

The E-bomb - A Weapon of Electrical Mass Destruction

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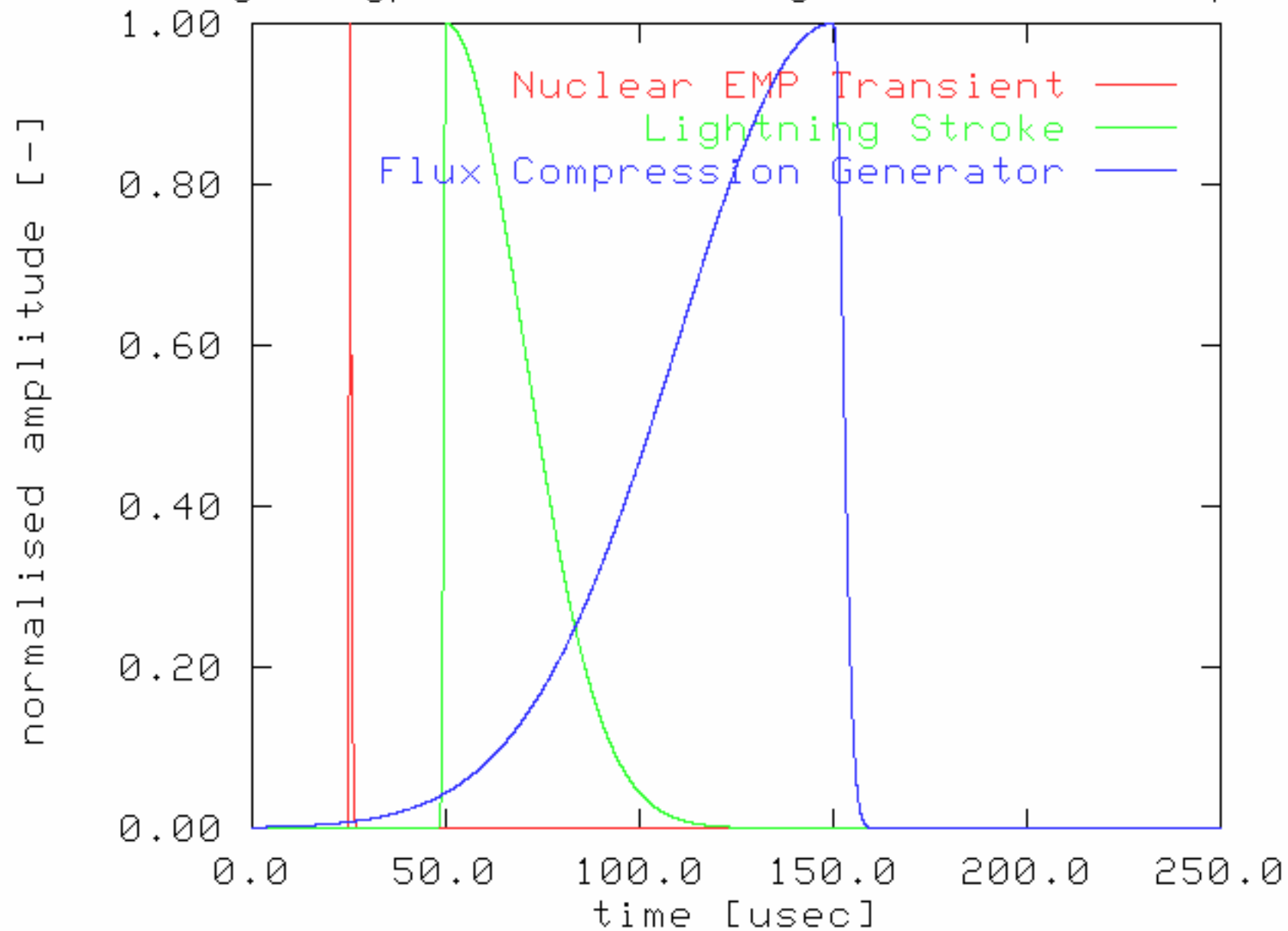
- | Carlo Kopp is a Computer Scientist, Electrical and Systems Engineer, Defence Analyst and Trade Journalist

- | 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



E-bomb Technology Base:

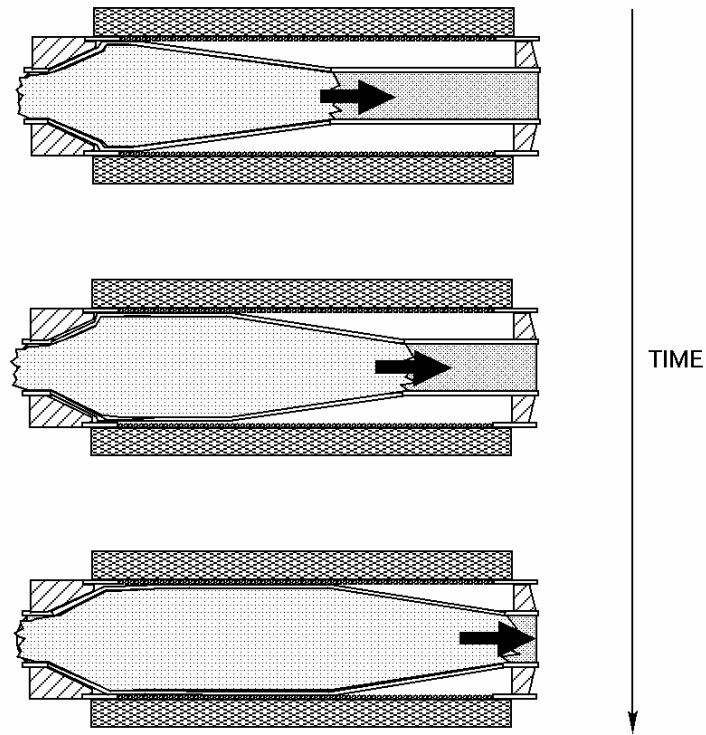
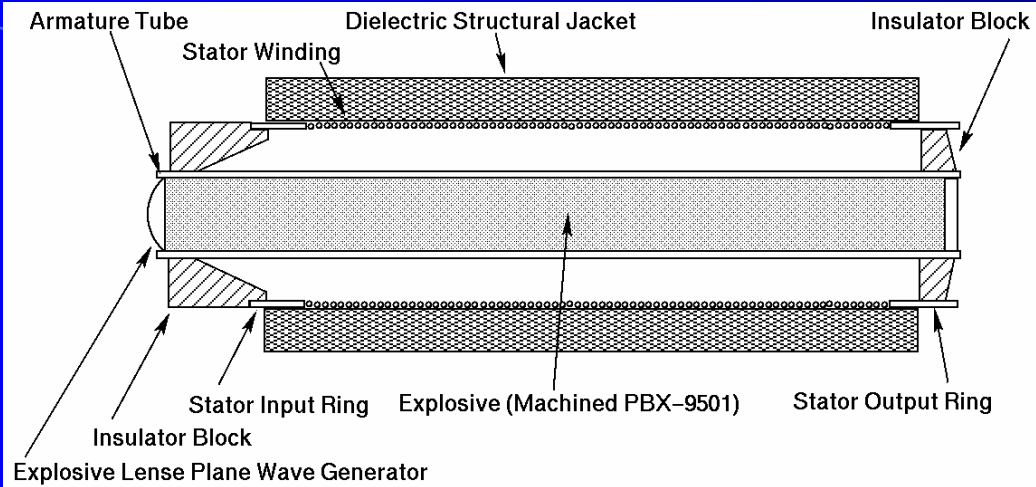
- | Power source - explosively pumped Flux Compression Generator (FCG)
- | FCG pioneered by Los Alamos Labs during the 1950s
- | FCG can produce tens of MegaJoules in tens to hundreds of microseconds
- | Peak current of an FCG is 1000 X that of a typical lightning stroke

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



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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

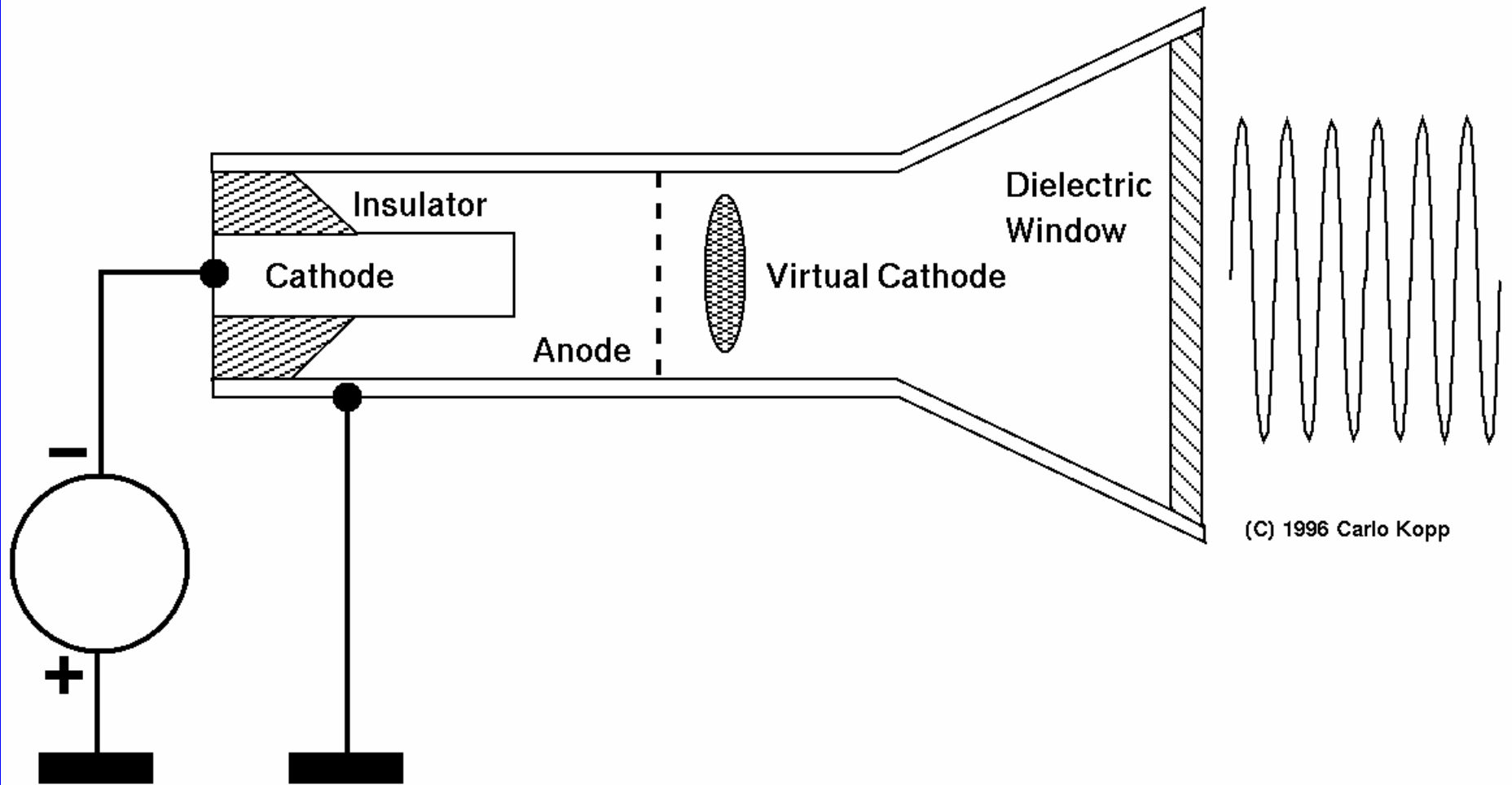
FCG Operation:

- | 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)



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FIG.3 AXIAL VIRTUAL CATHODE OSCILLATOR

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:

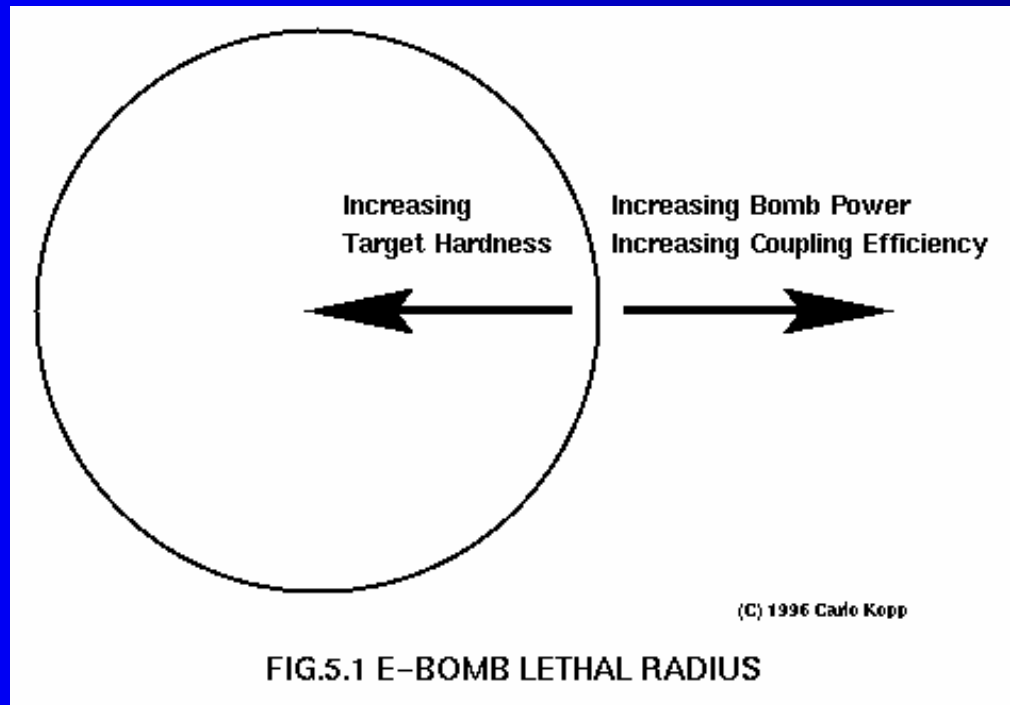
- | Semiconductor components using CMOS, RF Bipolar, RF GaAs, NMOS DRAM processes are destroyed by exposure to volts to tens of volts of electrical voltage
- | High speed - high density semiconductors are highly vulnerable due small junction sizes and low breakdown voltages

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:

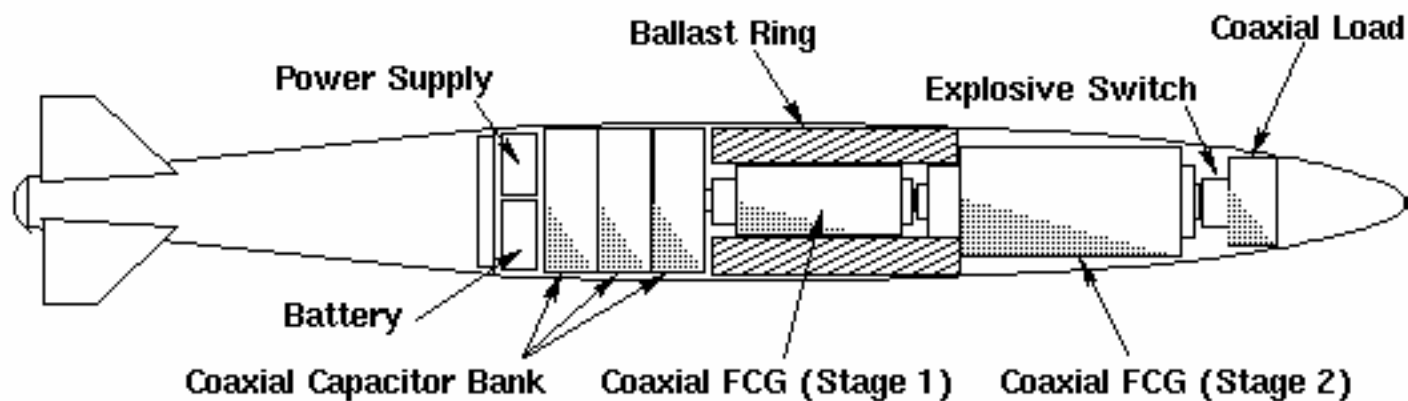
- | 10 GigaWatt 5 GHz HPM E-bomb initiated at several hundred metres altitude
- | Footprint has diameter of 400 - 500 metres with field strengths of kiloVolts/metre



Maximising Bomb Lethality:

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

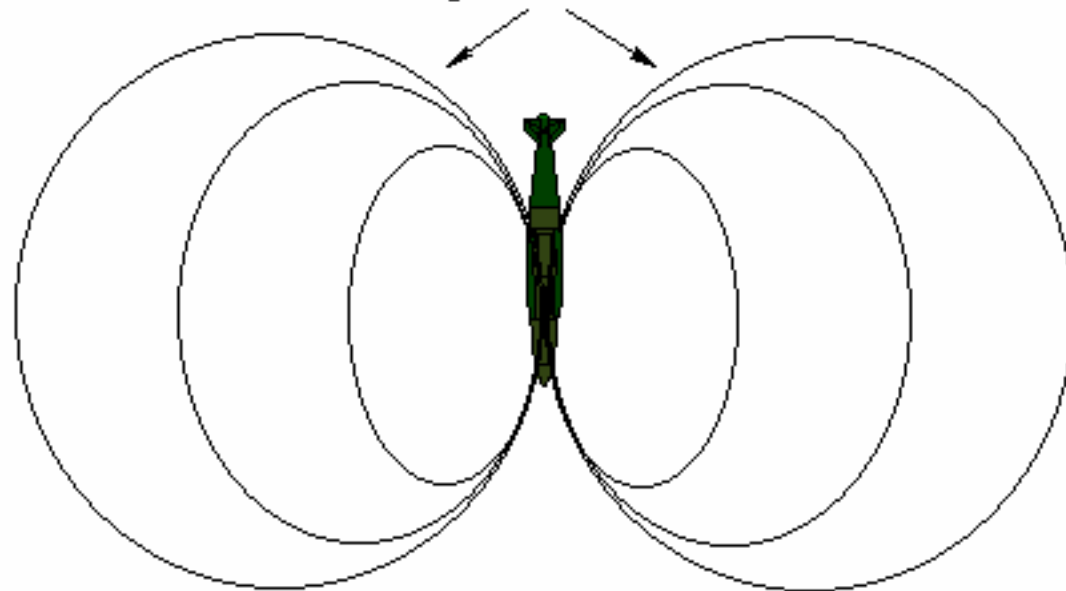
- | maximise peak power and duration of warhead emission (large FCG/Vircator)
- | maximise efficiency of internal power transfer in weapon
- | maximise coupling efficiency into target set



Mk.84 900 kg 3.84 m x 0.46 m dia

LOW FREQUENCY E-BOMB - GENERAL ARRANGMENT MK.84 PACKAGING

FCG Winding Radiation Pattern Lobes



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FIG.4 LOW FREQUENCY E-BOMB WARHEAD (MK.84 FORM FACTOR)

HPM E-bomb Lethality:

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

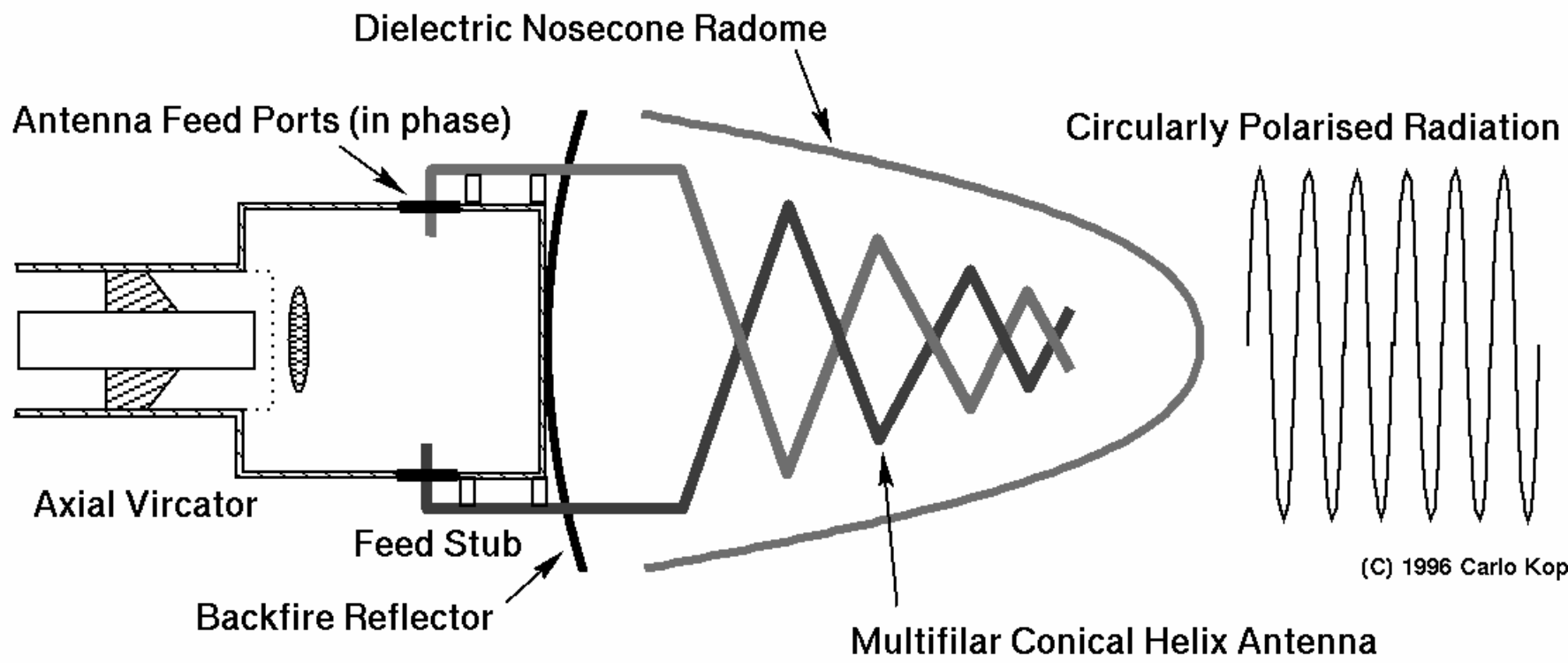
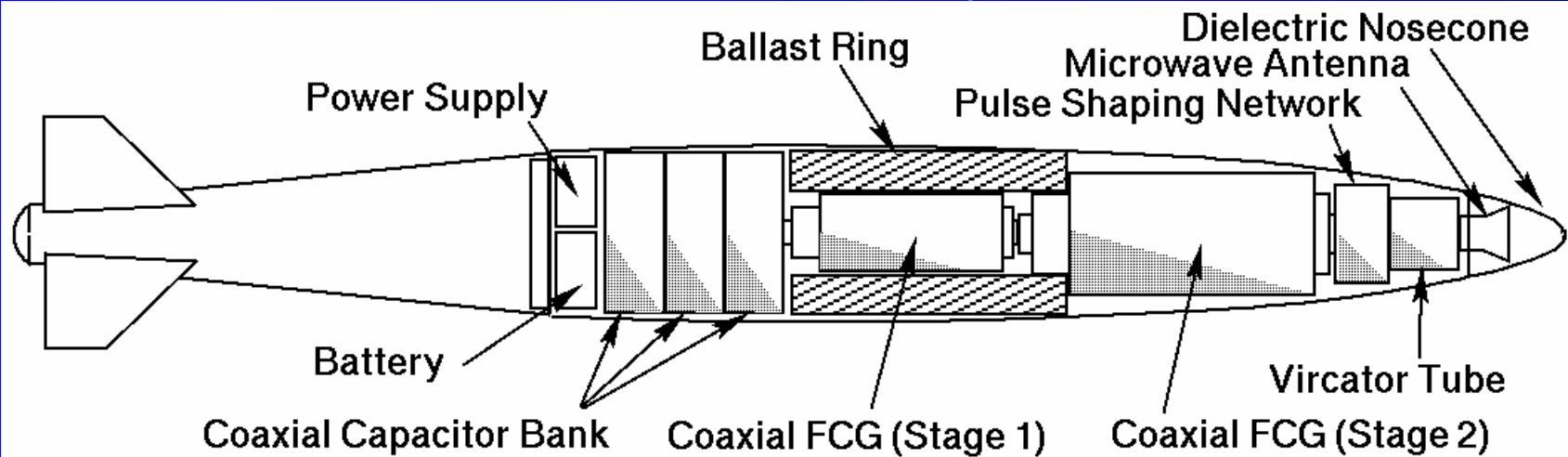


FIG.5.2 EXAMPLE OF VIRCATOR/ANTENNA ASSEMBLY



Mk.84 900 kg 3.84 m x 0.46 m dia

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HIGH POWER MICROWAVE E-BOMB – GENERAL ARRANGMENT 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:

- | Warhead comprises priming current source, FCG (cascade) and Vircator tube
- | Missile installations must supply 100% of weapon priming energy from own supply
- | 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

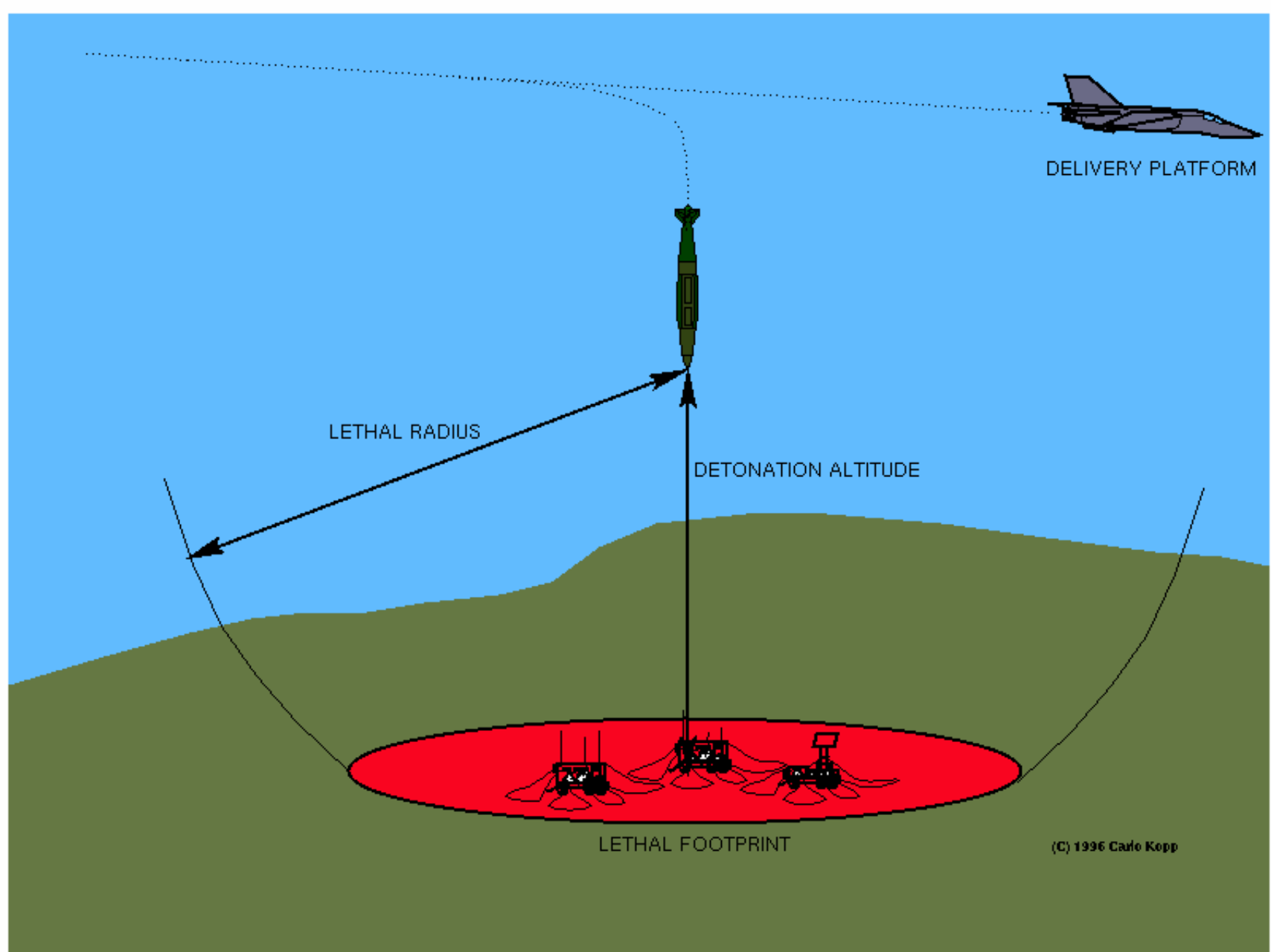


FIG.7 LETHAL FOOTPRINT OF LOW FREQUENCY E- BOMB IN RELATION TO ALTITUDE

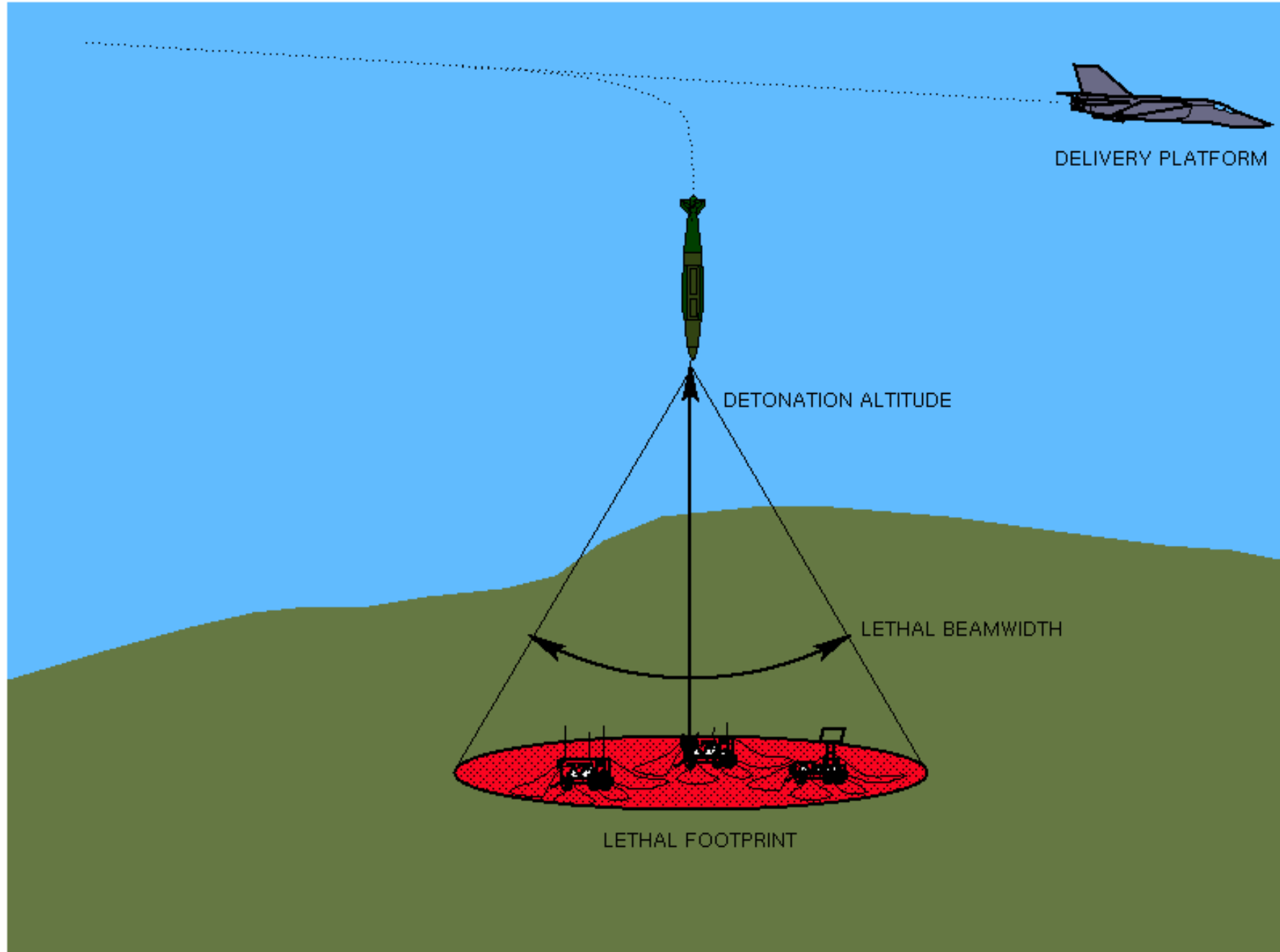


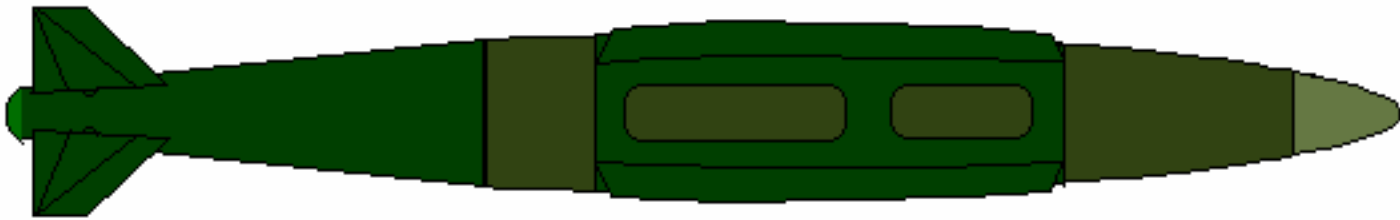
FIG.8 LETHAL FOOTPRINT OF A HPM E-BOMB IN RELATION TO ALTITUDE

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)



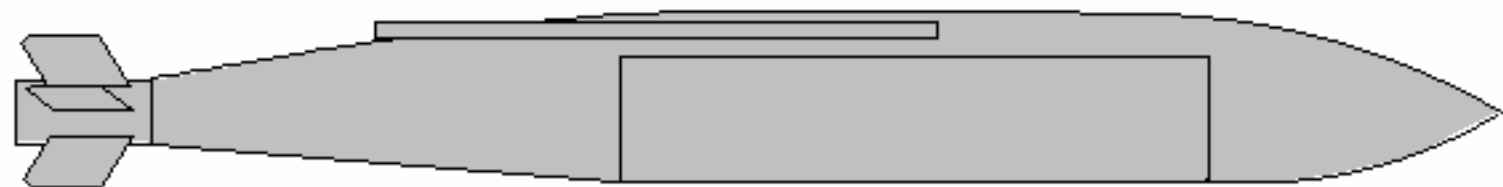
NORTHROP GAM (MK.84)



MDC JDAM (MK.84)



AWADI AGW (MK.84)



TI AGM-154C JSOW (800 lb/360 kg)

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FIG.9 GPS GUIDED BOMB/GLIDEBOMB KITS

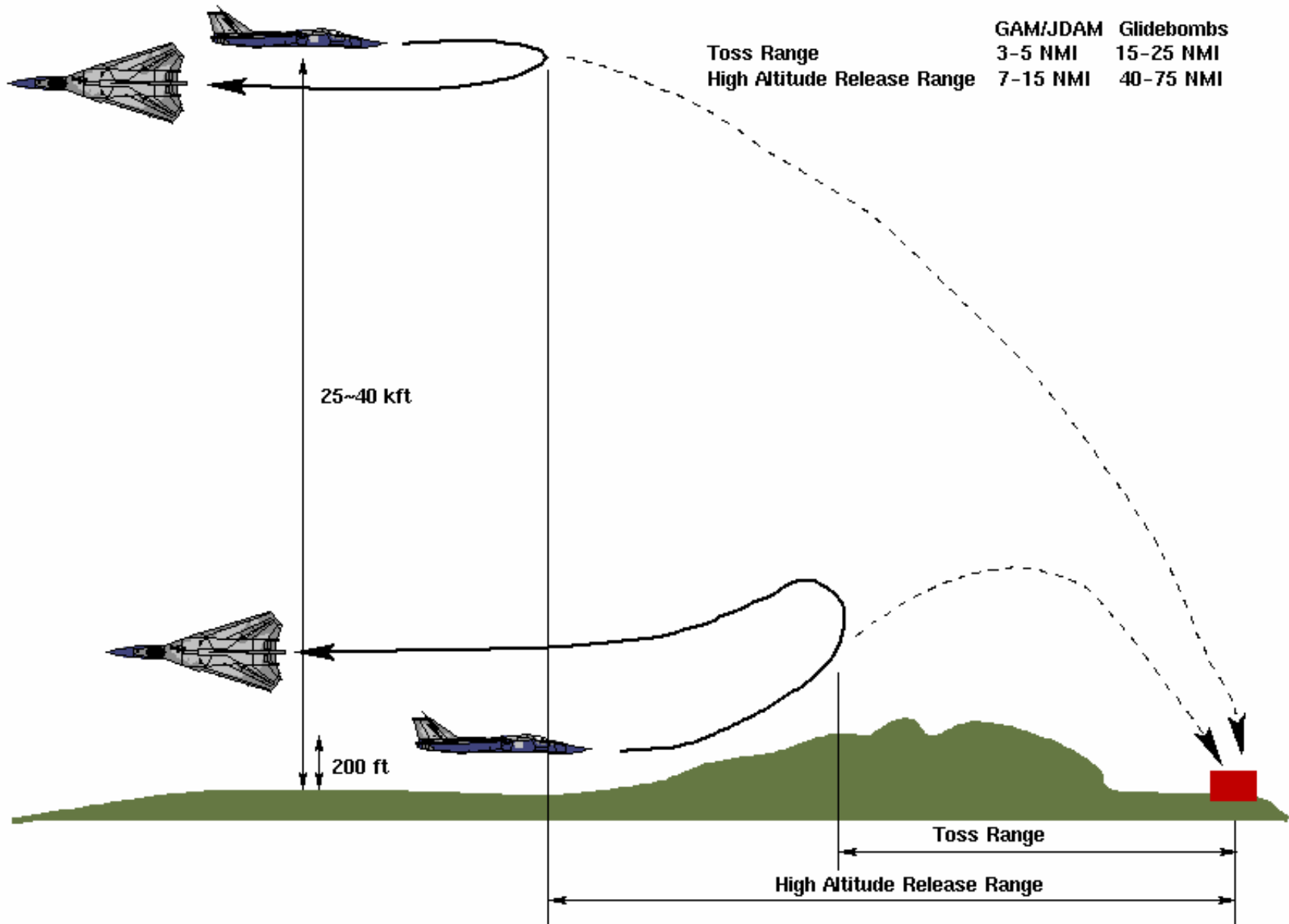


FIG.10 DELIVERY PROFILES FOR GPS/INERTIAL GUIDED WEAPONS

Defences Against E-bombs:

- | Destroy the delivery vehicle or launch platform
- | Electromagnetically harden important assets
- | Hide important assets

Vulnerability Reduction (Hardening):

- | convert computer rooms in to 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

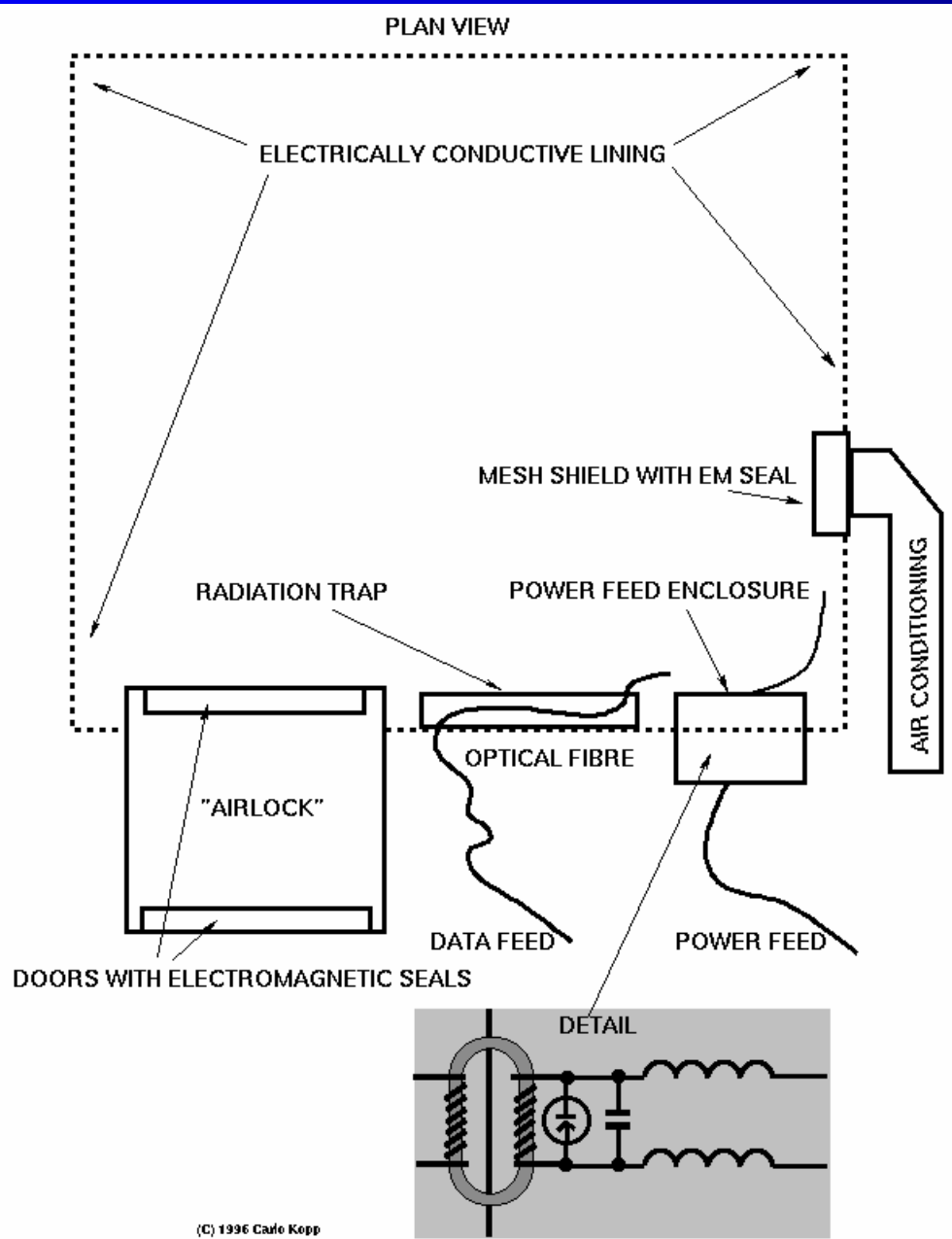


FIG.11 COMPUTER ROOM HARDENED AGAINST EM ATTACK

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

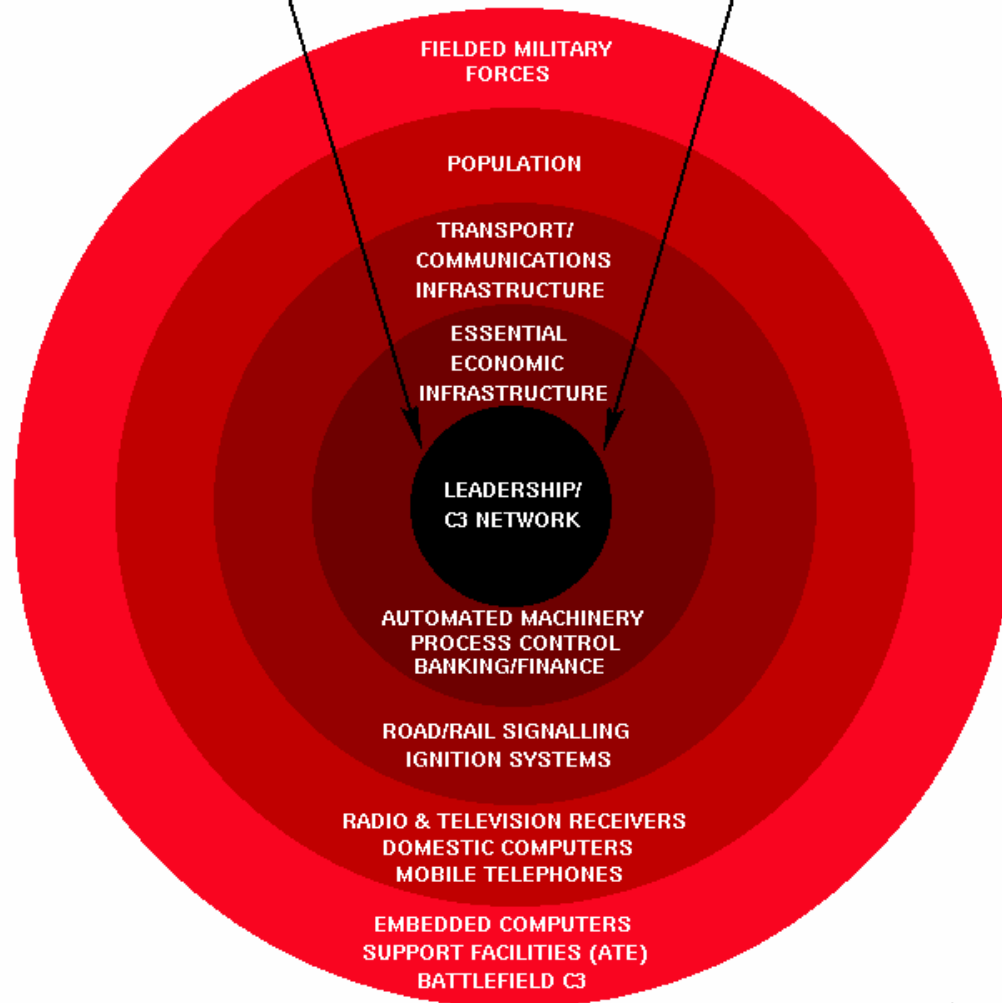
2.Strategic Warfare

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, nav aids, vehicle ignition systems vulnerable
- | Population - radio and TV receivers
- | Military forces in the field - eqpt vulnerable

GOVERNMENT TV/RADIO BROADCASTING FACILITIES
TELEPHONE SWITCHES, MICROWAVE AND SATELLITE COMMUNICATIONS,
KEY C3 POSTS

COMPUTER EQUIPMENT IN GOVERNMENT OFFICE BUILDINGS
MILITARY COMMAND POSTS AND HEADQUARTERS



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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