The E-bomb - A Weapon of Electrical Mass Destruction

by Carlo Kopp
Department of Computer Science
Monash University, Australia

The Author:

- 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

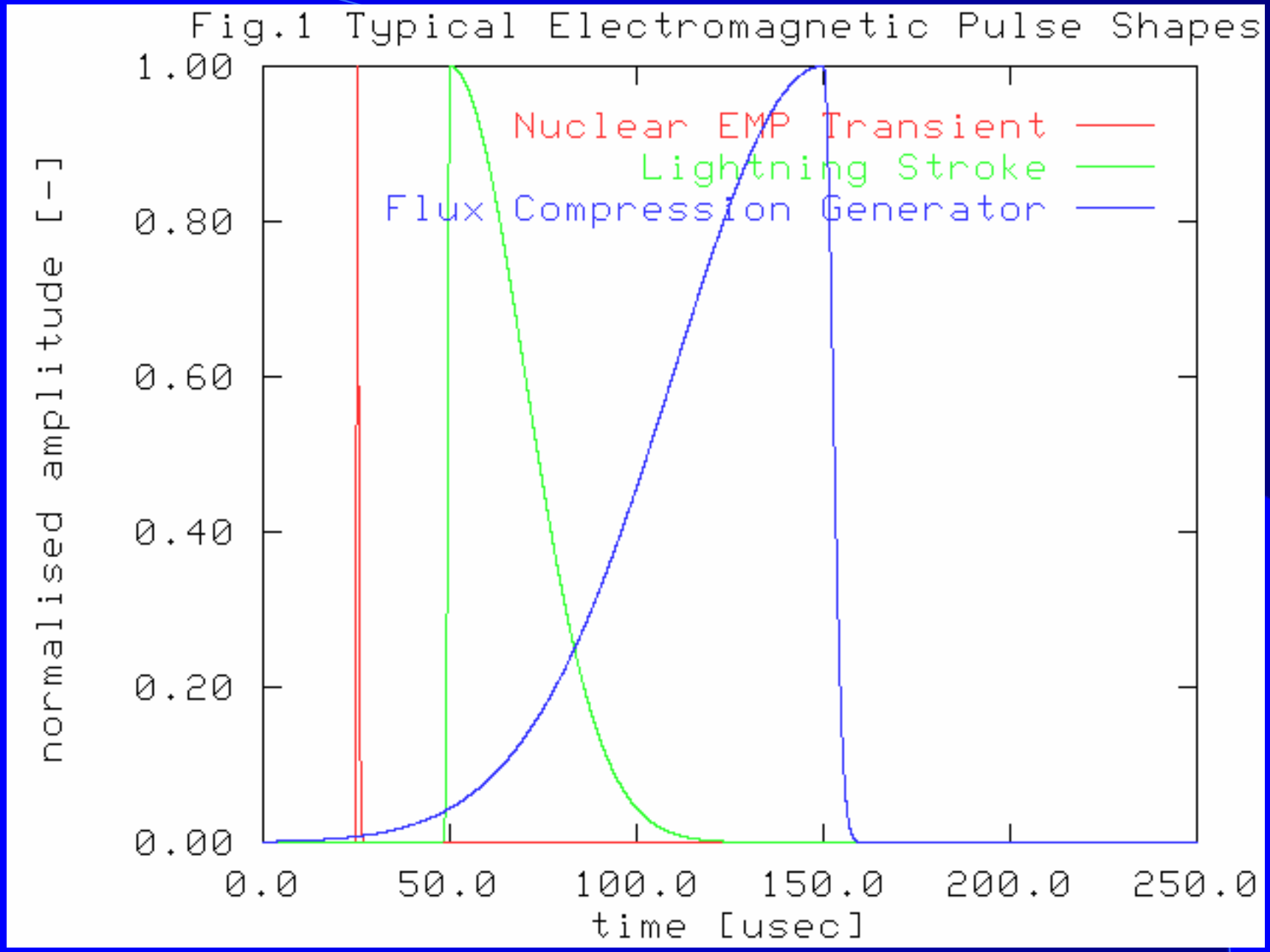


Fig.1 Typical Electromagnetic Pulse Shapes
Nuclear EMP Transient
Lightning Stroke
Flux Compression Generator
normalised amplitude [-]
1.00
0.80
0.60
0.40
0.20
0.00
0.0
50.0
100.0
150.0
200.0
250.0
time [usec]

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

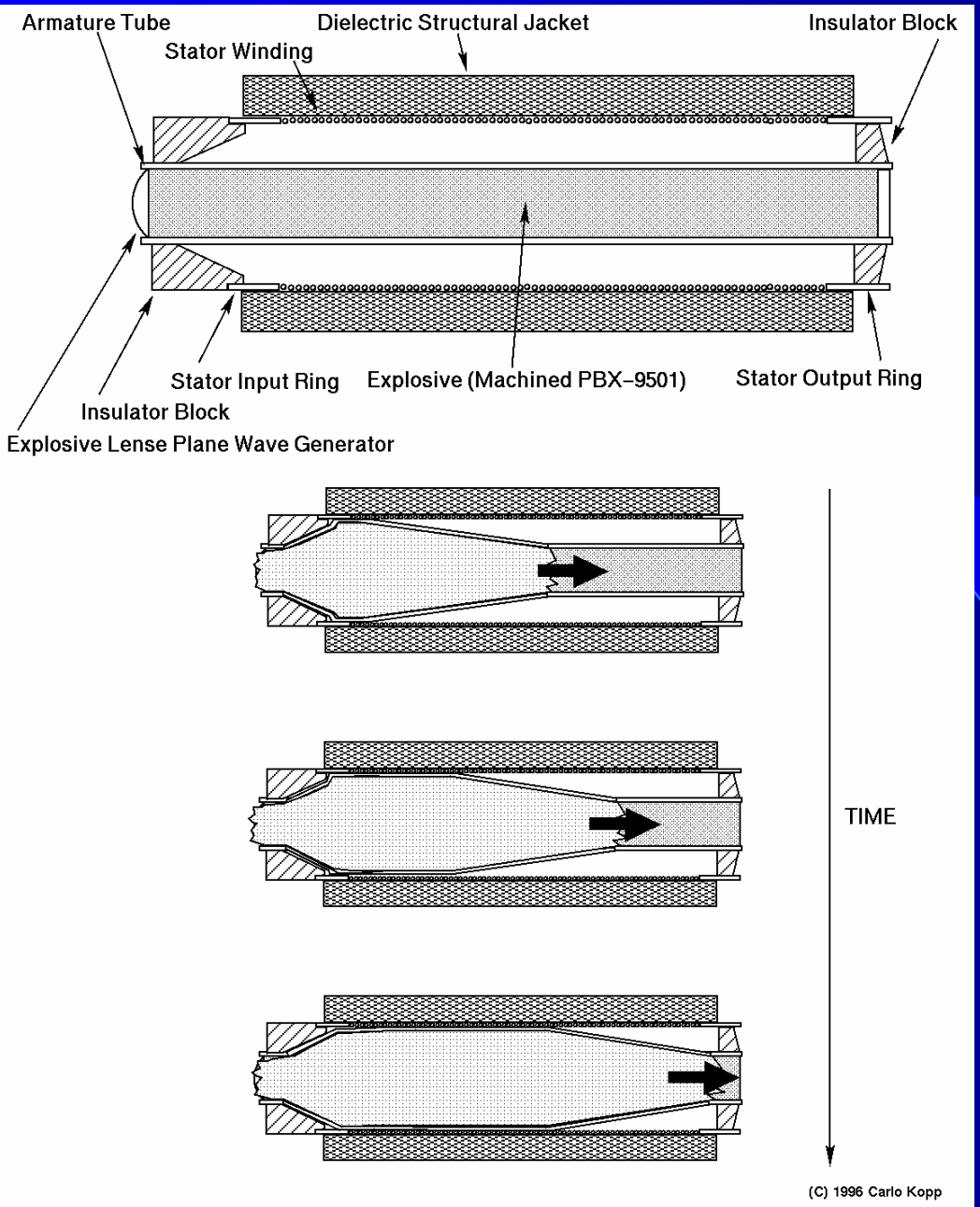


FIG.2 EXPLOSIVELY PUMPED COAXIAL FLUX COMPRESSION GENERATOR

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)

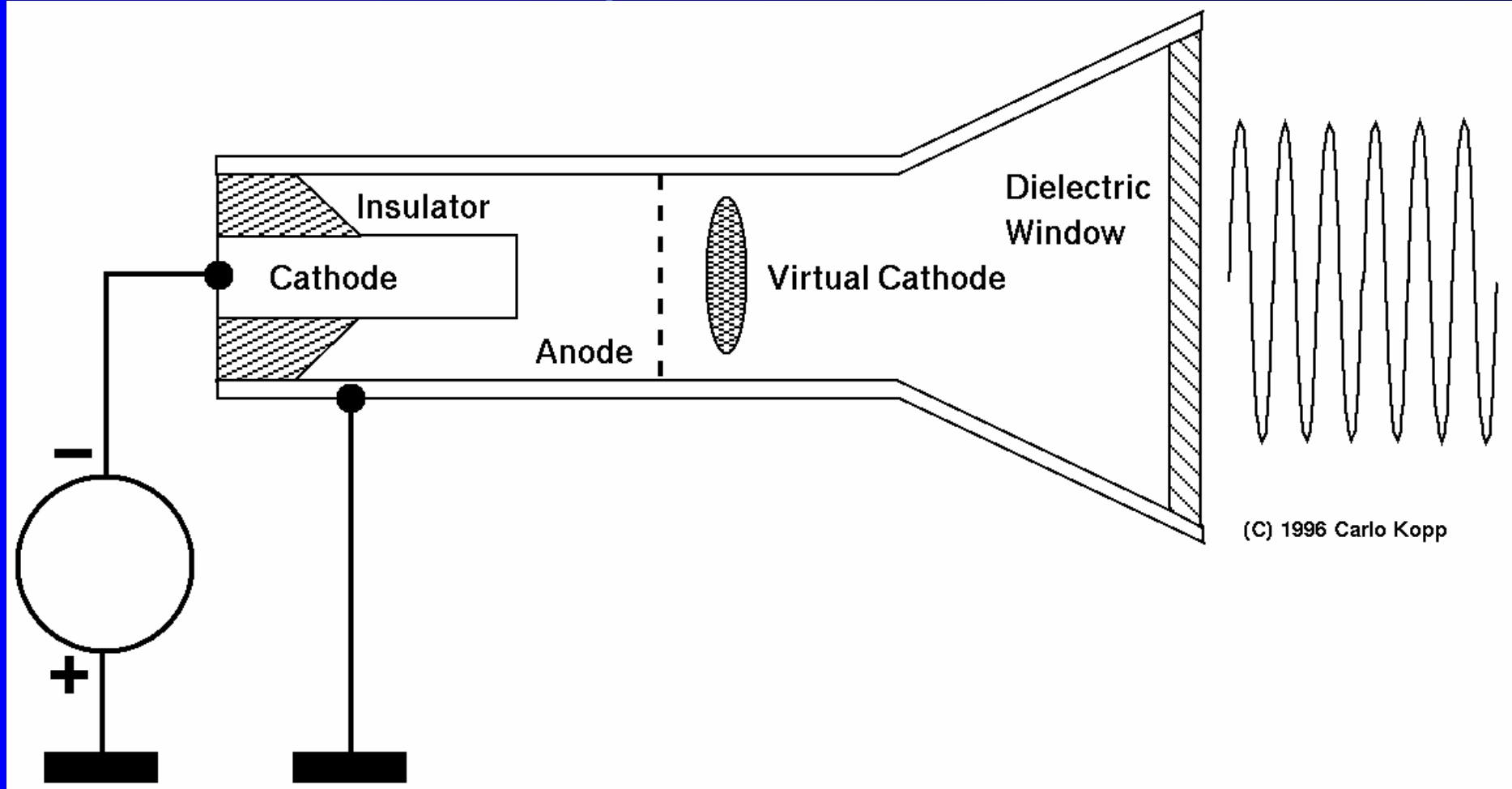


FIG.3 AXIAL VIRTUAL CATHODE OSCILLATOR

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

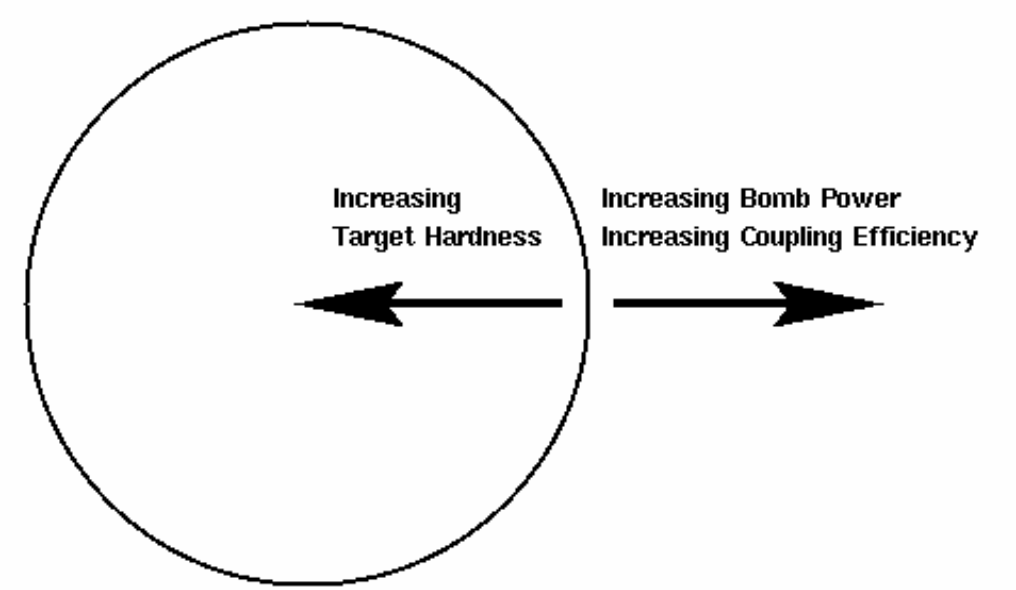


FIG.5.1 E-BOMB LETHAL RADIUS

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

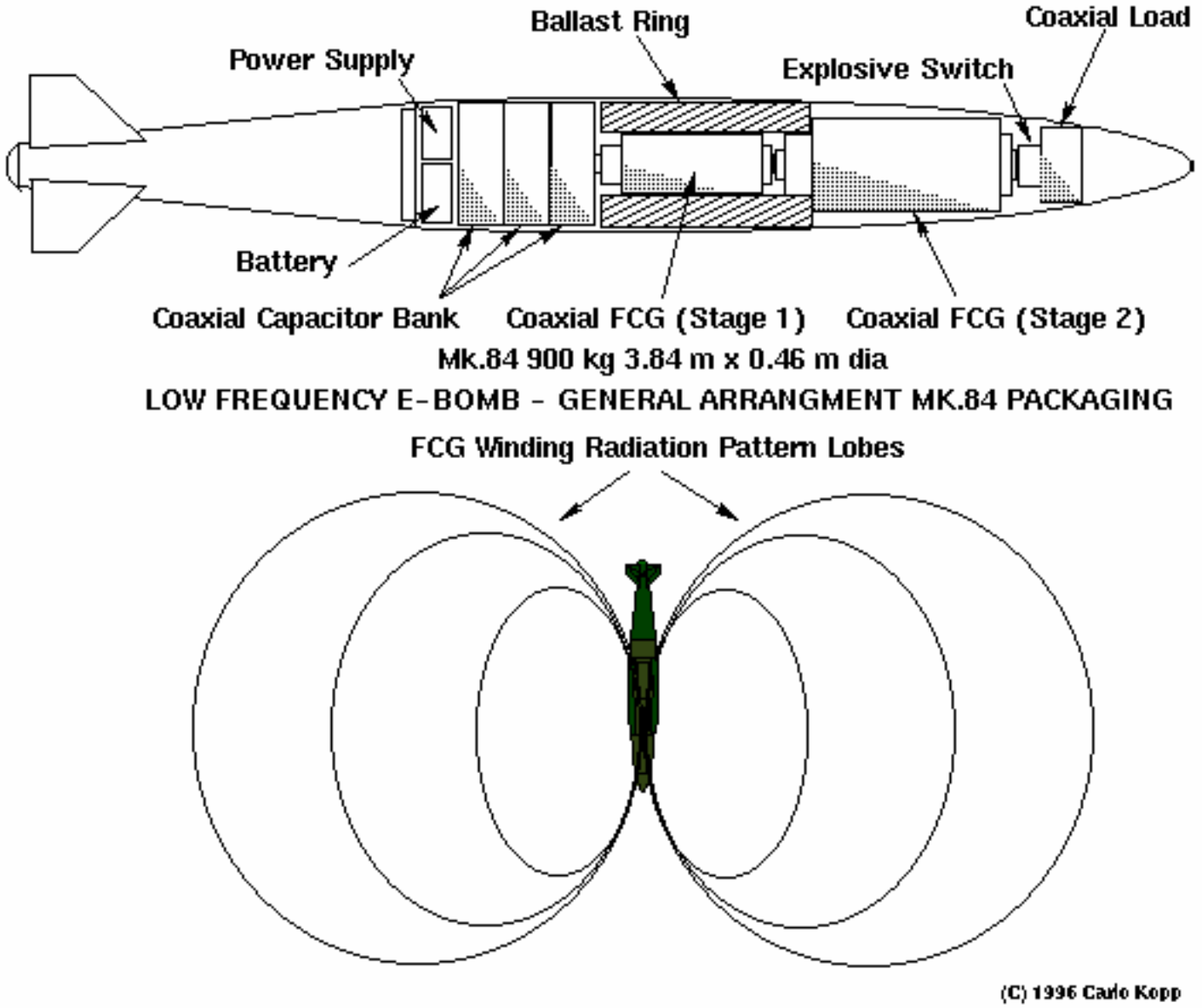


FIG.4 LOW FREQUENCY E-BOMB WARHEAD (MK.84 FORM FACTOR)

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

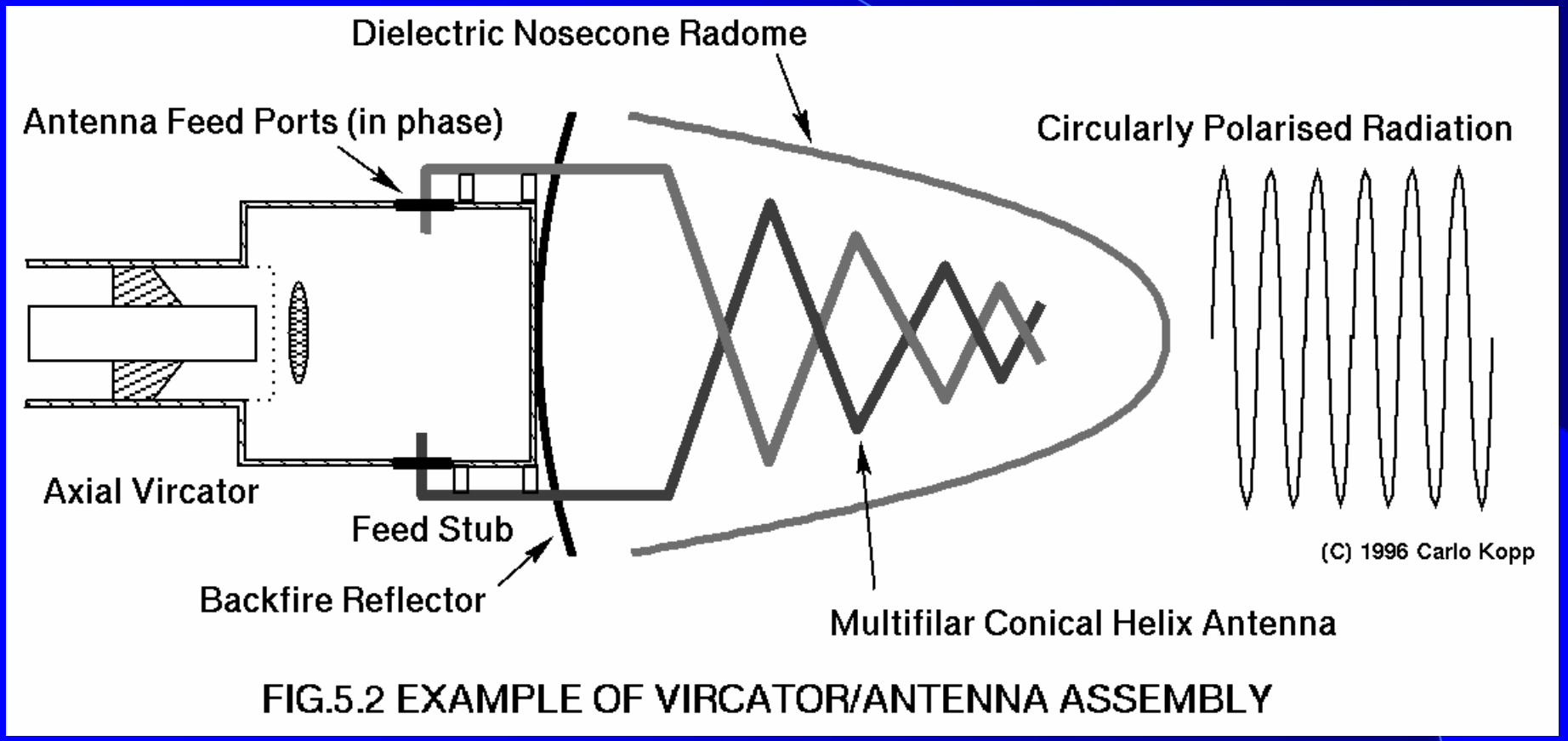
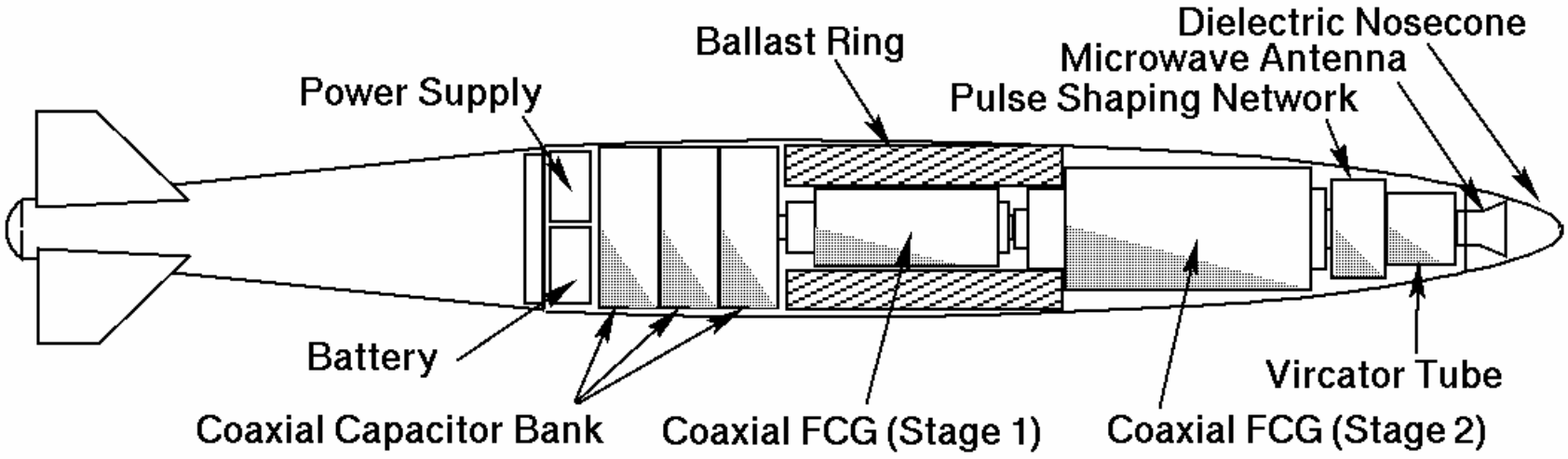


FIG.5.2 EXAMPLE OF VIRCATOR/ANTENNA ASSEMBLY



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

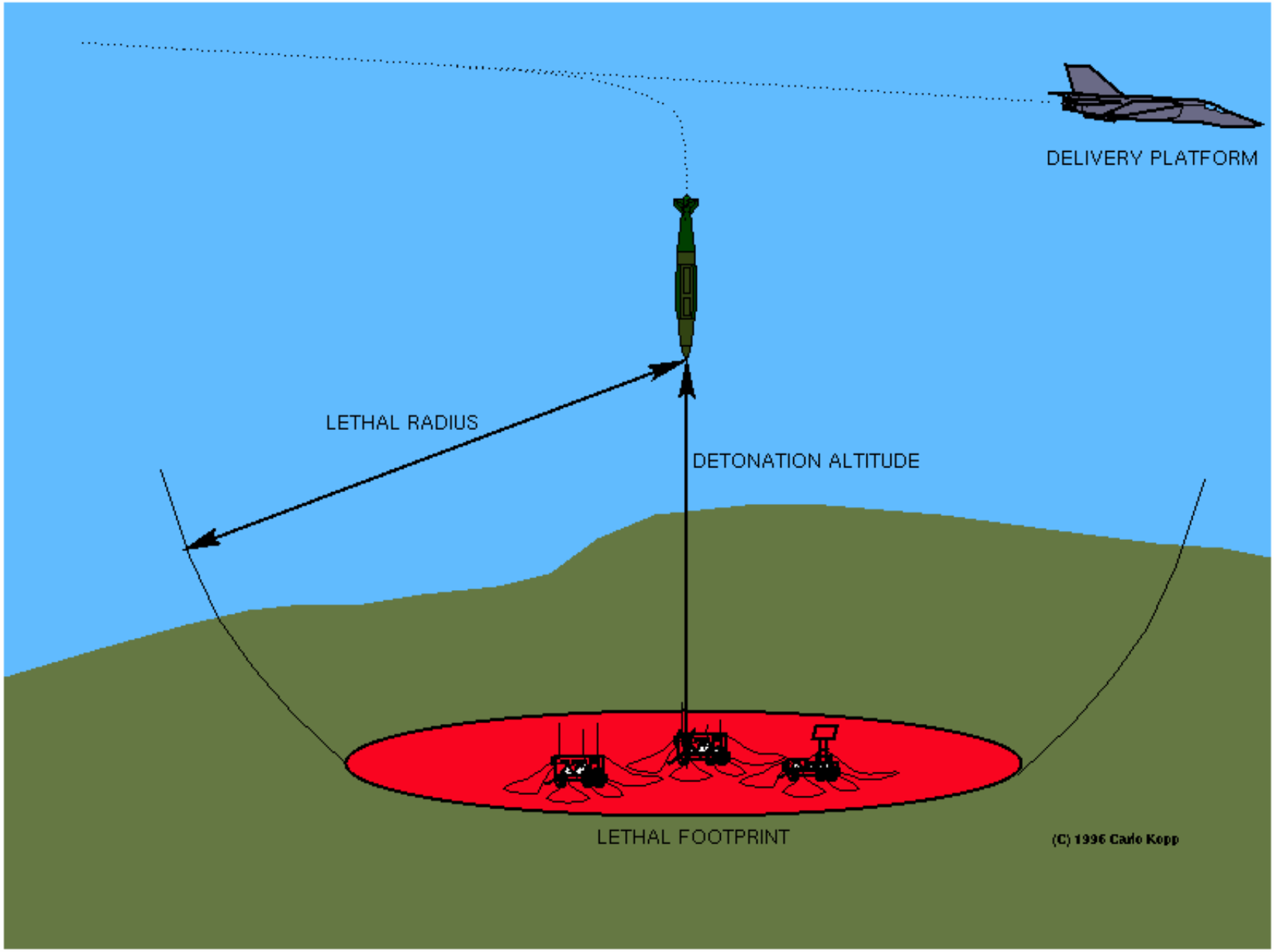


FIG.7 LETHAL FOOTPRINT OF LOW FREQUENCY E– BOMB IN RELATION TO ALTITUDE

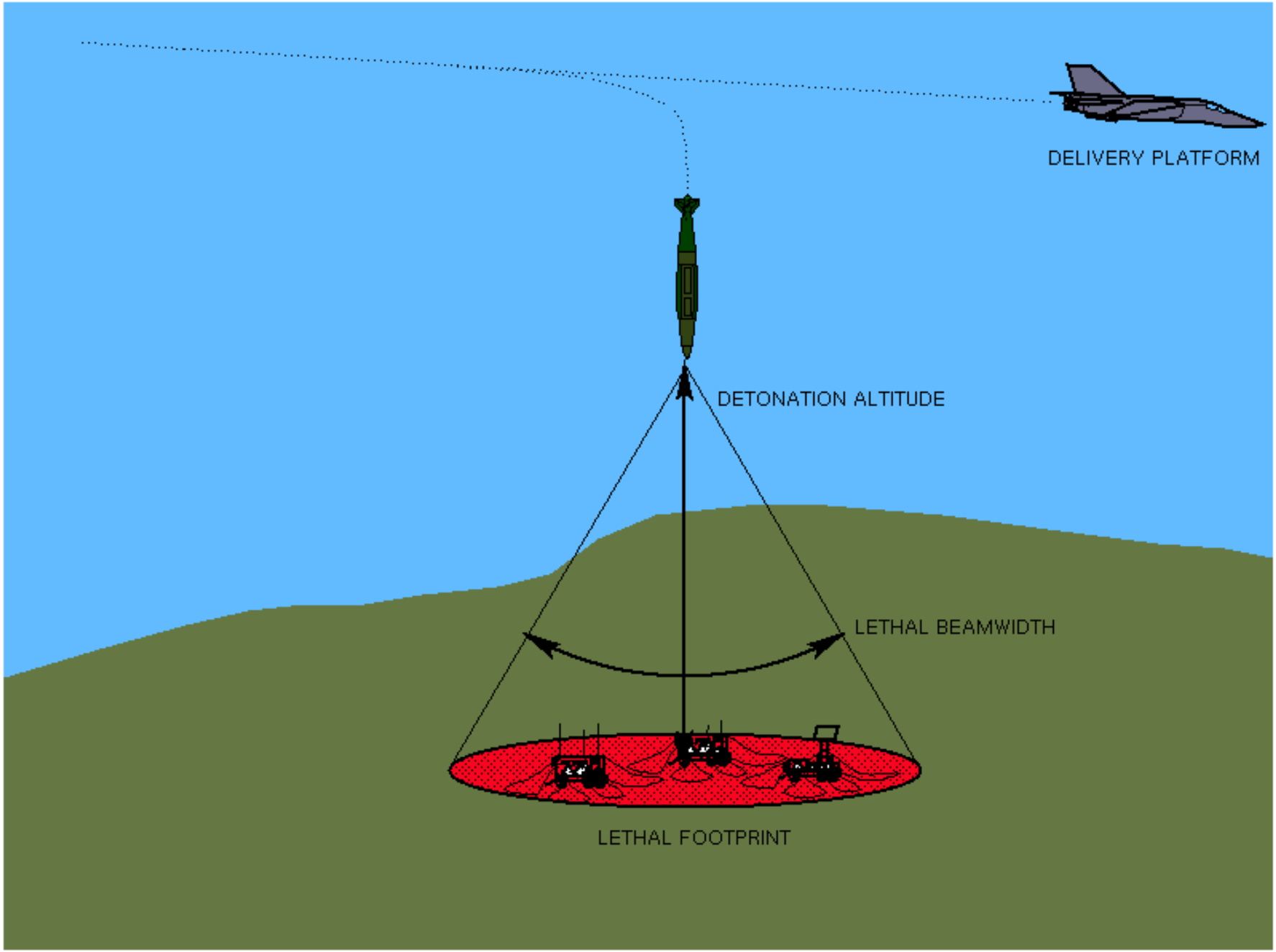
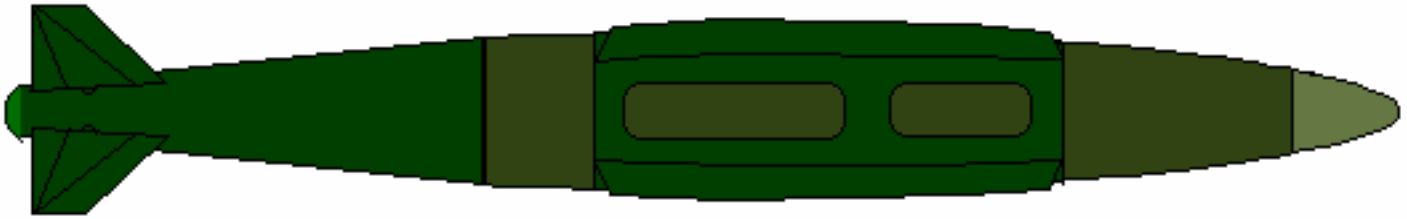


FIG.8 LETHAL FOOTPRINT OF A HPM E-BOMB IN RELATION TO ALTITUDE

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)

FIG.9 GPS GUIDED BOMB/GLIDEBOMB KITS

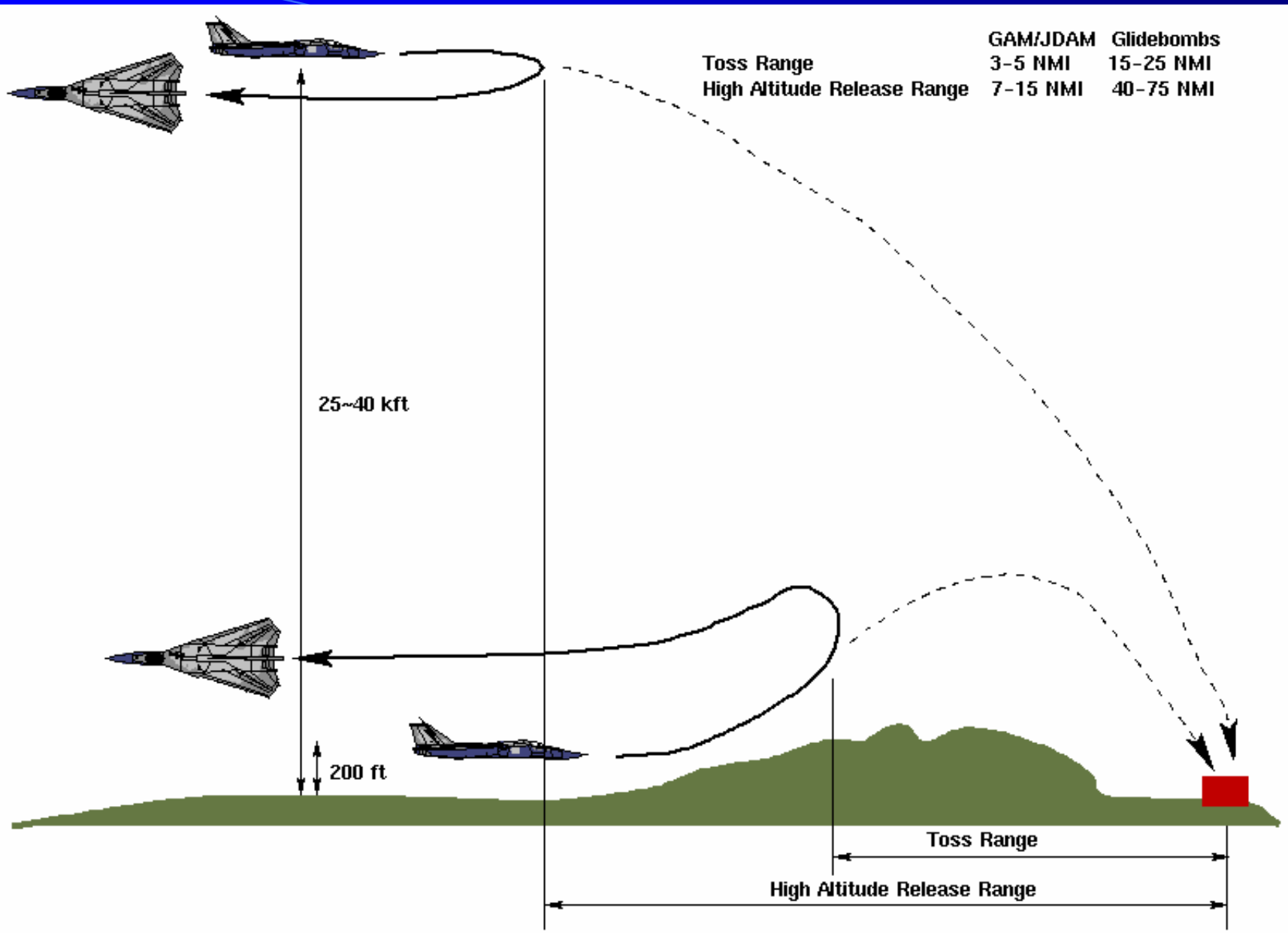


FIG.10 DELIVERY PROFILES FOR GPS/INERTIAL GUIDED WEAPONS

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

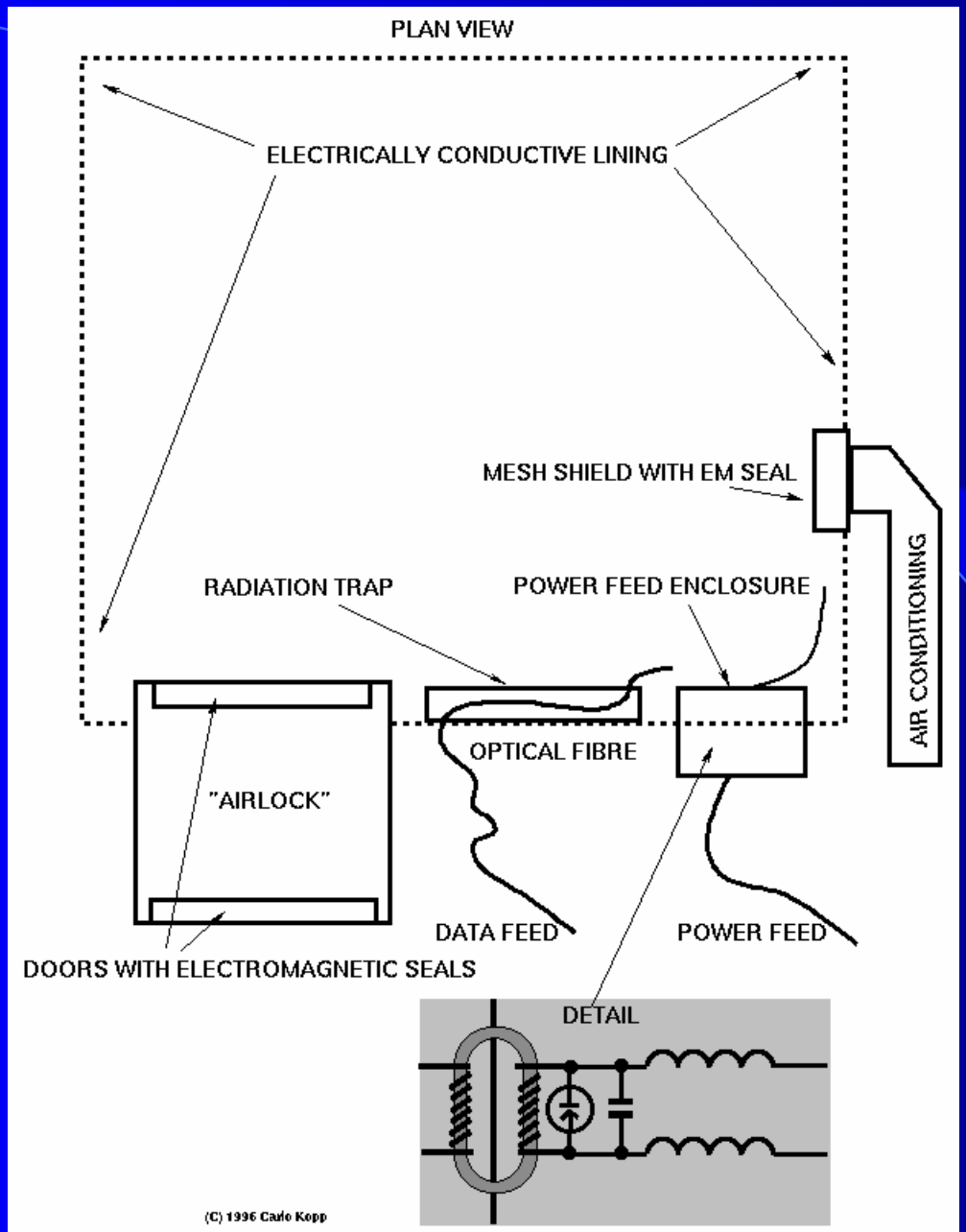


FIG.11 COMPUTER ROOM HARDENED AGAINST EM ATTACK

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

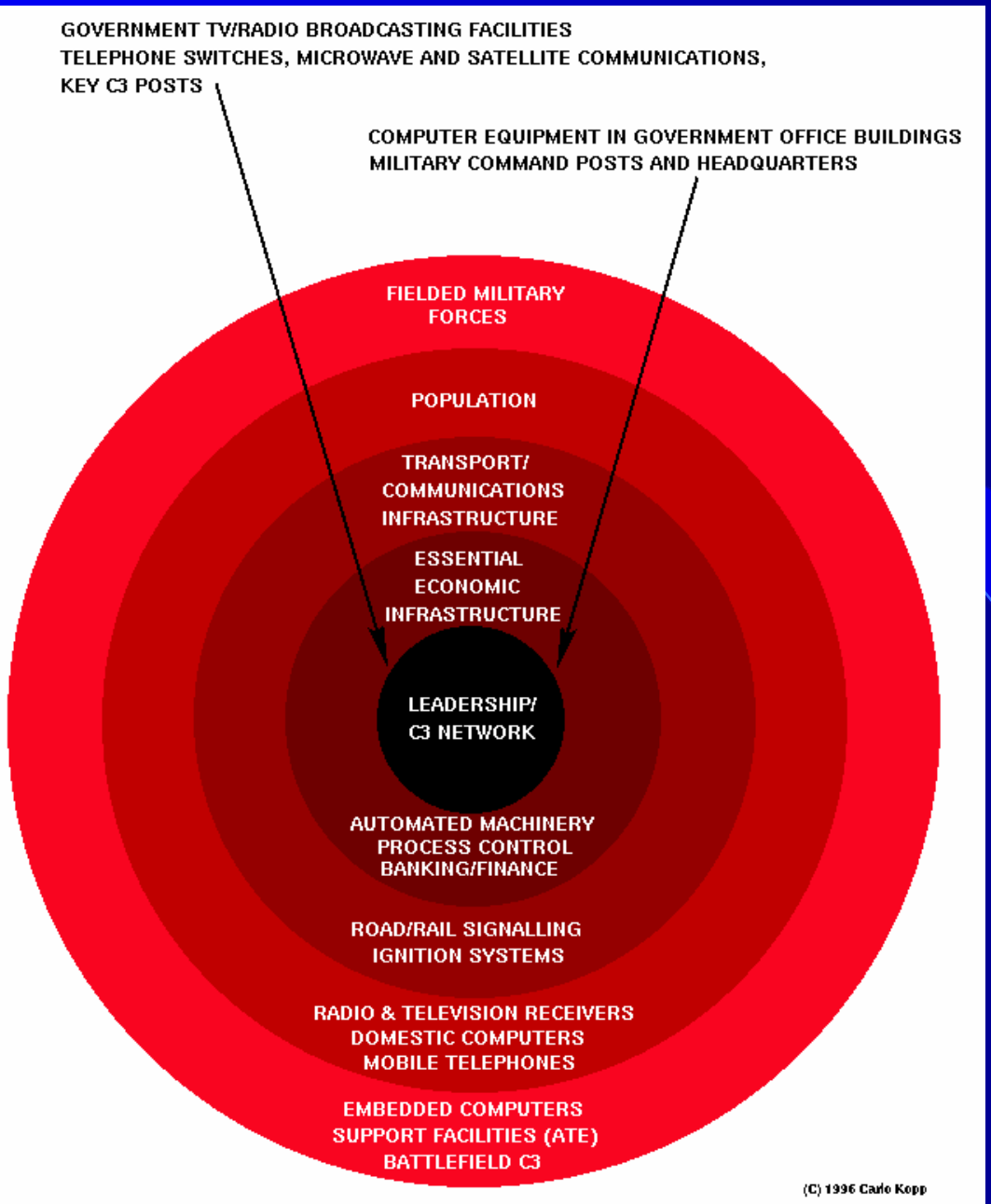


FIG.12 WARDEN'S "FIVE RINGS" STRATEGIC AIR ATTACK MODEL
IN THE CONTEXT OF ELECTROMAGNETICALLY VULNERABLE TARGET SETS

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