The E-bomb - A Weapon of Electrical Mass Destruction

by Carlo Kopp
Department of Computer Science
Monash University, Australia
(C) 1996 Carlo Kopp
Carlo Kopp is a Computer Scientist, Electrical and Systems Engineer, Defence Analyst and Trade Journalist.

Carlo has been publishing in the military aviation trade press since 1980, and his papers on doctrine have been published by the Royal Australian Air Force since 1992.
Introduction:

- Desert Storm Counter-C3 operations relied on air power and precision guided munitions
- Future campaigns will require more suitable weapons to achieve shock effect over large target sets with small attacking forces
- Electromagnetic bombs (E-bombs) can perform such a role
Fig. 1 Typical Electromagnetic Pulse Shapes

- Nuclear EMP Transient
- Lightning Stroke
- Flux Compression Generator
E-bomb Technology Base:

- Power source - explosively pumped Flux Compression Generator (FCG)
- FCG pioneered by Los Alamos Labs during the 1950s
- FCG can produce tens of MegaJoules in tens to hundreds of microseconds
- Peak current of an FCG is 1000 X that of a typical lightning stroke
The Physics of the FCG:

- Fast explosive compresses a magnetic field
- Compression transfers mechanical energy into the magnetic field
- Peak currents of MegaAmperes demonstrated in many experiments
FCG start current is provided by an external source:

- capacitor bank
- small FCG
- MHD device
- homopolar generator
FIG. 2 EXPLOSIVELY PUMPED COAXIAL FLUX COMPRESSION GENERATOR
FCG Internals:

- Armature - copper tube / fast explosive
- Stator - helical heavy wire coil
- Initiator - plane wave explosive lense
- Jacket - prevents disintegration due magnetic forces
FCG Operation:

- External power source pumps FCG winding with start current
- When start current peaks, explosive lense fired to initiate explosive burn
- Explosive pressure expands armature and creates moving short
- Moving armature compresses magnetic field
High Power Microwave (HPM) Sources:

Higher lethality than low frequency FCG fields, many device types:

- Relativistic Klystrons
- Magnetrons
- Slow Wave Devices
- Reflex Triodes
- Virtual Cathode Oscillators (vircators)
Vircator Physics:

- Relativistic electron beam punches through foil or mesh anode
- "Virtual" cathode formed by space charge bubble behind anode
- Peak power of tens of GW for 100s of nsec
- Anode typically melts in about 1 usec
- Cheap and simple to manufacture
- Wide bandwidth allows chirping of oscillation
Lethality Issues in E-bomb Warheads:

- Diversity of target set makes prediction of lethality difficult
- Different implementations of like equipment have differing hardness
- Coupling efficiency is critical to lethality
Coupling Modes:

**Front Door Coupling** through antennas.
- Destroys RF semiconductor devices in transmitters and receivers

**Back Door Coupling** through power/data cabling, telephone wiring
- Destroys exposed semiconductor devices
- Punches through isolation transformers.
Semiconductor Vulnerability:

- Semiconductor components using CMOS, RF Bipolar, RF GaAs, NMOS DRAM processes are destroyed by exposure to volts to tens of volts of electrical voltage
- High speed - high density semiconductors are highly vulnerable due small junction sizes and low breakdown voltages
Damage Mechanisms:

- Low frequency pulses produced by FCG create high voltage spikes on fixed wiring infrastructure.
- Microwave radiation from HPM devices creates high voltage standing waves on fixed wiring infrastructure.
- Microwave radiation from HPM devices can couple directly through ventilation grilles, gaps between panels, poor interface shielding - producing a spatial standing wave inside the equipment cavity.
Example Scenario:

- 10 GigaWatt 5 GHz HPM E-bomb initiated at several hundred metres altitude
- Footprint has diameter of 400 - 500 metres with field strengths of kiloVolts/metre

FIG.5.1 E-BOMB LETHAL RADIUS
Maximising Bomb Lethality:

Lethality is maximised by maximising the power coupled into the target set

- maximise peak power and duration of warhead emission (large FCG/Vircator)
- maximise efficiency of internal power transfer in weapon
- maximise coupling efficiency into target set
FIG. 4 LOW FREQUENCY E-BOMB WARHEAD (MK.84 FORM FACTOR)
Microwave bombs are potentially more lethal due better coupling and more focussed effects

- chirping allows weapon to couple into any in-band resonances
- circular polarisation of antenna allows coupling with any aperture orientation
- reducing detonation altitude increases field strength at the expense of footprint size
FIG. 5.2 EXAMPLE OF VIRCATOR/ANTENNA ASSEMBLY
HIGH POWER MICROWAVE E–BOMB – GENERAL ARRANGEMENT MK.84 PACKAGING WARHEAD USING VIRCATOR AND 2 STAGE FLUX COMPRESSION GENERATOR

FIG.6 HPM E–BOMB WARHEAD (Mk.84 FORM FACTOR)
Targeting E-bombs:

- fixed installations (buildings, radar and comms sites) - conventional methods
- radiating mobile / hidden targets (ships, mobile SAMs) - use ESM or ELS
- non radiating mobile / hidden targets - use Unintentional Emissions (UE)

*UE results from Van Eck radiation and LAN/comms wiring emissions,
Characteristic signatures allow identification of target type and location*
Delivery of E-bombs:

1. Warhead comprises priming current source, FCG (cascade) and Vircator tube.
2. Missile installations must supply 100% of weapon priming energy from own supply.
3. Bomb installations - weapon can be precharged before release from aircraft.

* A free fall E-bomb is more lethal than a missile borne HPM warhead as a larger proportion of the weapon is the warhead.
FIG. 7 LETHAL FOOTPRINT OF LOW FREQUENCY E-BOMB IN RELATION TO ALTITUDE
FIG. 8 LETHAL FOOTPRINT OF A HPM E-BOMB IN RELATION TO ALTITUDE
Delivery Options:

- dumb bombs have a CEP of 100 - 1000 ft (free fall delivery)
- GPS aided bombs have a CEP of 40 ft (free fall but guided)
- Standoff missiles have a CEP of 40 ft (GPS inertial with propulsion)
- Cruise Missiles have a CEP 10-40 ft (eg USAF AGM-86 derivative)
FIG.9 GPS GUIDED BOMB/GLIDEBOMB KITS
FIG. 10 DELIVERY PROFILES FOR GPS/INERTIAL GUIDED WEAPONS
Defences Against E-bombs:

- Destroy the delivery vehicle or launch platform
- Electromagnetically harden important assets
- Hide important assets
Vulnerability Reduction (Hardening):

- convert computer rooms into Faraday cages
- use optical fibres for data
- isolate power feeds with transient arrestors
- use non-electrical power feed schemes
- use electromagnetic “air lock”
- shielding must be comprehensive
Susceptibility Reduction (Preventing Attack):

- redundant topology
- UE reduction - stringent electromagnetic control regime
- Low Probability of Intercept (LPI) Comms and Radar
- decoy emitters
Proliferation:

- E-bombs use non-strategic materials and manufacturing
- US and CIS capable of deploying E-bombs in next half decade
- Possession of drawings and samples would allow Third World manufacture of E-bombs
- USAF estimated US$1,000-2,000 per round for FCG manufacture at US labour rates
- Counterproliferation regimes will be ineffective
Military Applications of the E-bomb

Doctrine and Strategy
1. Electronic Combat

- The objective is to paralyse the opponent’s C3I and IADS as quickly as possible.
- The E-bomb enables rapid attrition of enemy electronic assets over large areas.
- The E-bomb offers important force multiplication effects compared to the use of conventional weapons.

*The E-bomb is a Weapon of Electrical Mass Destruction*
2. Strategic Warfare

The Warden “Five Rings” model was tested and proven during Desert Storm:

- Leadership and C3 targets highly vulnerable
- Economic vitals - finance, stock markets, manufacturing, petroleum, oil/gas are highly vulnerable
- Transport infrastructure - signalling, navaids, vehicle ignition systems vulnerable
- Population - radio and TV receivers
- Military forces in the field - eqpt vulnerable
FIG. 12. WARDEN'S 'FIVE RINGS' STRATEGIC AIR ATTACK MODEL IN THE CONTEXT OF ELECTROMAGNETICALLY VULNERABLE TARGET SETS
E-bomb Advantages in Strategic Warfare

- Not lethal to humans
- Negligible collateral damage
- High tempo campaigns possible due the powerful “shock” effect of using a WEMD
- No mass media coverage of bombing casualties (broadcast eqpt destroyed) will reduce the threshold for the use of strategic air power and missile forces
3. Theatre Warfare

- Offensive Counter Air operations - disable aircraft in flight, on the ground and destroy their supporting infrastructure
- Sea Control - disable surface combatants prior to attack with conventional weapons
- Battlefield Interdiction - disable mobile C3I and concentrations of tanks, armoured vehicles and helicopters
4. Punitive Missions

- The E-bomb is a useful punitive weapon as it can cause much economic and military damage with no loss of civilian life.
- E-bombs could be profitably used against countries which sponsor terrorism and info-terrorism.
Conclusions:

- E-bomb is a WEMD
- High payoff in using E-bombs against fundamental infrastructure, resulting in substantial paralysis
- E-bombs will become a decisive capability in Strategic Warfare and Electronic Combat
- E-bombs are a non-lethal weapon
- The critical issues for the next decade are the deployment of E-bombs and the hardening of fundamental infrastructure