hardness, or ability to resist damage. Equipment which has been intentionally shielded and hardened against electromagnetic attack will withstand orders of magnitude greater field strengths than standard commercially rated equipment. The second major problem area in determining lethality is that of coupling efficiency, which is a measure of how much power is transferred from the field produced by the weapon into the target. Only power coupled into the target can cause useful damage.

IV. COUPLING MODES

Two principal coupling modes are: Front Door Coupling, Back Door Coupling

- Front Door Coupling occurs typically when power from an electromagnetic weapon is coupled into an antenna associated with radar or communications equipment. The antenna subsystem is designed to couple power in and out of the equipment, and thus provides an efficient path for the power flow from the electromagnetic weapon to enter the equipment and cause damage.
- Back Door Coupling occurs when the electromagnetic field from a weapon produces large transient currents (termed spikes, when produced by a low frequency weapon) or electrical standing waves (when produced by a HPM weapon) on fixed electrical wiring and cables interconnecting equipment, or providing connections to mains power or the telephone network. Equipment connected to exposed cables or wiring will experience either high voltage transient spikes or standing waves which can damage power supplies and communications interfaces if these are not hardened. Moreover, should the transient penetrate into the equipment, damage can be done to other devices inside.

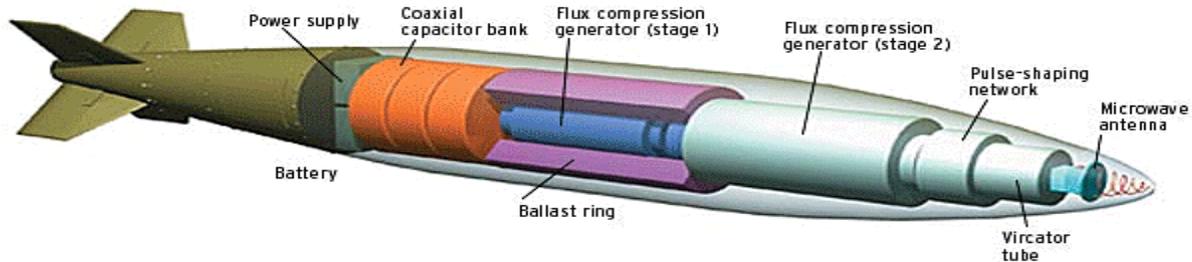
V. MAXIMISING E-BOMB LETHALITY

The first step in maximising bomb lethality is to maximise the peak power and duration of the radiation of the weapon. For a given bomb size, this is accomplished by using the most powerful flux compression generator which will fit the weapon size, and by maximising the efficiency of internal power transfers in the weapon. Energy which is not emitted is energy wasted at the expense of lethality. The second step is to maximise the coupling efficiency into the target set. A good strategy for dealing with a complex and diverse target set is to exploit every coupling opportunity available within the bandwidth of the weapon.

VI. E-BOMB ANATOMY

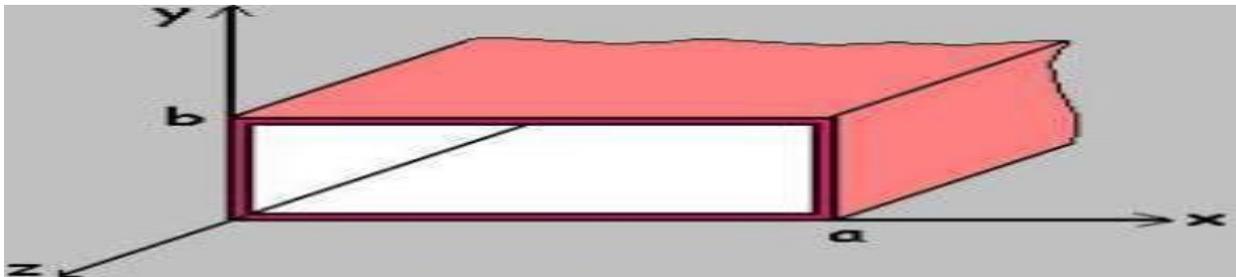
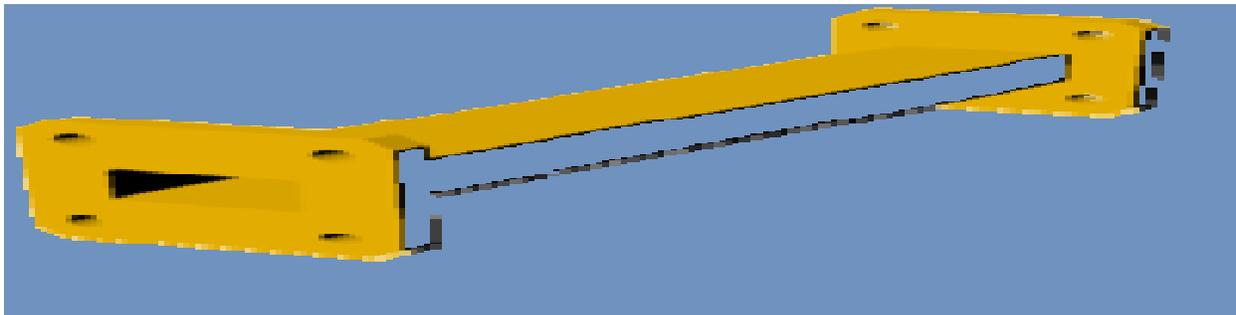
In this hypothetical design for an e-bomb, a two-stage flux compression generator provides gigawatts of power to the virtual cathode oscillator (vircator), which produces the high-power microwaves. The bomb's destructiveness depends on the microwave source and target's vulnerability to electromagnetic attack, among other things, but a 10-

GW, 5-GHz HPM device would have a “lethal” footprint 400 to 500 meters across, producing field strengths of several kilovolts per meter.



VII. PHYSICAL SPECIFICATIONS

For this model, a frequency range between 0.5 GHz and 3 GHz is used. The reason to choose this range is that the ultrahigh frequency (UHF) region from 300 MHz to 3 GHz is extensively populated with radars, television broadcasting and mobile communications involving aircraft and surface vehicles. According to the described frequency range, an appropriate rectangular waveguide is selected.



let the inner dimensions of the waveguide be :

a: larger dimension of the waveguide

b: smaller dimension of the waveguide.

Since $a > b$, the TE₁₀ mode has the lowest cutoff frequency

The model impedance for the rectangular waveguide that operates in TE₁₀ mode is :

$$Z_{1,0} = Z_0 \left[1 - \left(\frac{\lambda}{2a} \right)^2 \right]^{-1/2}$$

where

Z_0 : wave impedance of free space ($\mu / \epsilon = 120\pi$)

λ : operating wavelength ($\lambda = c / f$, where the c is the speed of light in free space, 3×10^8 m/s)

a : larger dimension of the waveguide

Once the model impedance is determined, the peak electric field (E-field) in the waveguide is given by:

$$E_{\max}(\text{waveguide}) = \sqrt{\frac{4}{ab} Z_{1,0} P_{\text{avg}}}$$

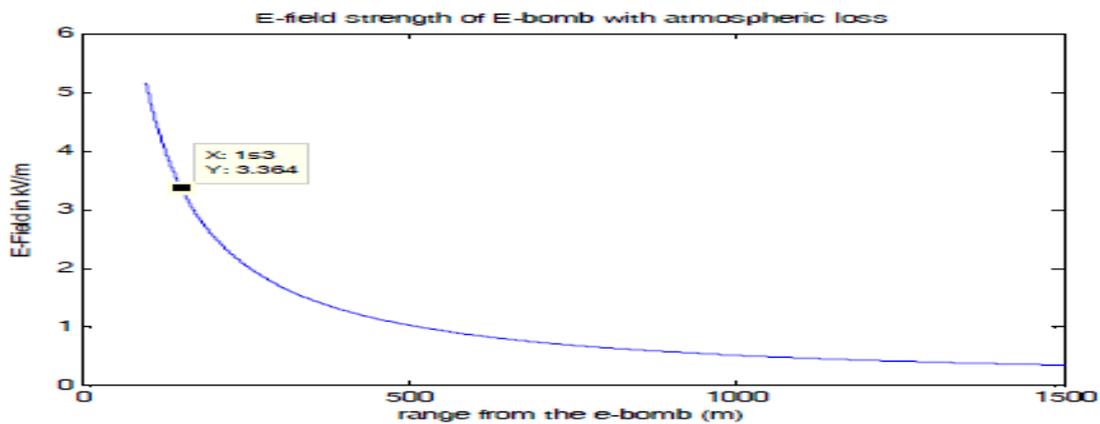
where

Z : model impedance of waveguide

P : average power of HPM source

a : larger dimension of the waveguide

b : smaller dimension of the waveguide



VIII. THE DELIVERY OF CONVENTIONAL ELECTROMAGNETIC BOMBS

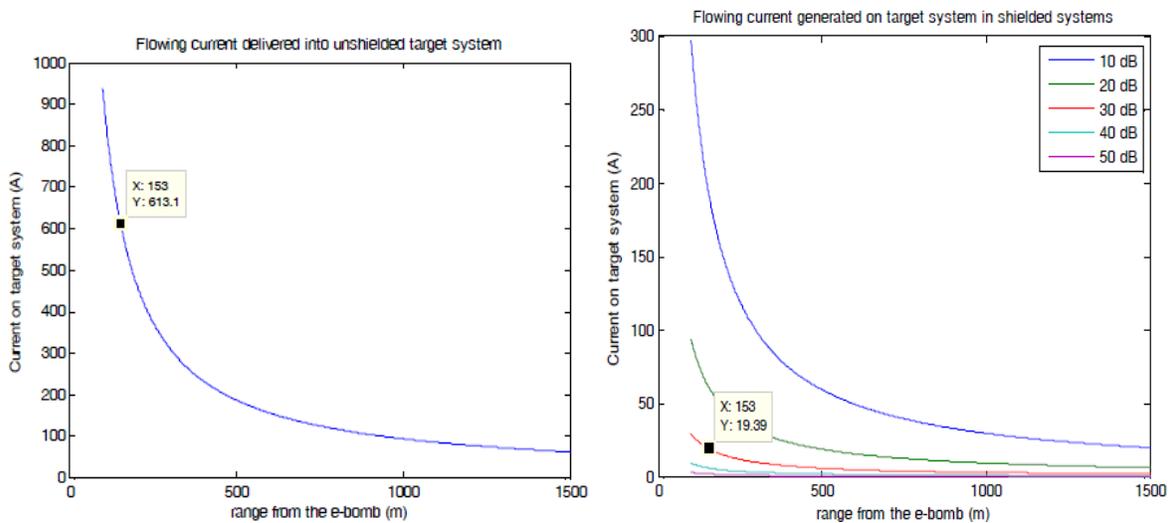
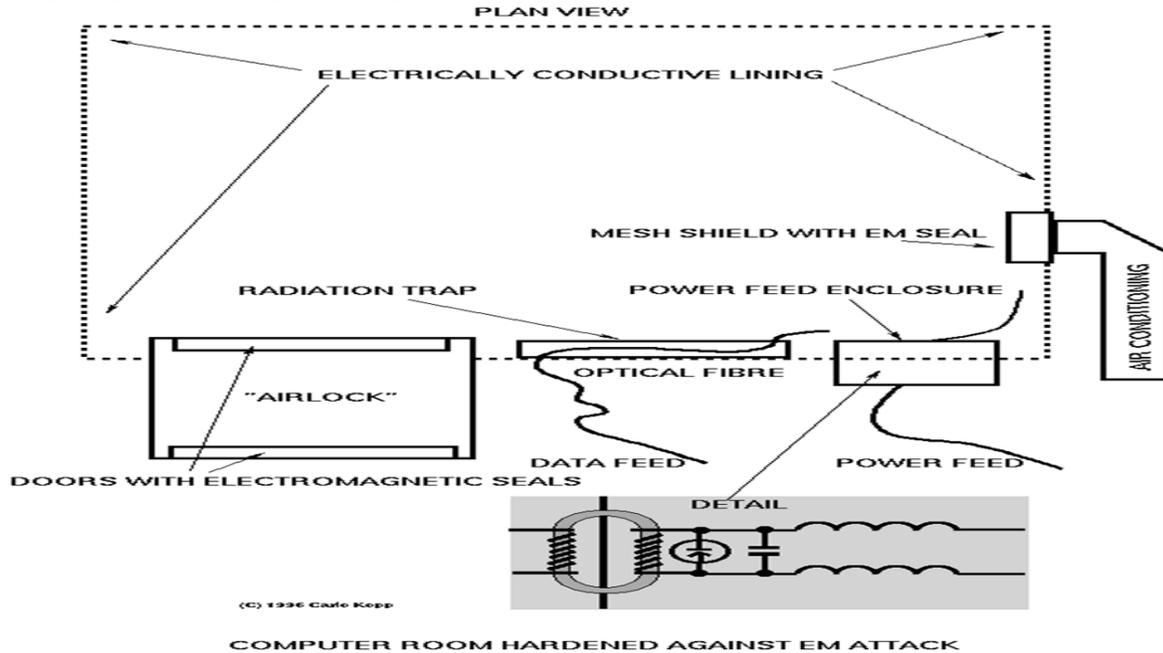
We could deliver an e-bomb in a number of ways: cruise missile, unmanned aerial vehicle, or aerial bomb. An electromagnetic bomb delivered by a conventional aircraft can offer a much better ratio of electromagnetic device mass to total bomb mass, as most of the bomb mass can be dedicated to the electromagnetic device installation itself. A missile borne electromagnetic warhead installation will comprise the electromagnetic device, an electrical energy converter, and an onboard storage device such as a battery. As the weapon is pumped, the battery is drained. The electromagnetic device will be detonated by the missile's onboard fusing system.



The recent advent of GPS satellite navigation guidance kits for conventional bombs and glide bombs has provided the optimal means for cheaply delivering such weapons. While GPS guided weapons without differential GPS enhancements may lack the pinpoint accuracy of laser or television guided munitions, they are still quite accurate and importantly, cheap, autonomous all weather weapons.

IX. DEFENCE AGAINST ELECTROMAGNETIC BOMBS

The most effective defence against electromagnetic bombs is to prevent their delivery by destroying the launch platform or delivery vehicle, as is the case with nuclear weapons. The most effective method is to wholly contain the equipment in an electrically conductive enclosure, termed a Faraday cage, which prevents the electromagnetic field from gaining access to the protected equipment



X. EFFECTS ON TARGETS

E-bomb interactions with system electronics can be categorized in four levels of destructive effect (upset, lock-up, latch-up, and burnout) and are dependent upon : Distance to the target ; Vulnerability of the target ; Operating frequency ; Coupled power level and power density on the target ; Bandwidth ; Burst rate and pulse duration ; Dwell time on the target ; Coupling mode or entry points. These potential effects of e-bombs on targets can be categorized as:

A. Soft-Kill

A soft kill is produced when the effects of the weapon cause the operation of the target equipment or system to be temporarily disrupted. Soft kill can occur in two forms:

- a) Upset
Upset is a temporary alteration of the electrical state of one or more nodes, in which the nodes no longer function normally. Upset means particular interaction as observed between a weapon and the operating state of the target system at the time, as the state changes, upsets could subside.
- b) Lock-up
Lock-up produces a temporary alteration similar to upset, but electrical reset or shut off and restart is necessary to regain functionality after the radiation is removed.

B. Hard-Kill

A hard kill is produced when the effects of the weapon cause permanent electrical damage to the target equipment or system, necessitating either the repair or the replacement of the equipment or system. Hard kill can be seen in two forms:

- a) Latch-up
Latch-up is an extreme form of lockup in which parasitic elements are excited and conduct current in relatively large amounts until either the node is permanently self-destroyed or the electrical power is switched off to the node.
- b) Damage/Burnout
Damage/burnout is electrical destruction of a node by some mechanism like latch-up, metallization burnout, or junction burnout.

XI. LIMITATIONS OF E-BOMB

The limitations of electromagnetic weapons are determined by weapon implementation and means of delivery. Weapon implementation will determine the electromagnetic field strength achievable at a given radius, and its spectral distribution. Means of delivery will constrain the accuracy with which the weapon can be positioned in relation to the intended target. While the relationship between electromagnetic field strength and distance from the weapon is one of an inverse square law in free space, the decay in lethal effect with increasing distance within the atmosphere will be greater due quantum physical absorption effects.

XII. THE IMPLICATION OF E-BOMB FOR INDIAN ARMED FORCE

Any Indian Land Forces unit equipped with an e-bomb might engage in a new way of war — with significant operational advantages over nations equipped with conventional weapons only. Communications and command systems are key elements in C4ISR systems for land warfare as well. Such systems are one of the first targets attacked in order to limit the opponent's operations. The Indian Armed Forces could use e-bombs to mount an effective attack against an enemy's C4ISR systems.

Some of the possible threats for today's naval forces have been defined as: Aircraft attack; Ship-based or land-based helicopters; Ship-launched or submarine-launched anti-ship missiles (ASM). The best defense against an opponent's missile-equipped platforms is to disable the delivering platform. In this aspect, the use of e-bombs may be a good defensive measure since it can degrade the effectiveness of ASM delivering platforms such as aircraft and ship-based/landbased helicopters.

The number of missiles that an aircraft can carry limits air-to-air engagements. Instead of having a limited payload, e-bomb-equipped Indian fighter aircraft might be effective against numerous air targets. This is likewise a major advance in Suppression of Enemy Air Defense (SEAD) operations. Since an e-bomb has the potential to defeat multiple air defense systems, the capability gained by the e-bomb would be a major development for Indian Air Forces.

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