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SURVEY OF WEAPONS DEVELOPMENT AND TECHNOLOGY

WR708

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SESSION III

- NUCLEAR EFFECTS

CONVENTIONAL EXPLOSIVE

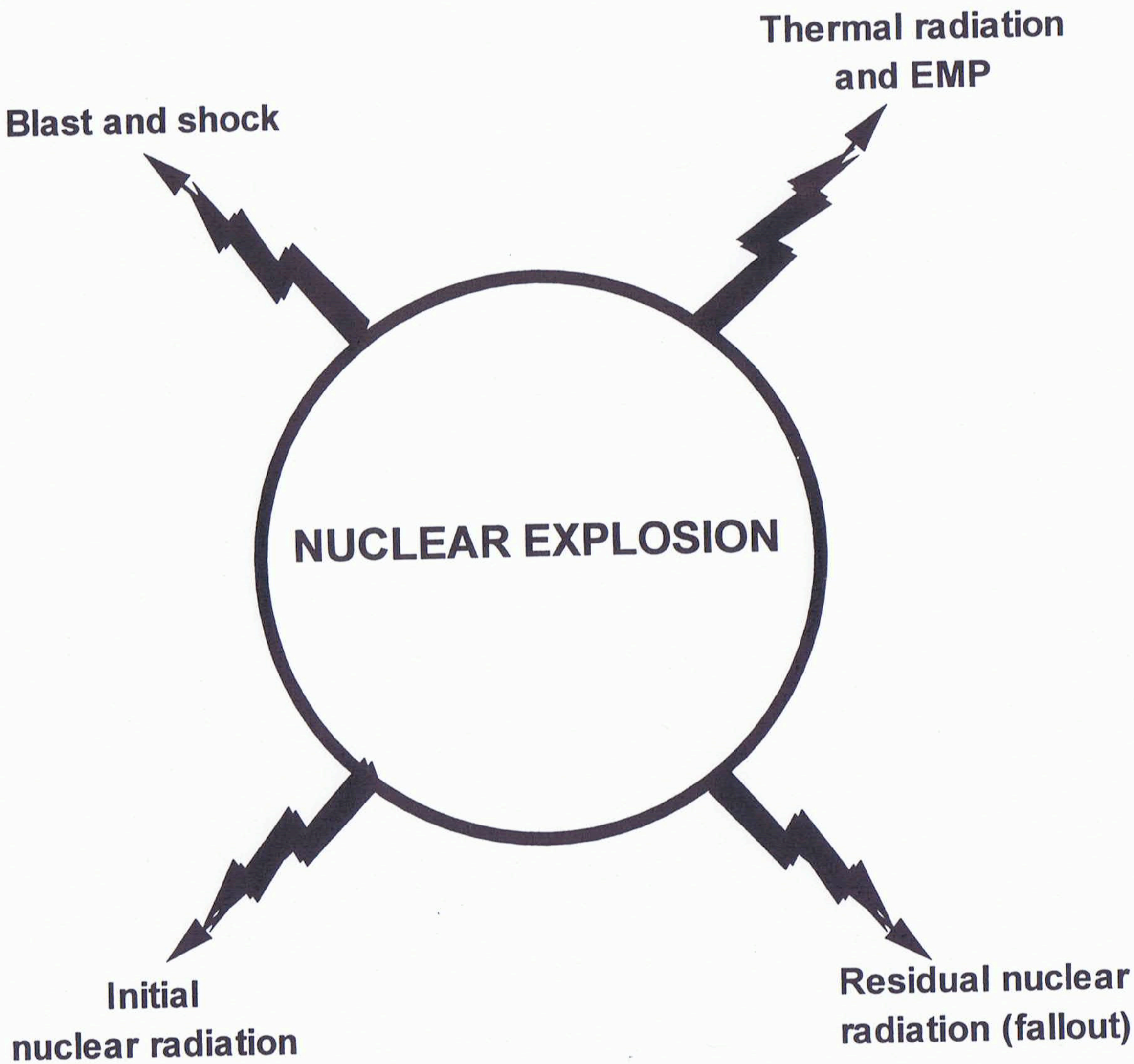
RELEASE OF ENERGY ARISES FROM THE BREAKING OF CHEMICAL BONDS (ELECTRON BONDS) IN THE HIGH EXPLOSIVE MATERIAL

NUCLEAR EXPLOSIVE

RELEASE OF ENERGY ARISES FROM THE BREAKING OR MAKING OF NUCLEAR BONDS (HADRON-HADRON)

FISSION AND FUSION YIELDS ENERGY RELEASE + PARTICLES

Effects of a Nuclear Explosion



Nuclear Effects Generalities

Subject Generally Divided into 3 areas

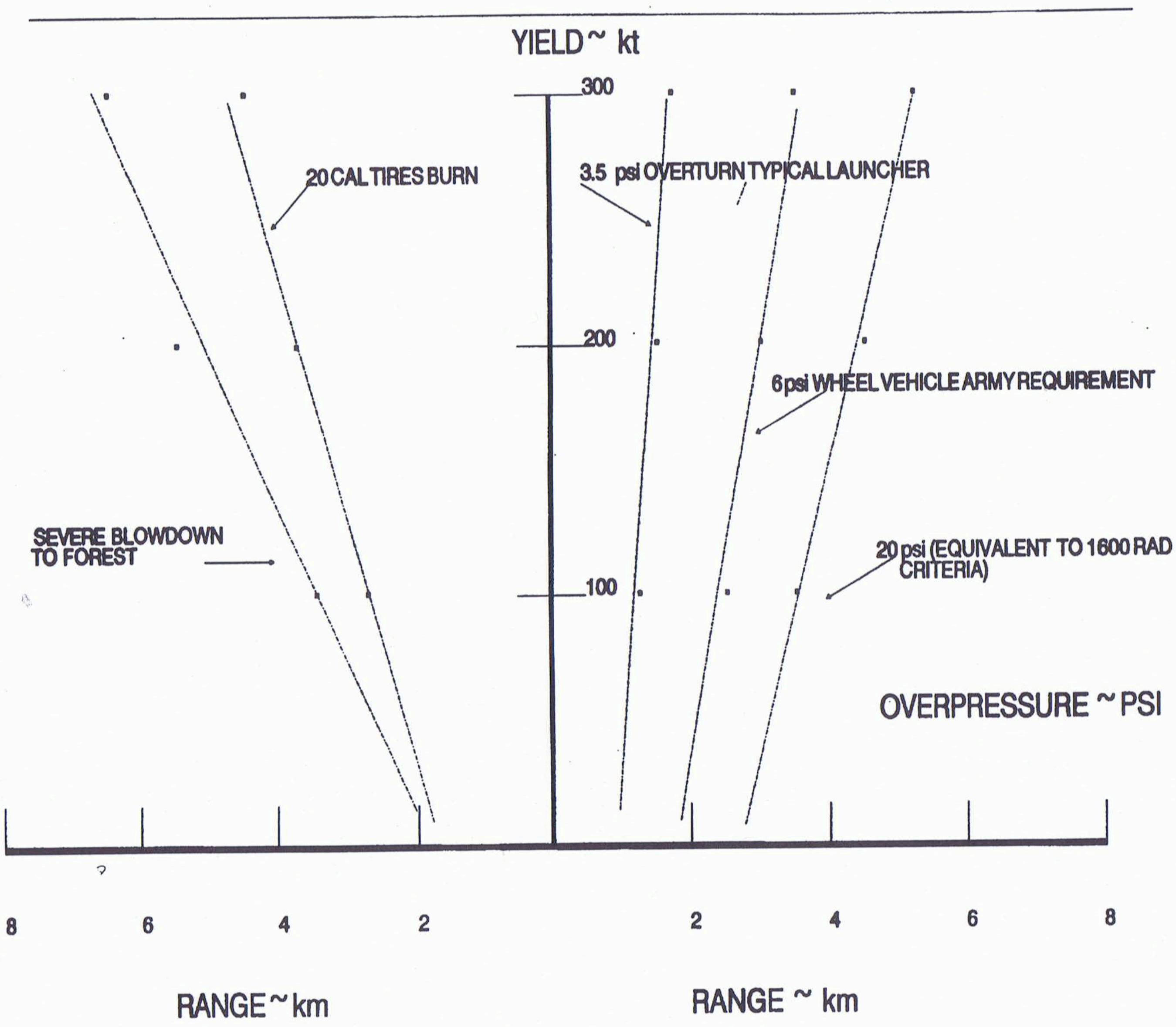
- Phenomenology
  - Physics at the weapons source
- Interaction of the nuclear
- Military effects
  - Smashing (over pressure)
  - Turning over (dynamic - winds)
  - Fires (Thermal pulse)
  - Radiation
  - Craters

What are Nuclear Effects Calculations Used For?

- Determine how "hard" (radiation, blast, etc.) to make the weapon system (major cost implication)
- Determine the proper yield/accuracy combination
- Placement of weapon system on the battlefield
- Targeting
- Number of nuclear weapons required to achieve an objective
- Safety zones
- Etc.

- Historically, this is an area that has caused much discussion and argument. However, over the years, DNA has developed tools to standardize the methodology and has contributed greatly to the understanding of this area.
  - Textbooks
  - Nomograms/Slide Rules
  - T159 - Programs
  - HP 41 CX - Programs
  - Personal Computer Software

NUCLEAR SEPARATION DISTANCE



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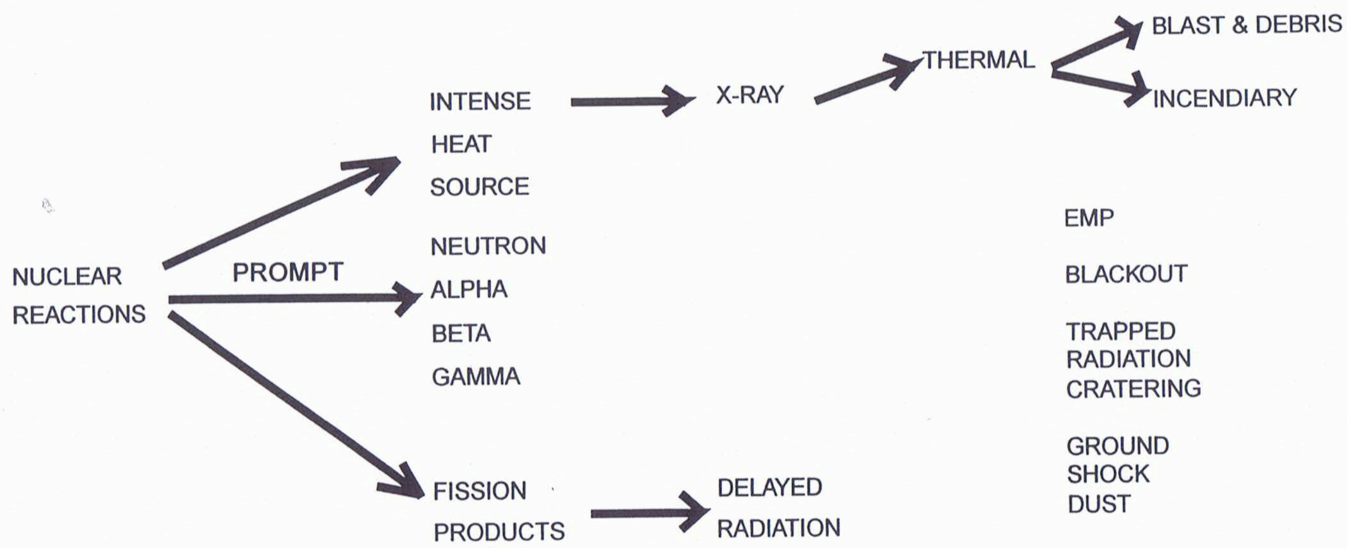
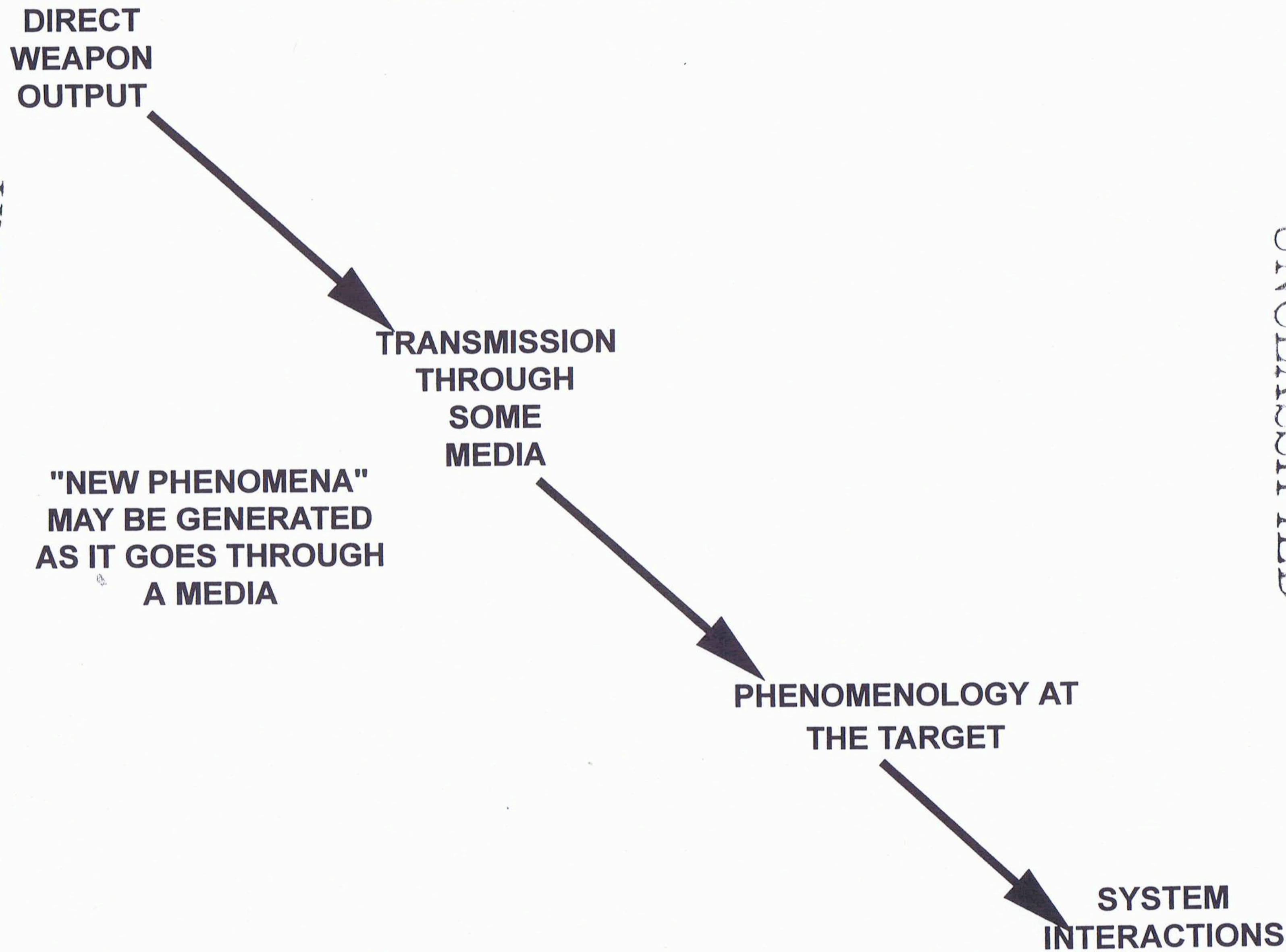
CONVENTIONAL WEAPON

NUCLEAR WEAPON



Nuclear Effects



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THE NUCLEAR PHENOMENOLOGY EXPERIENCED BY A SYSTEM DEPENDS ON:

- YIELD OF WEAPON
- DESIGN OF WEAPON
- WHERE WEAPON WAS DETONATED
- WHERE SYSTEM IS
- FOR SOME EFFECTS, WHAT SYSTEM IS DOING

NEUTRONS COME DIRECTLY FROM

Fission

N + fissionable material ► two or more fission fragments + neutrons + energy

And

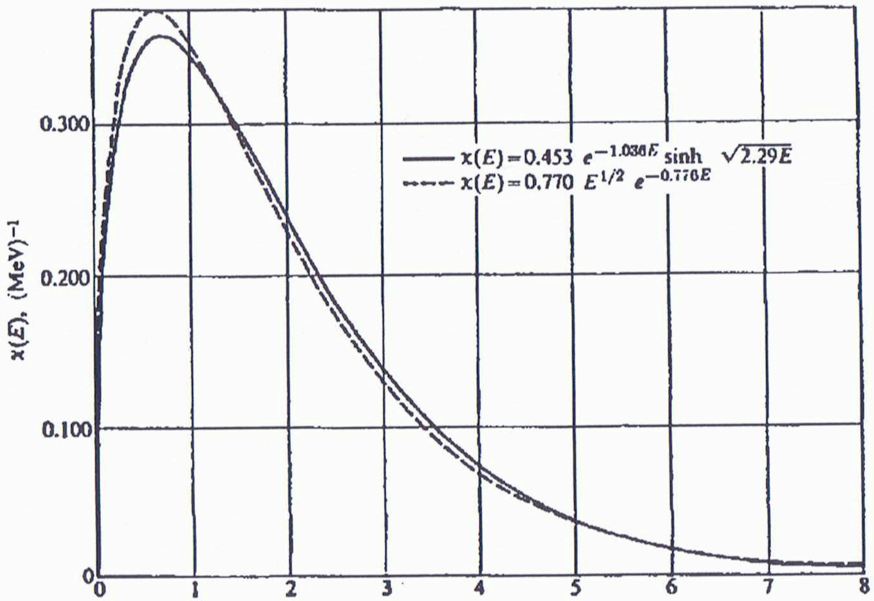
Fusion

D + T ► H_e^4 + neutron + energy

T + T ► H_e^4 + 2 neutrons + energy

D + D ► H_e^3 + neutron + energy

Fission Neutron Energy Spectrum



Neutron Energy (MeV)

Reference: Lamarsh, 1966

Neutron Spectra

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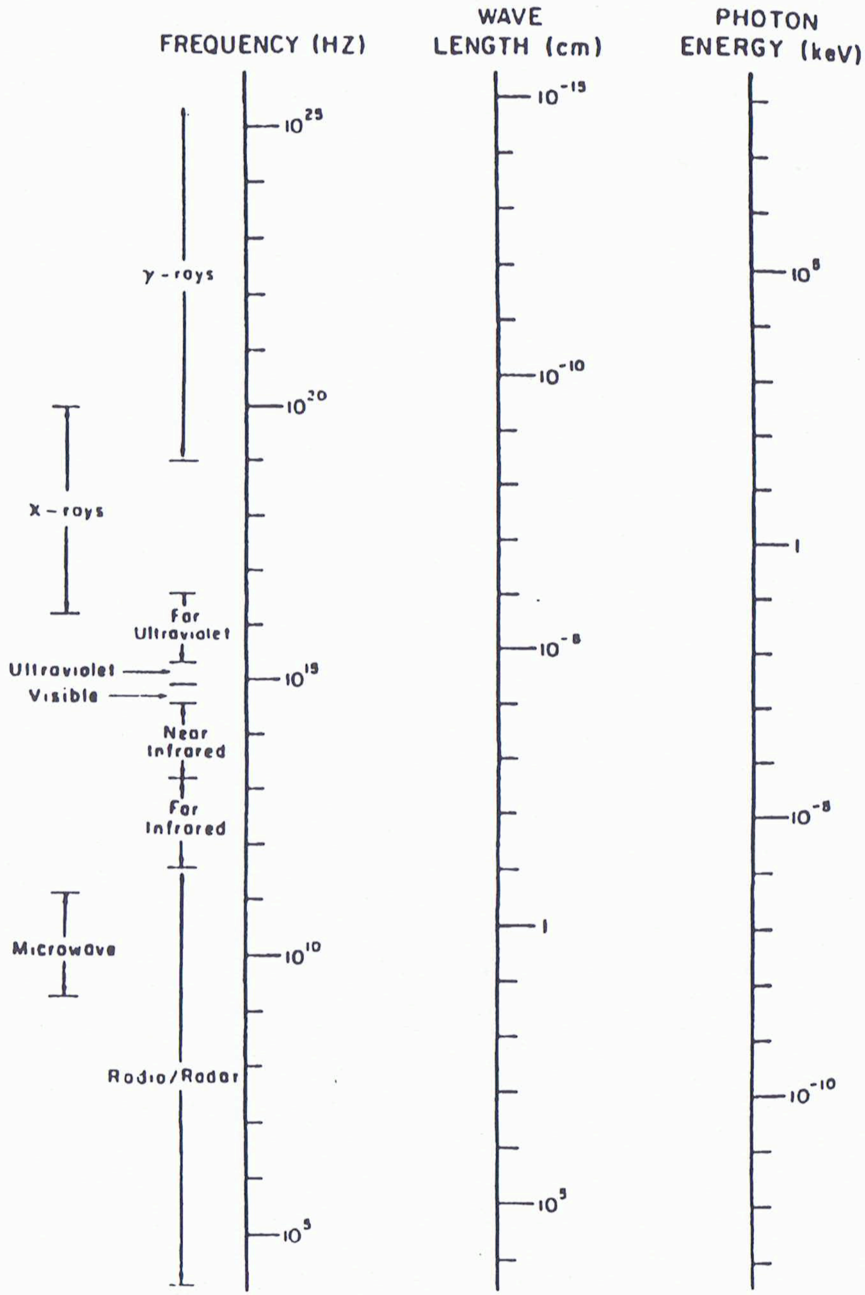

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GAMMA RAYS

ELECTROMAGNETIC RADIATION

SOURCE:

- DETONATION FISSIONS

EARLY

- NEUTRON INELASTIC SCATTER IN WEAPON DEBRIS
- NEUTRON INELASTIC SCATTER IN THE AIR AND GROUND

LATER

- CAPTURE OF SLOW NEUTRONS BY NITROGEN
- FISSION PRODUCT DECAY

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BLAST AND THERMAL

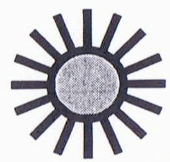
IT'S HOT, HOT,----
SO IT RADIATES HEAT

THERE'S HIGH, HIGH, HIGH PRESSURE----
SO IT TRANSMITS A PRESSURE PULSE

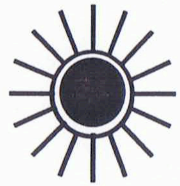
SEQUENCE OF EVENTS AFTER A NUCLEAR DETONATION IN THE ATMOSPHERE

1. ONCE UPON A TIME THERE WAS A NUCLEAR WEAPON--NOW THERE'S THIS 10 MILLION PLUS DEGREE BLOB OF VAPORIZED MATERIAL OCCUPYING ROUGHLY THE SAME VOLUME (78% OF ENERGY IS IN X-RAY).

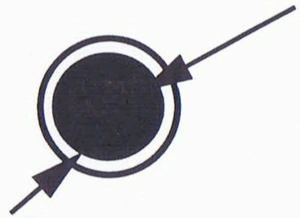
2. THIS VOLUME RADIATES ELECTROMAGNETIC ENERGY IN THE X-RAY SPECTRUM.



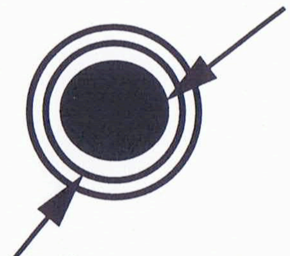
3. THE MEAN FREEPATH OF "X-RAYS" IS .3 cm AT SEALEVEL. THE SURROUNDING LAYER OF AIR IS SUPERHEATED. <u>INITIAL X-RAY FIREBALL</u>



4. THIS ABSORPTION AND RERADIATING PROCESS RESULTS IN A RAPIDLY EXPANDING RADIATION FIREBALL. <u>RADIATION GROWTH PHASE.</u>



5. THE WEAPON DEBRIS SNOWPLOWS AIR AND A "NUCLEAR SHOCK" IS FORMED. RADIATION FIREBALL CONTINUES TO GROW, BUT GROWTH SLOWS BECAUSE COOLING REDUCES MFP.



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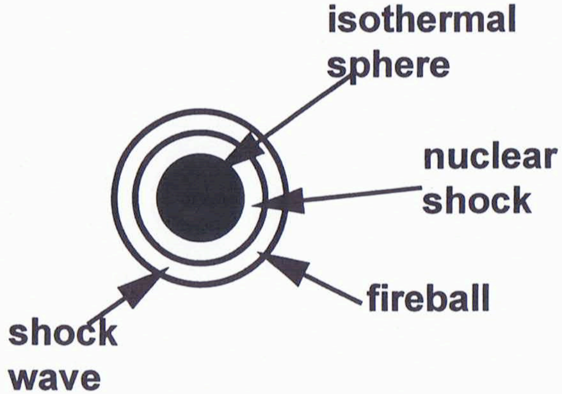
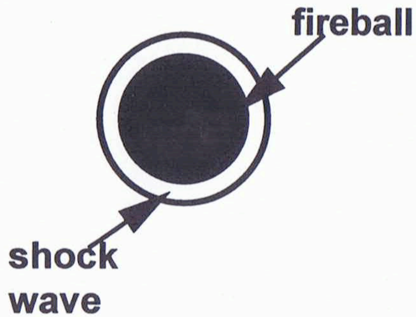
6. [redacted] SHOCKWAVE ASSOCIATED WITH THE FRONT BECOMES DOMINANT. NUCLEAR SHOCK STARTS TO "CATCH-UP." <u>HYDRODYNAMIC SEPARATION</u>

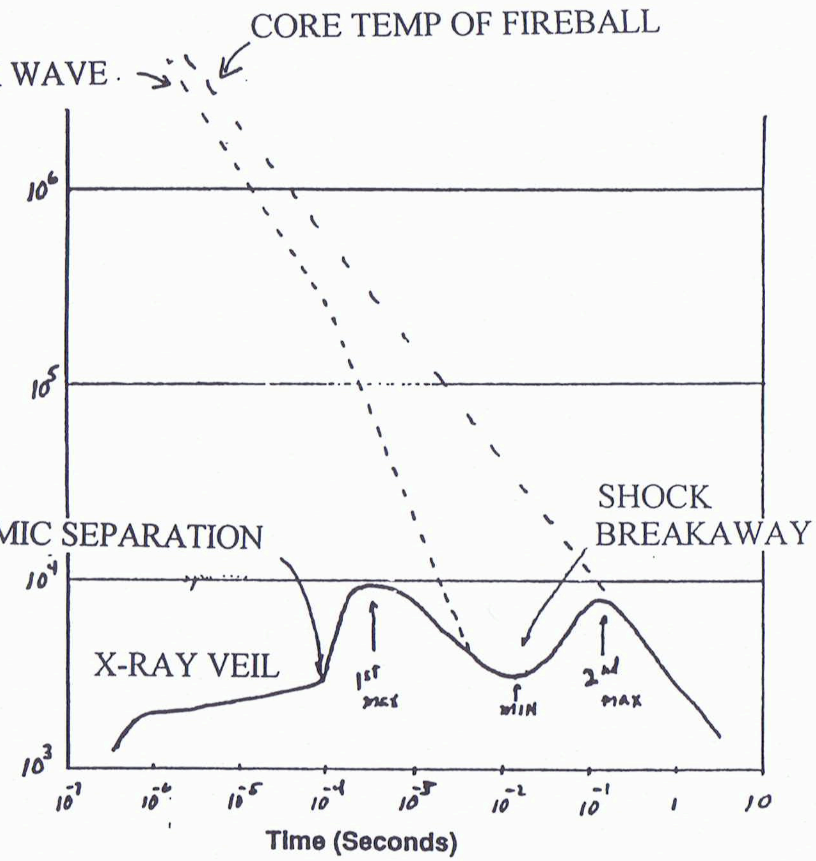


7. NUCLEAR SHOCK CATCHES UP, BUT REINFORCED SHOCKWAVE COOLS TO 3,000 DEGREES CELSIUS AND STARTS TO BECOME TRANSPARENT. <u>SHOCK BREAKAWAY.</u>



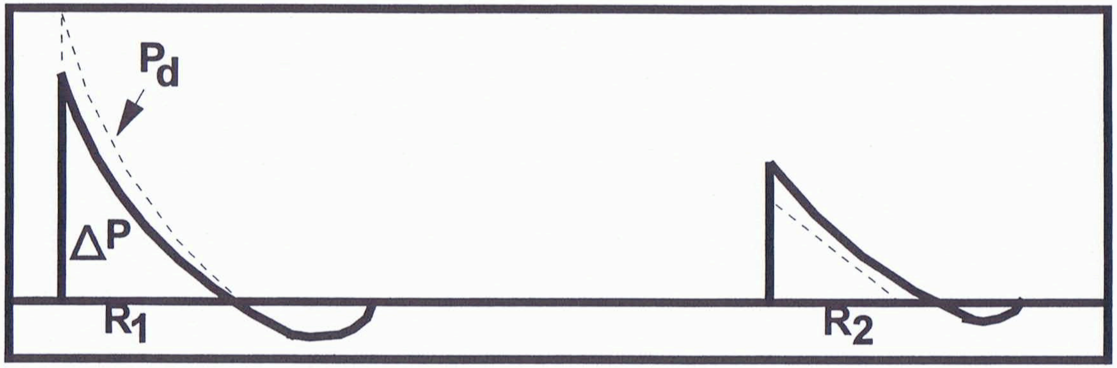
8. NO FURTHER INTERACTION BETWEEN EXPANDING SHOCKWAVE AND FIREBALL.

THERMAL Observed Thermal Pulse



USE: FROM A KNOWLEDGE OF SHOCK BREAKAWAY AND A BANG METER (DISTANCE TRAVELED/TIME) THE YIELD CAN BE DETERMINED

BLAST



$R_2 > R_1$

OVERPRESSURE $\Delta P = P - P_o$

DYNAMIC (GUST) $P_d = 1/2\ MV^2$

TIME DEPENDENCE

$P_d > \Delta P$ ($\Delta P > 100$ PSI)

$P_d < \Delta P$ ($\Delta P < 100$ PSI)

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AWAY FROM SOURCE AIRBLAST

SCALABLE PHENOMENA — SACH'S SCALING $\left[\frac{D_1}{D_0}\right] = \left[\frac{W_1}{W_0}\right]^{1/3}$

BASIS IS COMPLETE DATA FOR 1 CASE EX: 1 kT STANDARD

FOR ALTITUDES OTHER THAN SEA LEVEL $\left[\frac{D_1}{D_0}\right] = \left[\frac{W_1}{W_0}\right]^{1/3}\left[\frac{P_0}{P}\right]^{1/3}$

OTHER IMPORTANT ASPECTS:

MACHSTEM AND TRIPLE POINT PATH
OPTIMAL HOB FOR MAXIMIZING OVERPRESSURE
PRECURSOR

WILL BE COVERED LATER AND IN THE EFFECTS MOVIE

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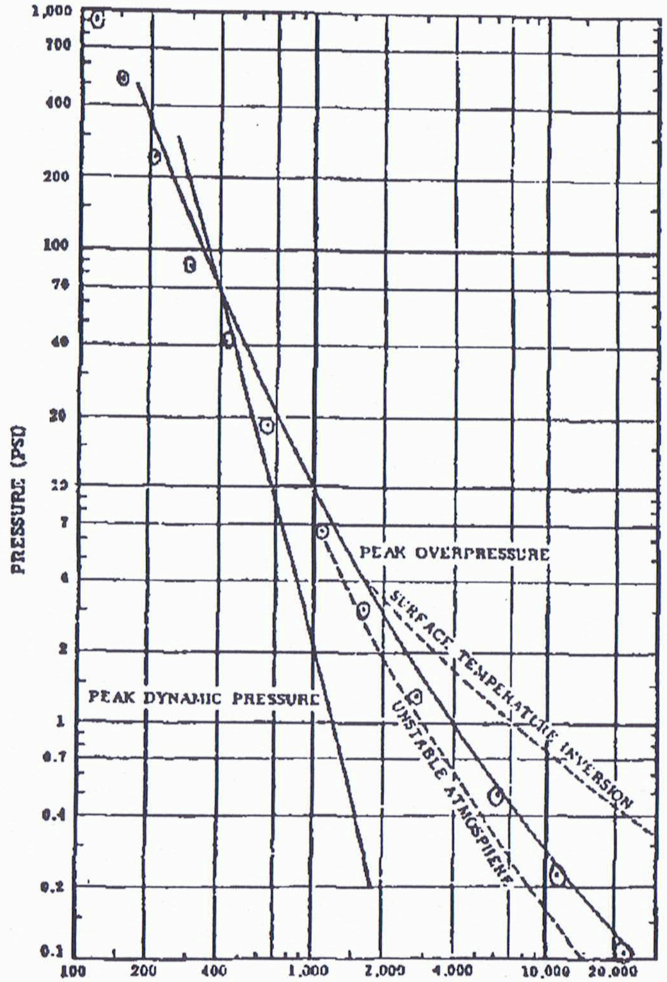
⊙ = Data from AFWL - TR 73-75



Distance from Ground Zero (feet)
1 Kiloton Standard (from Glasstone)

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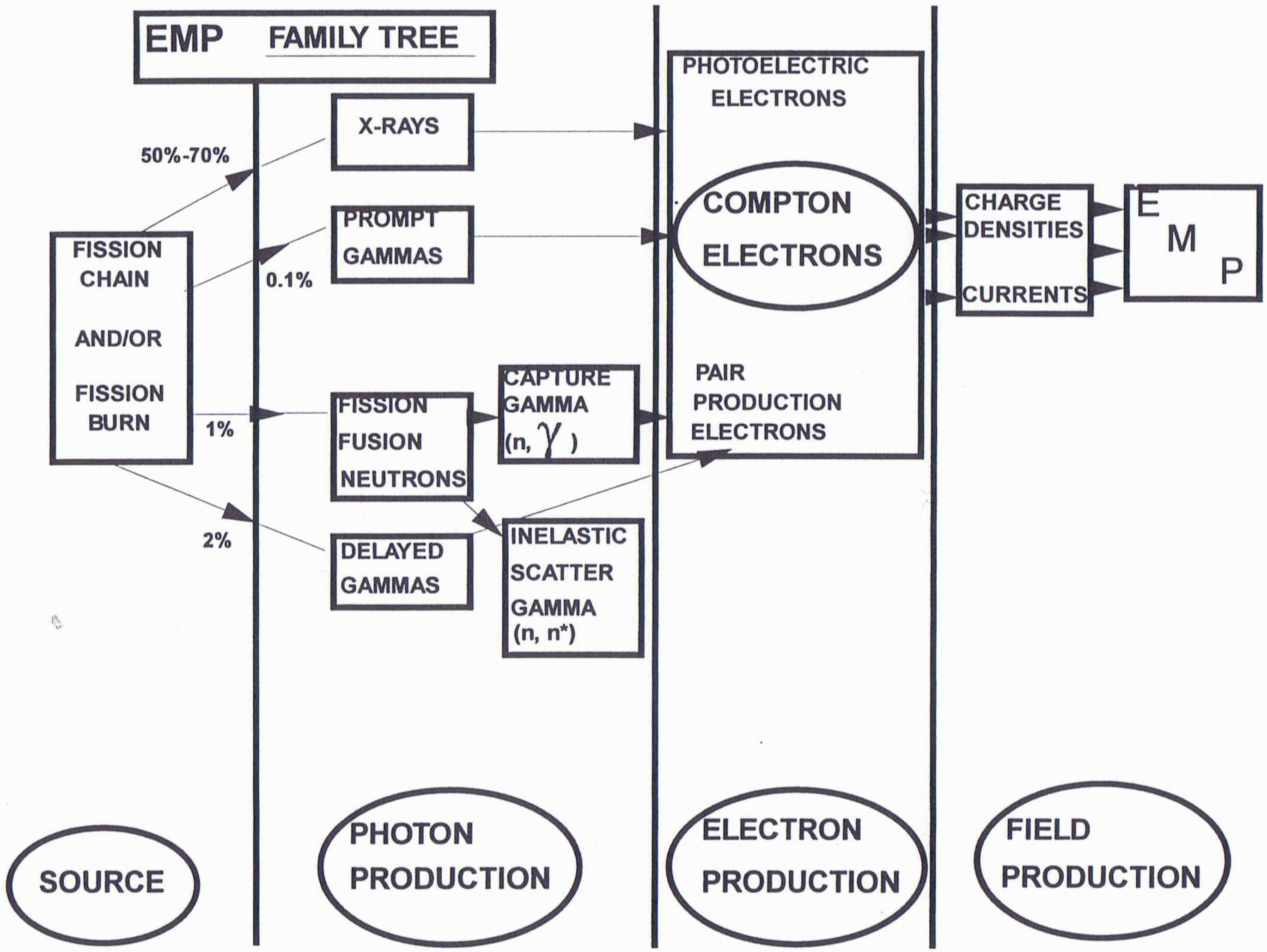

Bottom Line: electron moves in assymetric field

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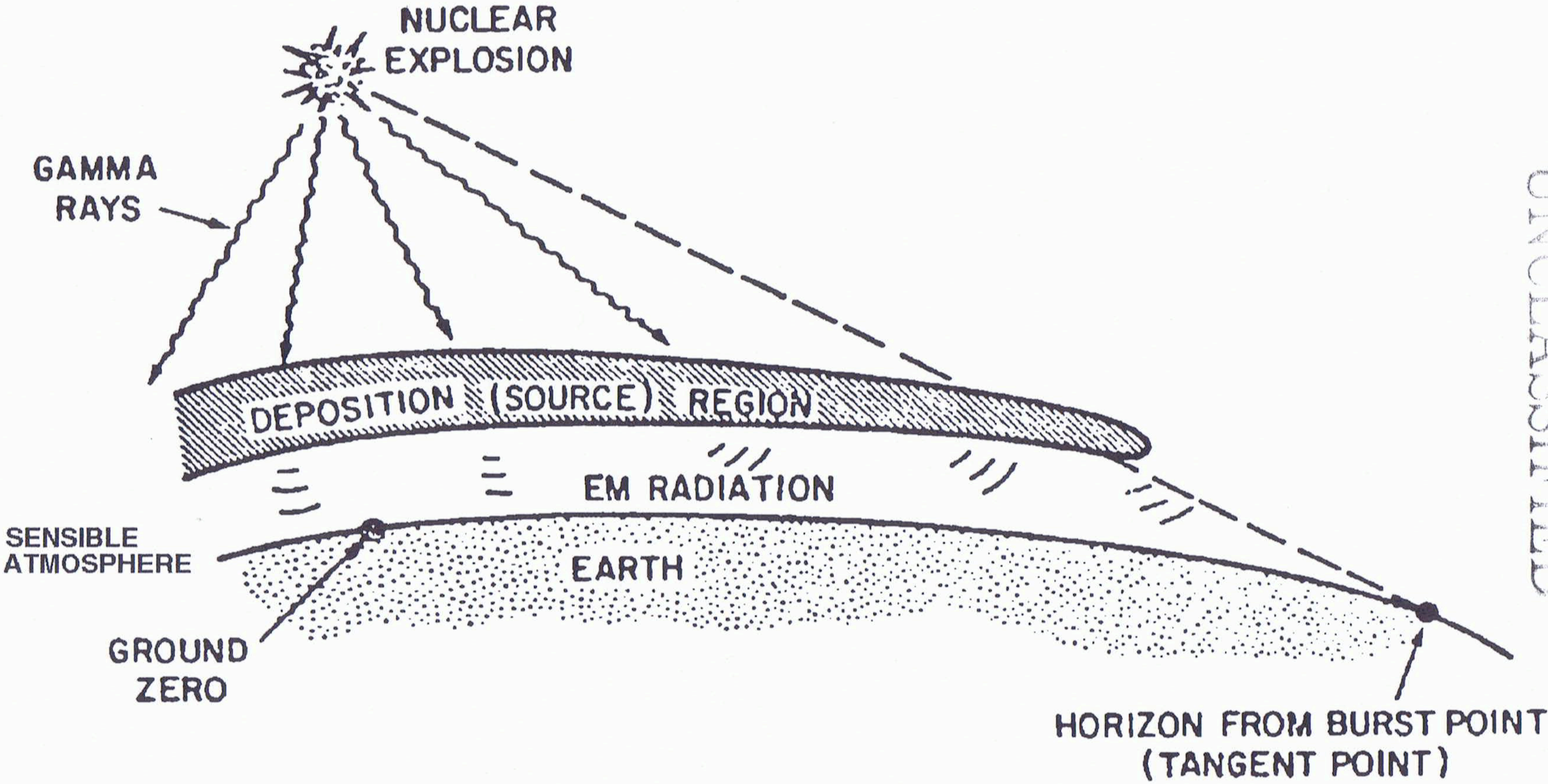
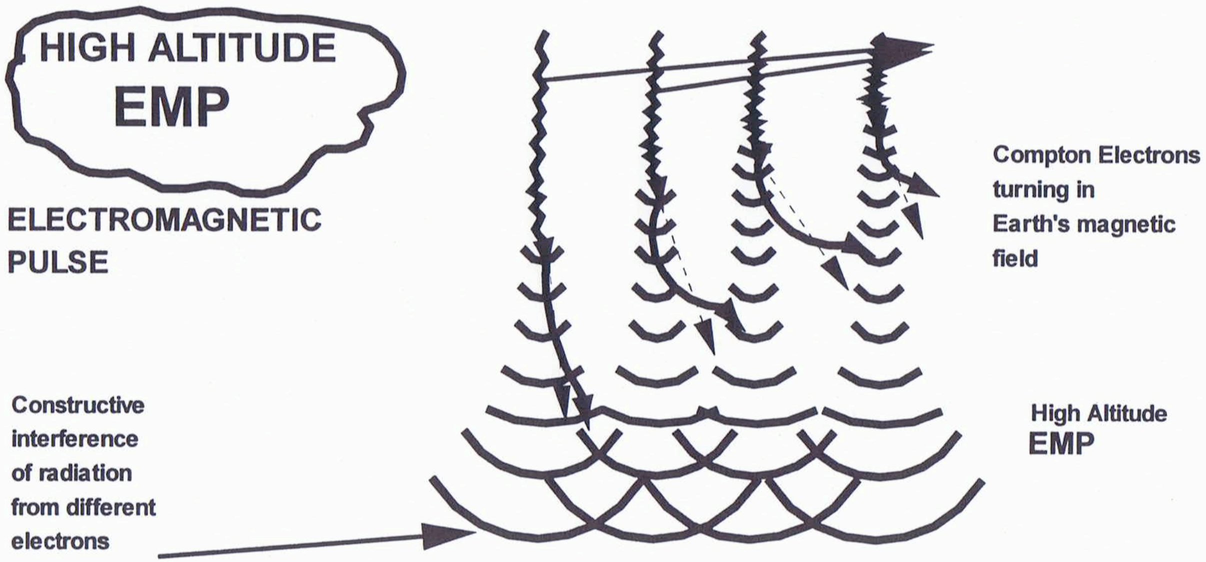
High Altitude EMP





KEY Points

1. Each γ gives a downward traveling compton electron.
2. The electrons are turned by the earth's magnetic field.
3. The relativistic electrons radiate energy downward.
4. The γ 's and EMP radiation travel at the same speed.
   This leads to constructive interference of radiation from all electrons.

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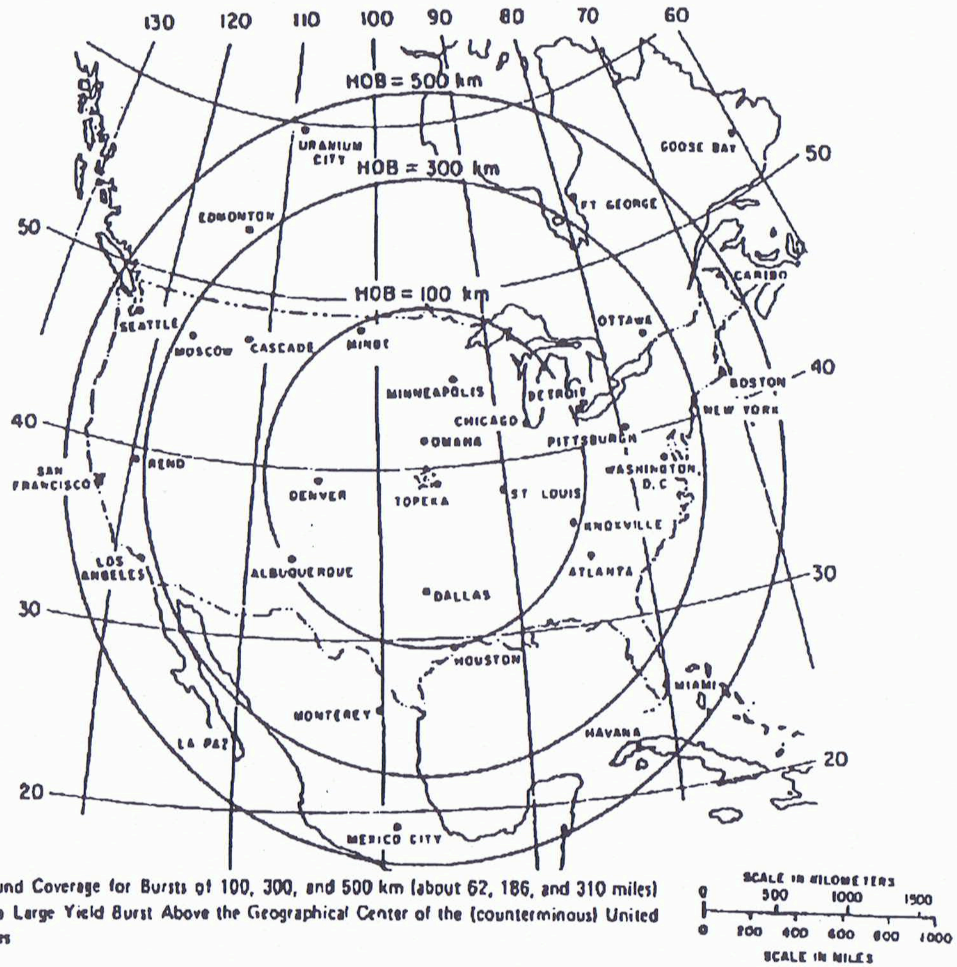
EMP PULSE



Ground Coverage for Bursts of 100, 300, and 500 km (about 62, 186, and 310 miles) for a Large Yield Burst Above the Geographical Center of the (counterminous) United States

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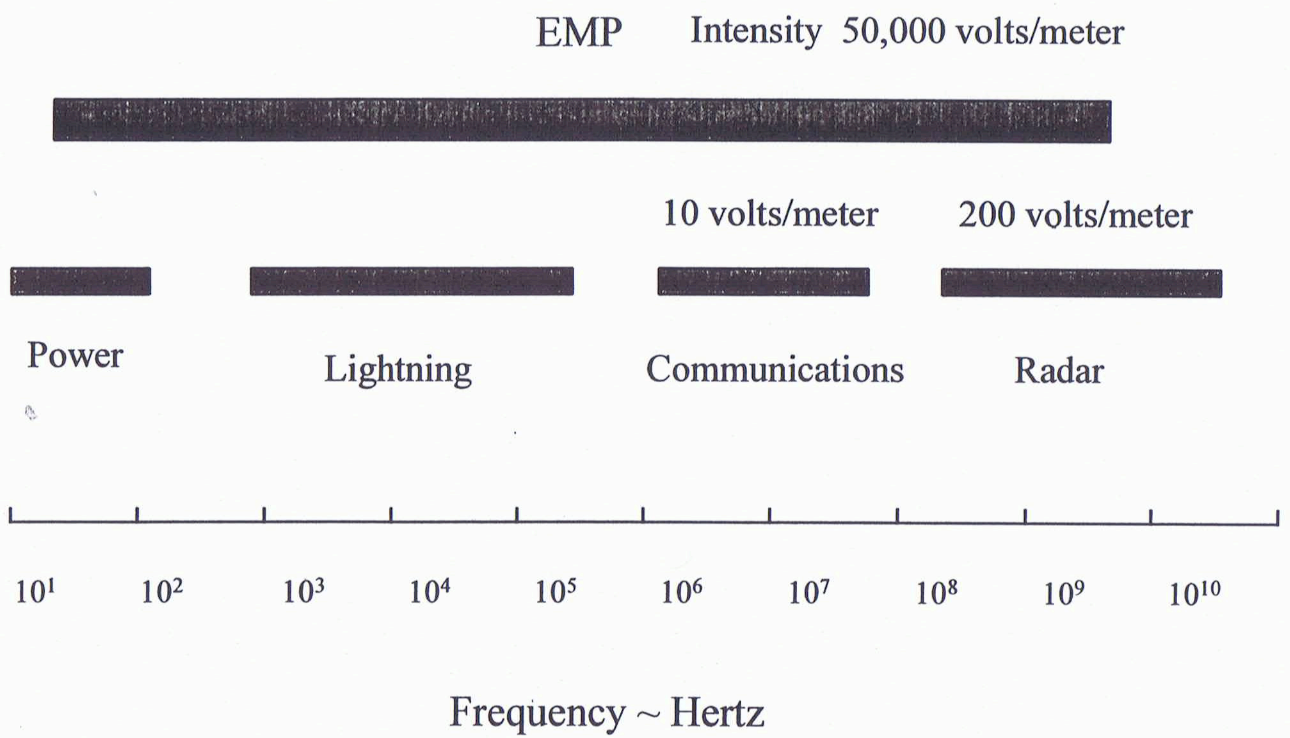
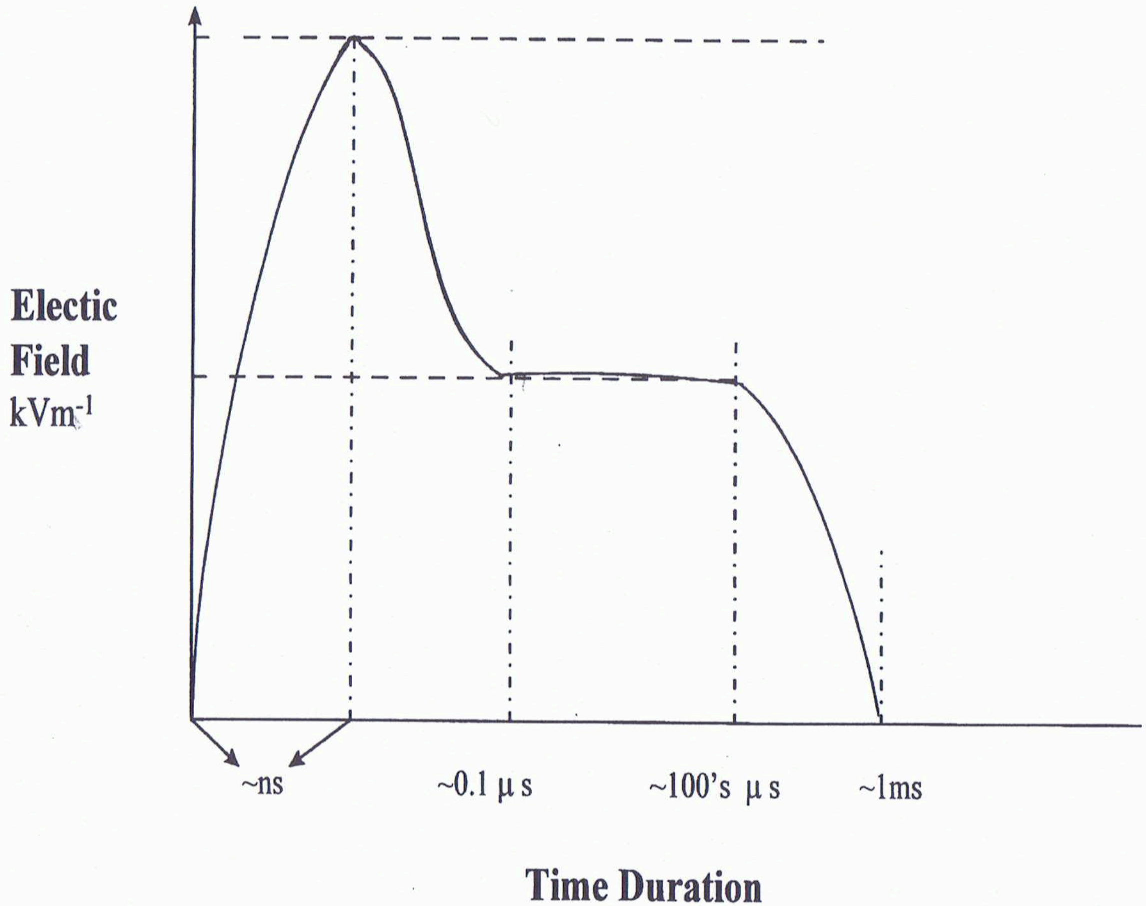
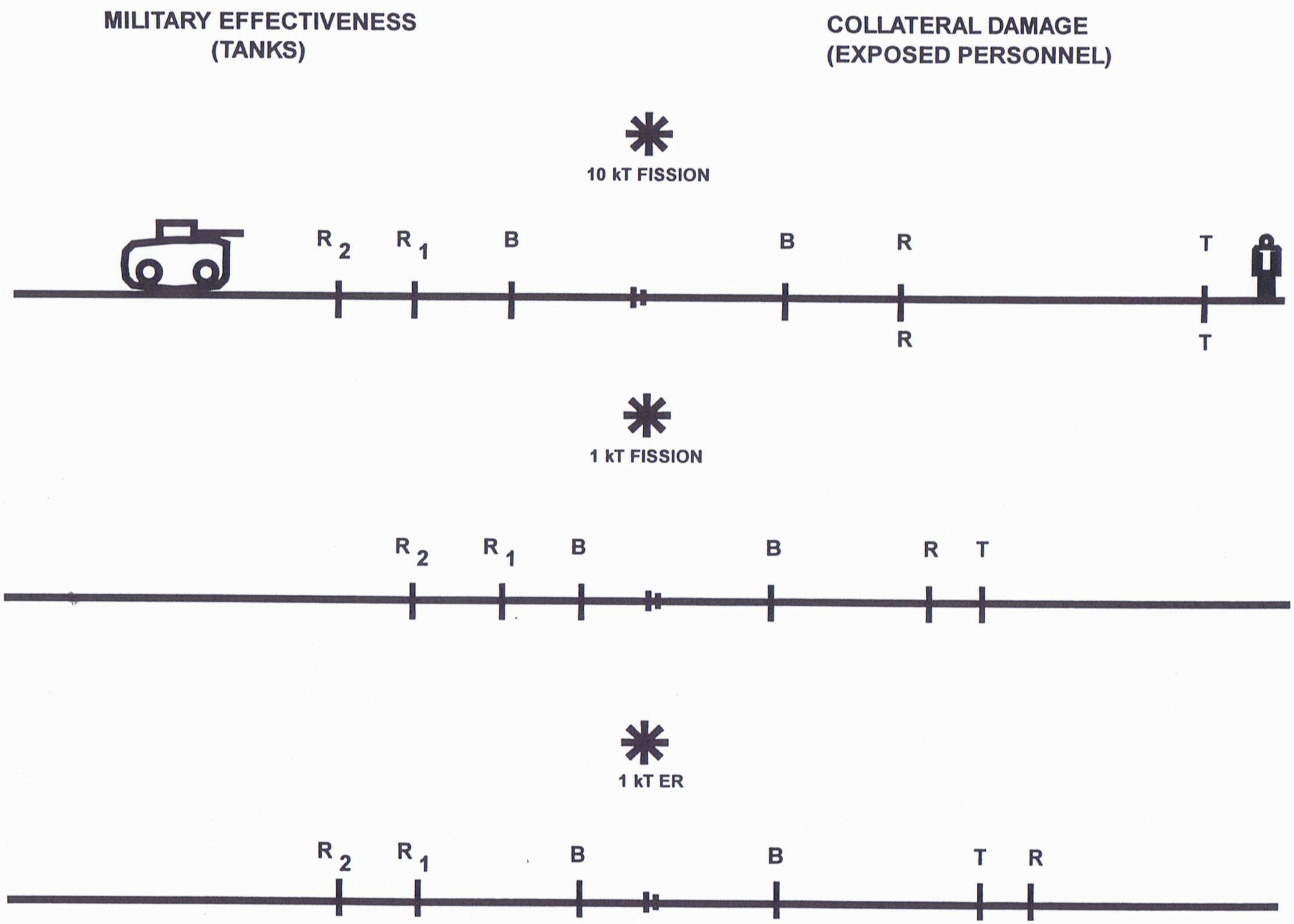
Frequency Spectrum Comparison



Representative EMP Pulse

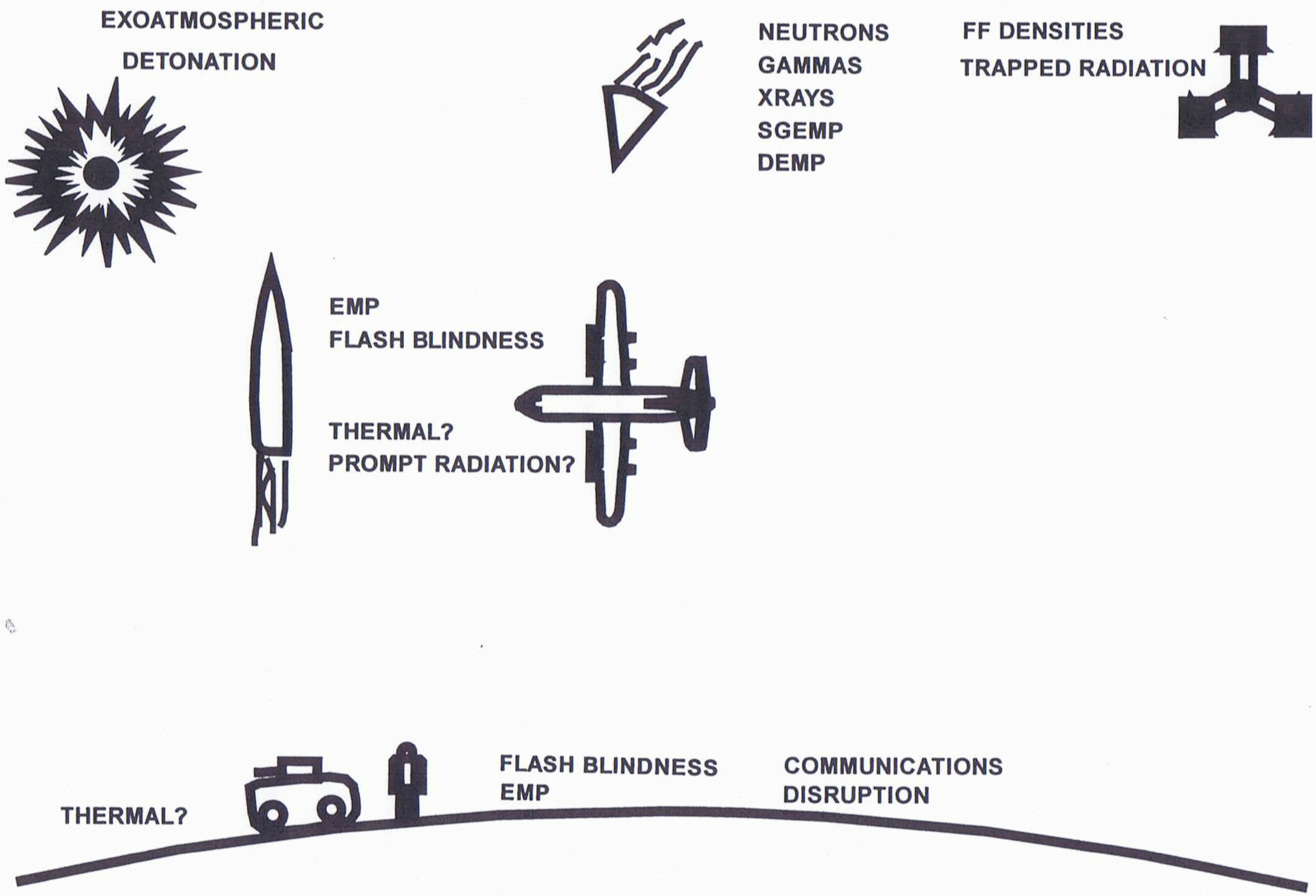


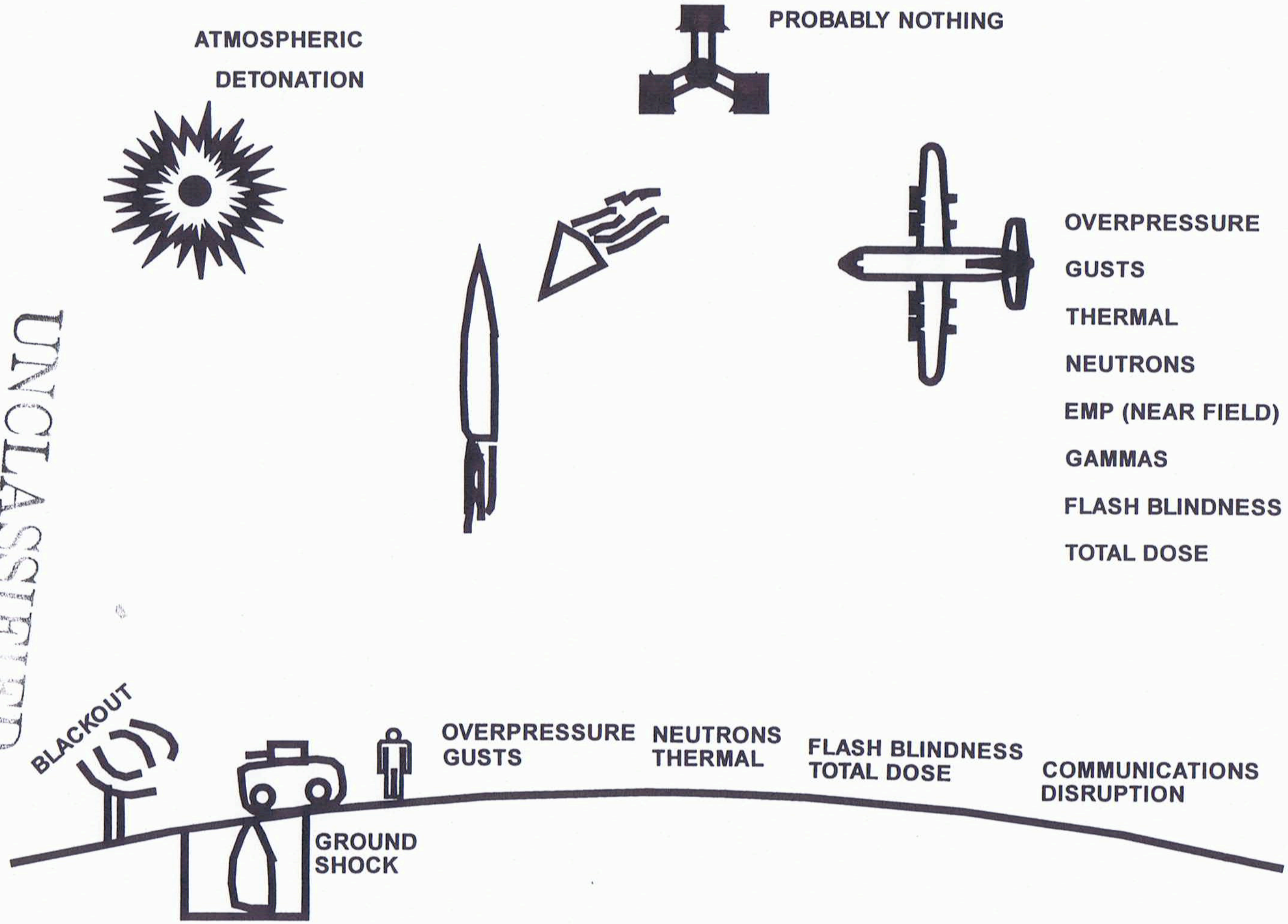

MILITARY EFFECTIVENESS
(TANKS)
COLLATERAL DAMAGE
(EXPOSED PERSONNEL)
10 kT FISSION
R 2
R 1
B
B
R
T
R
T
1 kT FISSION
R 2
R 1
B
B
R
T
1 kT ER
R 2
R 1
B
B
T
R

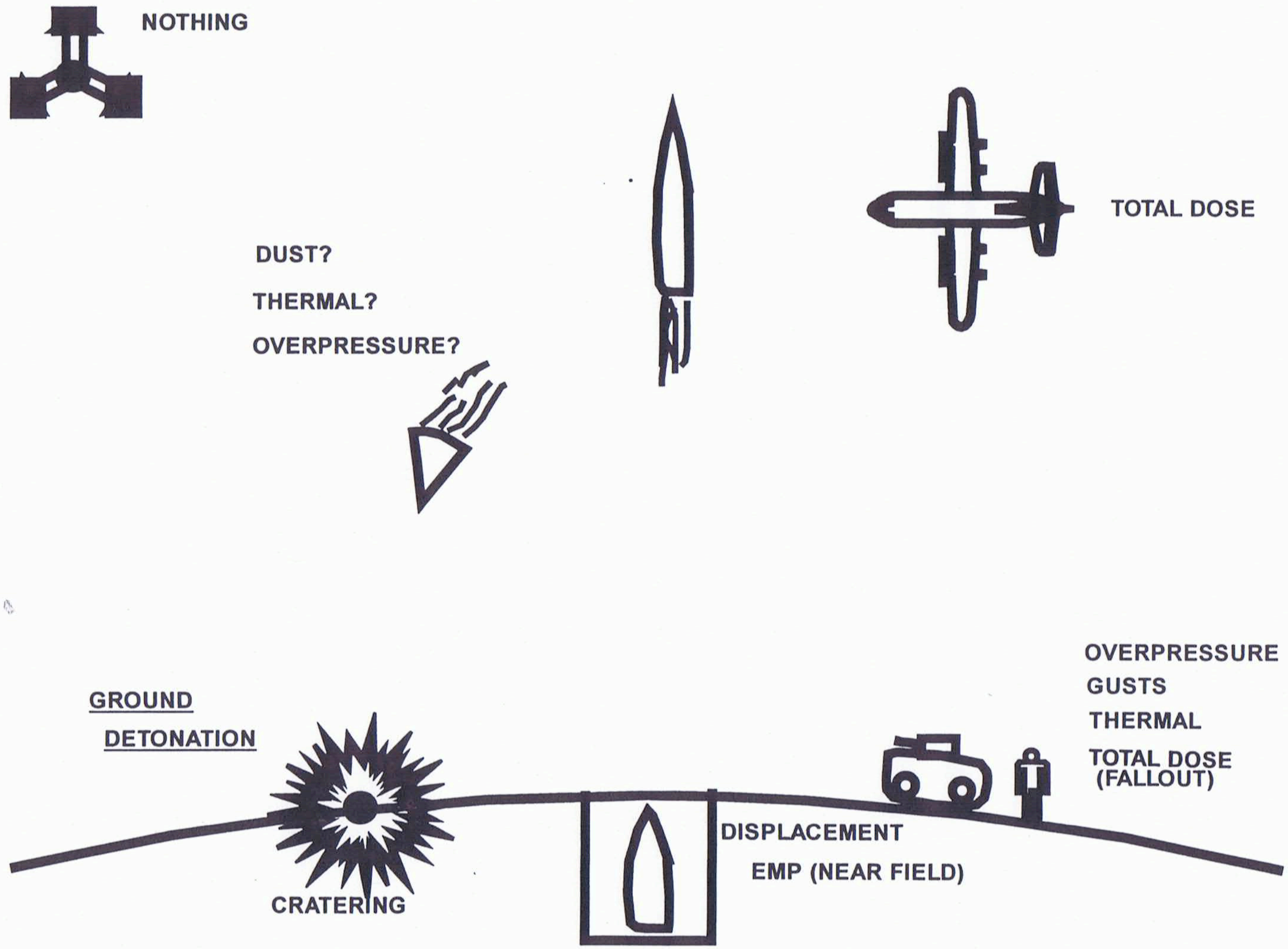
1 MT DETONATIONS AT VARIOUS HOB's (CO-Altitude)

	N 10^{12} n/cm^2	N 10^{15} n/cm^2	$\dot{\gamma}$ 10^{8} rad/sec	$\dot{\gamma}$ 10^{13} rad/sec	X-ray 20 cal/cm^2	X-ray 130 cal/cm^2	Thermal 4 cal/cm^2	Thermal 80 cal/cm^2	Over 2 psi	Over 10 psi	Over 3000 psi
Exoatmospheric	157	5.6	760	2.4	56.8	22.2	-----	-----	-----	-----	-----
100,000 ft	12.5	5.5	190	2.3	10.4	6.0	98	22	8.5	4.6	.7
1,800 ft	6.2	2.5	9.0	1.3	-----	-----	49	19	29.5	10.8	.8
Surface	5.6	2.3	8.5	1.3	-----	-----	40.4	12.1	25	10	1.1

Distances to Effect Levels in kilo-feet


EXOATMOSPHERIC
DETONATION
NEUTRONS
GAMMAS
XRAYS
SGEMP
DEMP
FF DENSITIES
TRAPPED RADIATION
EMP
FLASH BLINDNESS
THERMAL?
PROMPT RADIATION?
THERMAL?
FLASH BLINDNESS
EMP
COMMUNICATIONS
DISRUPTION


ATMOSPHERIC
DETONATION
PROBABLY NOTHING
OVERPRESSURE
GUSTS
THERMAL
NEUTRONS
EMP (NEAR FIELD)
GAMMAS
FLASH BLINDNESS
TOTAL DOSE
BLACKOUT
OVERPRESSURE
GUSTS
NEUTRONS
THERMAL
FLASH BLINDNESS
TOTAL DOSE
COMMUNICATIONS
DISRUPTION
GROUND
SHOCK


NOTHING
TOTAL DOSE
DUST?
THERMAL?
OVERPRESSURE?
GROUND
DETONATION
CRATERING
DISPLACEMENT
EMP (NEAR FIELD)
OVERPRESSURE
GUSTS
THERMAL
TOTAL DOSE
(FALLOUT)

Useful Rules-of-Thumb for Prompt Effects

- Emergency Risk
  - Thermal -- 3 cal/cm2
  - Blast -- 4 psi
- Casualty from Blast
  - Exposed personnel -- 18 psi
  - Severe Tank Damage -- 49 psi
- Radiation Dose
  - Casualty -- 8,000 rads
  - Emergency Risk -- 150 rads

Radiation Dose Immediate Casualty -- 8,000 rads

Range	Yield	Adjustment factor
~0.5 km	~1 KT fission	~100m range for every factor 2 in yield
~1 km	~ 1 KT enhanced Radiation	~100m range for every factor 2 in yield
~1 km	~ 25 KT typical Fission	~100m range for every factor 2 in yield

Radiation Dose-Prompt Effects

Casualty	8,000 rads	~0.5 km	1 KT fission
Casualty	8,000 rads	~ 1 km	1 KT ER
Casualty	8,000 rads	~ 1 km	25 KT fission
Emergency Risk	150 rads	~1.5 km	1 KT ER
Emergency Risk	150 rads	~1.5 km	25 KT fission

SOME EFFECTS LEVELS OF INTEREST

PEOPLE

THERMAL	2-5 CAL/CM2
OVERPRESSURE	>7 PSI
RADIATION	>100 RADS

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Nuclear Targeting

- Through intelligence data, the targets have a vulnerability number associated with it that allows the DoD to assign a weapon VN number.
- Vulnerability Number (VN)

  XXPA   XXQA

  First 2 digits are related to the amount of pressure:
  - P = over pressure (smash)
  - Q = dynamic pressure (winds)
  - A = adjustment for yield (tables geared to 20 kT)
- A typical VN:

  Airfield = 12 P0 ~ 10 psi

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REFERENCES

•THE EFFECTS OF NUCLEAR WEAPONS 3RD EDITION, GLASSTONE AND DOLAN, 1977, UNC

•CAPABILITIES OF NUCLEAR WEAPONS, DNA EM-1 PARTS I & II, SRD RS-3141 8798