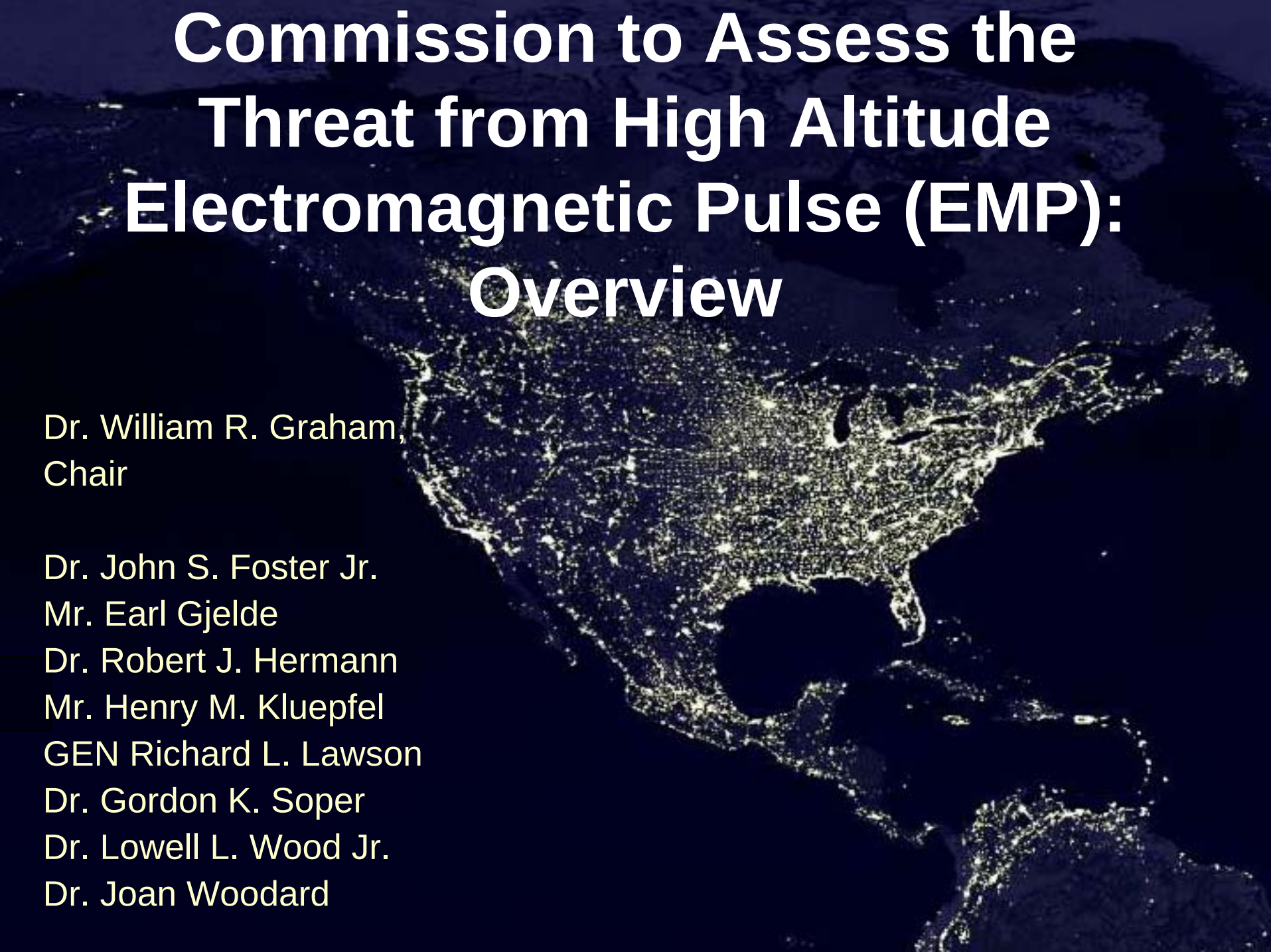
Commission to Assess the Threat from High Altitude Electromagnetic Pulse (EMP): Overview



Dr. William R. Graham, Chair

Dr. John S. Foster Jr.
Mr. Earl Gjelde
Dr. Robert J. Hermann
Mr. Henry M. Kluepfel
GEN Richard L. Lawson
Dr. Gordon K. Soper
Dr. Lowell L. Wood Jr.
Dr. Joan Woodard

EMP Commission Charter: Title XIV
Duties of Commission

- Assess the EMP Threat to the US:
  - Nature and magnitude of EMP threats within the next 15 years
    - From all potentially hostile states or non-state actors
  - Vulnerability of US military and especially civilian systems
  - Capability of the US to repair and recover from damage to military and civilian systems
  - Feasibility and cost of EMP hardening select military and civilian systems
- Recommend protection steps the US should take

Commission considered:
- **Only EMP threats produced by high-altitude detonation of a nuclear weapon**
- **Threat assessment based on present and possible future capabilities of potential adversaries because of 15-year outlook**

Commissioners

- Dr. John S. Foster, Jr. (Director LLNL; Director DDR&E)
- Mr. Earl Gjelde (Chief Engineer and Acting Director, Bonnevile Power Administration; Under Secretary Dept of Interior, COO, Dep of Energy)
- Dr. William R. Graham (Chairman) (Director, OSTP; Science Advisor to President Reagan)
- Dr. Robert J. Hermann (Director, NRO; Asst Sec USAF; Vice President, United Technologies)
- Mr. Henry (Hank) M. Kluepfel (VP SAIC; Advisor to the President's NSTAC)
- GEN Richard L. Lawson, USAF (Ret.) (DCINC US European Command; Director Plans and Policy JCS)
- Dr. Gordon K. Soper (PDATSD NCB; Director Nuclear Forces C3; Chief Scientist DCA)
- Dr. Lowell L. Wood, Jr. (Director's Staff LLNL; Technical Advisor, SSCI & HASC)
- Dr. Joan B. Woodard (Exec VP & Deputy Director Sandia National Labs)

Seven Commissioners were appointed by the Secretary of Defense and two by the Director of the Federal Emergency Management Agency

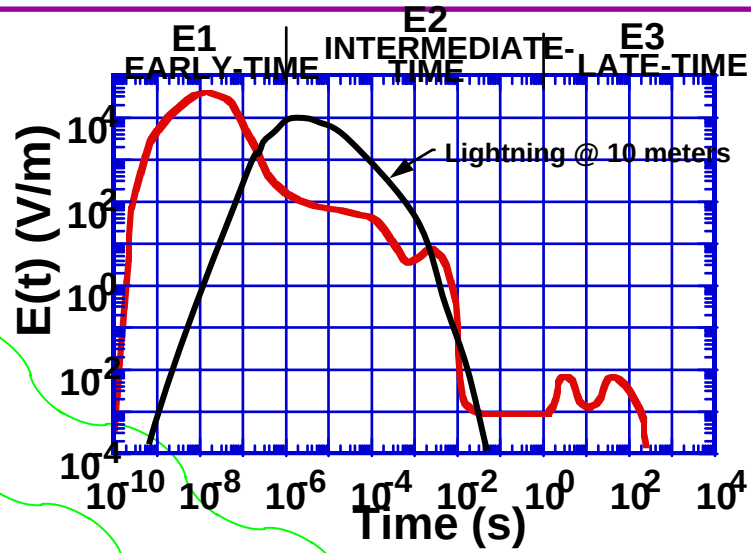
Early-Time HEMP Mechanism (E1)

Weapon-emitted prompt γ-rays

The more individually energetic the γ-rays, the more swiftly they're emitted, and the larger the total quantity of them, the more intense – and the higher frequency – is the HEMP

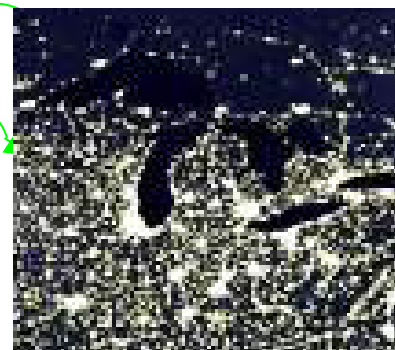
The induced HEMP pulse and the weapon-emitted γ's both travel at the speed of light, resulting in buildup of large HEMP fields in billionths of a second

B_{Earth}



Compton-scattered air-atom electrons

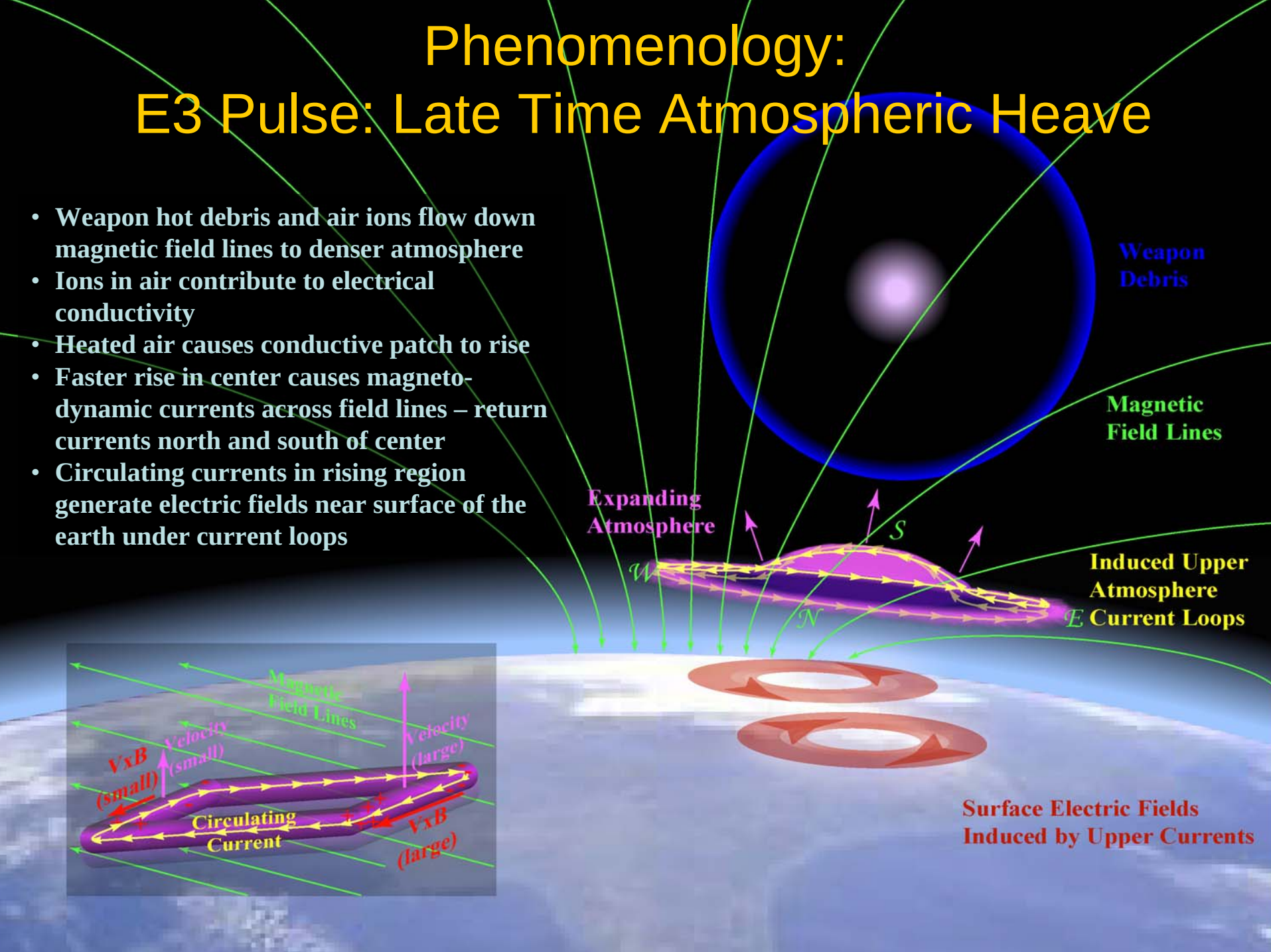
Induced HEMP



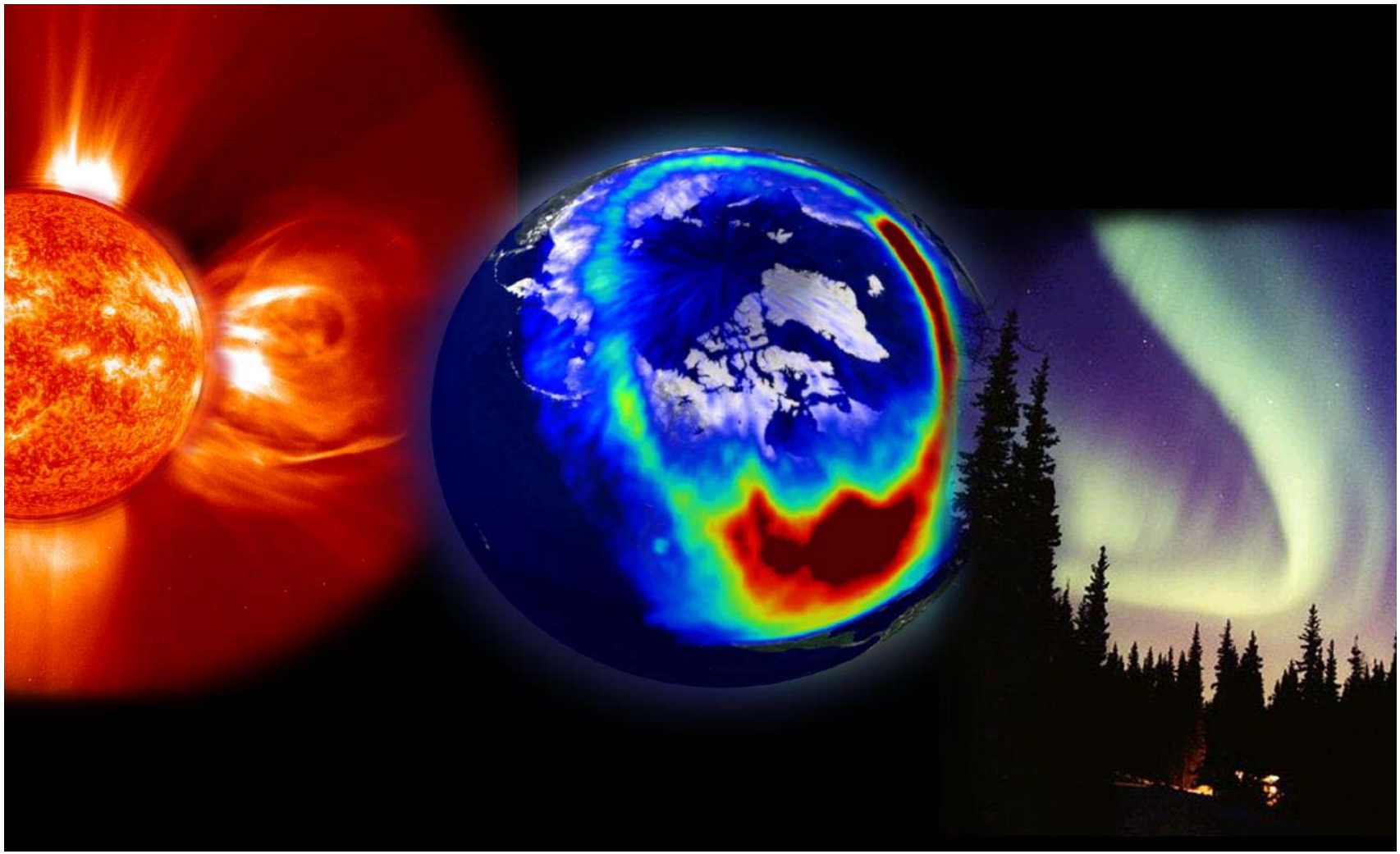
In contrast to the air of near-surface bursts, the thin upper atmosphere allows <u>coherent</u> gyration of the Compton-scattered electrons in the Earth's magnetic field – thus <u>all</u> the g-irradiated atmosphere becomes a titanic antenna

Phenomenology:
E3 Pulse: Late Time Atmospheric Heave

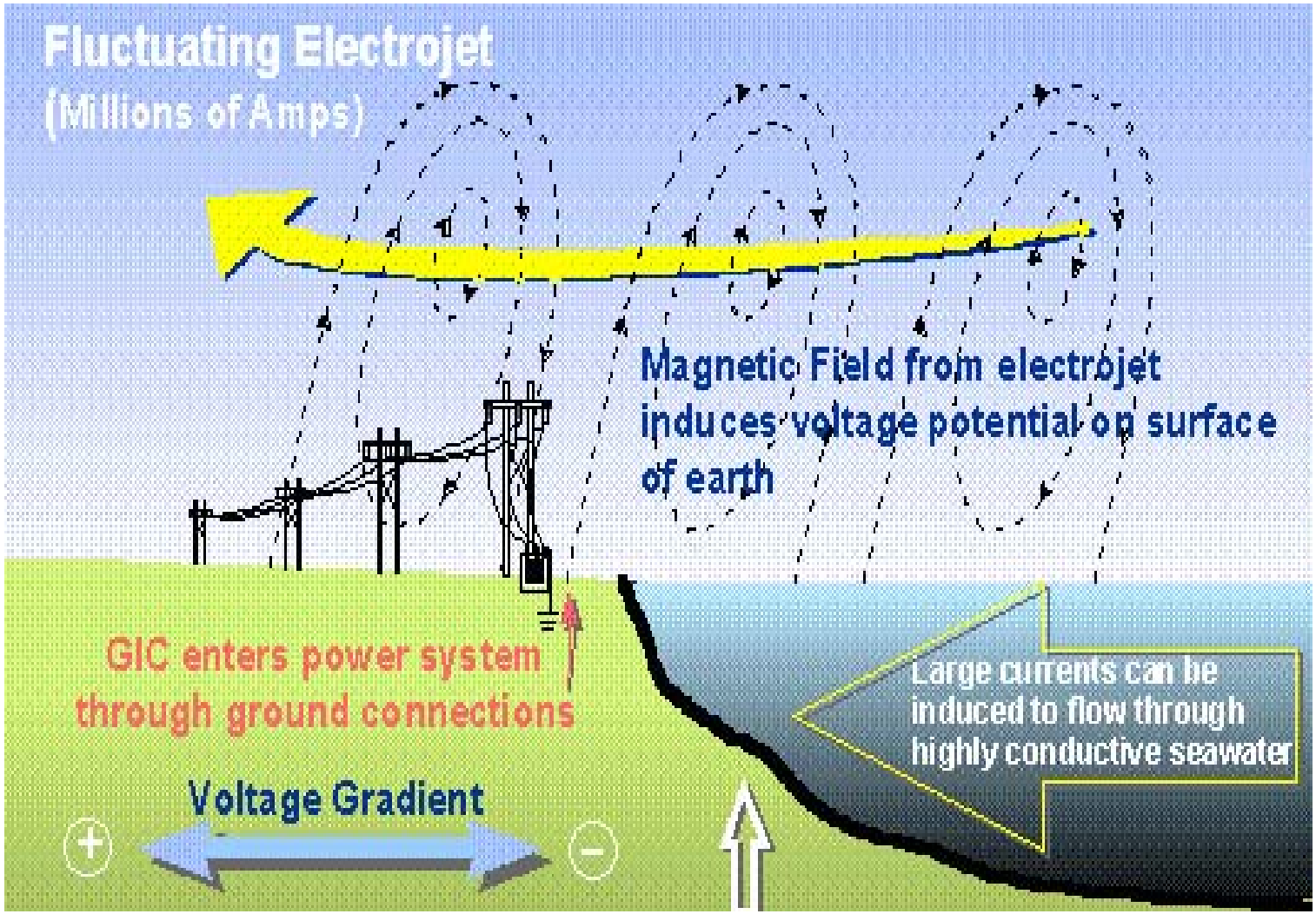
- **Weapon hot debris and air ions flow down magnetic field lines to denser atmosphere**
- **Ions in air contribute to electrical conductivity**
- **Heated air causes conductive patch to rise**
- **Faster rise in center causes magneto-dynamic currents across field lines – return currents north and south of center**
- **Circulating currents in rising region generate electric fields near surface of the earth under current loops**



Geomagnetic Storms

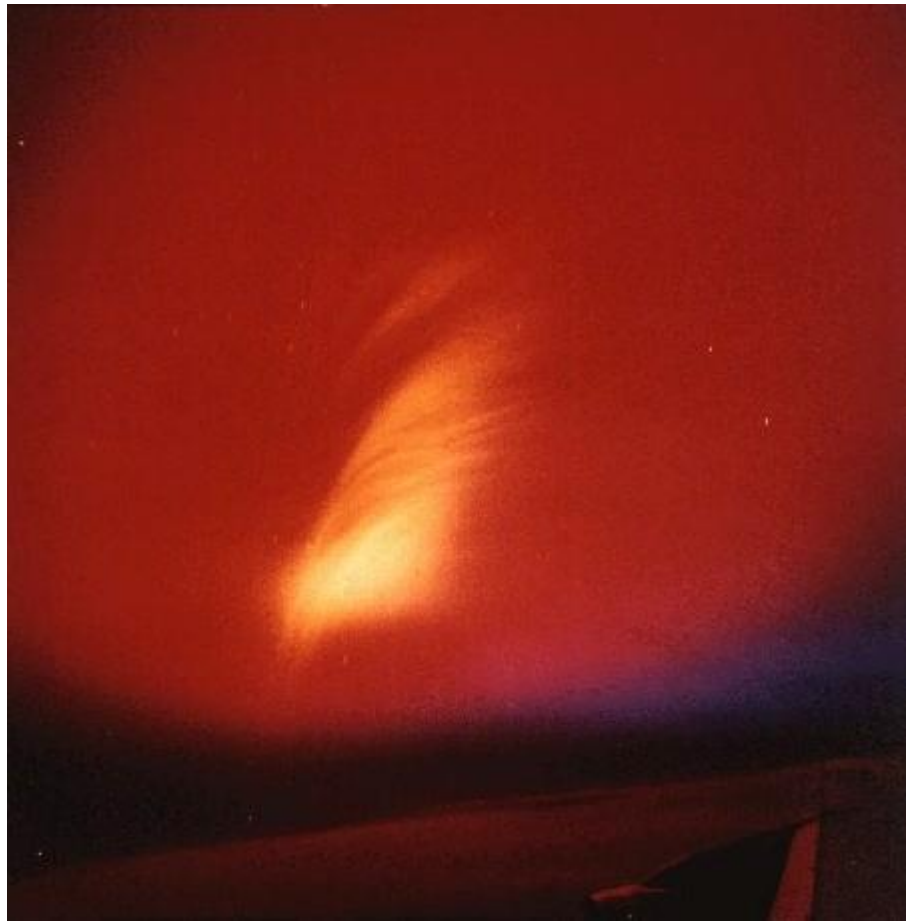


Geomagnetic Storm Coupling



Starfish

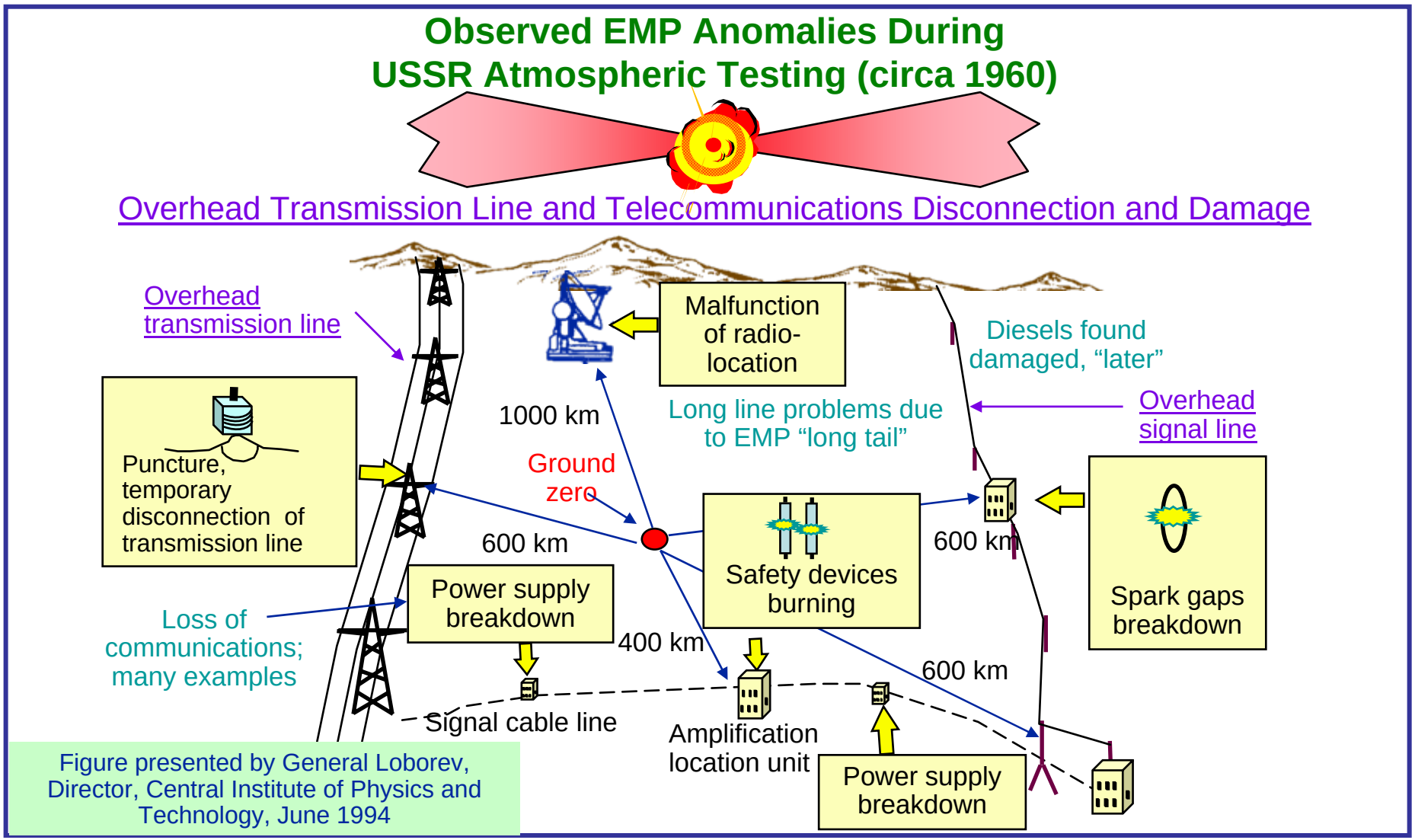
Widespread red air glow (6300 å) amid dark clouds, caused mostly by x-ray-excited atomic oxygen (i.e., oxygen by photoelectrons liberated by Starfish X-rays)



Starfish debris fireball observed from a KC135 with atmospheric fluorescence between the observer and the detonation point.

EMP Threat: Historical Evidence

- EMP observed during US and Russian atmospheric test programs
- EMP damages and disrupts electronics—does not directly harm people

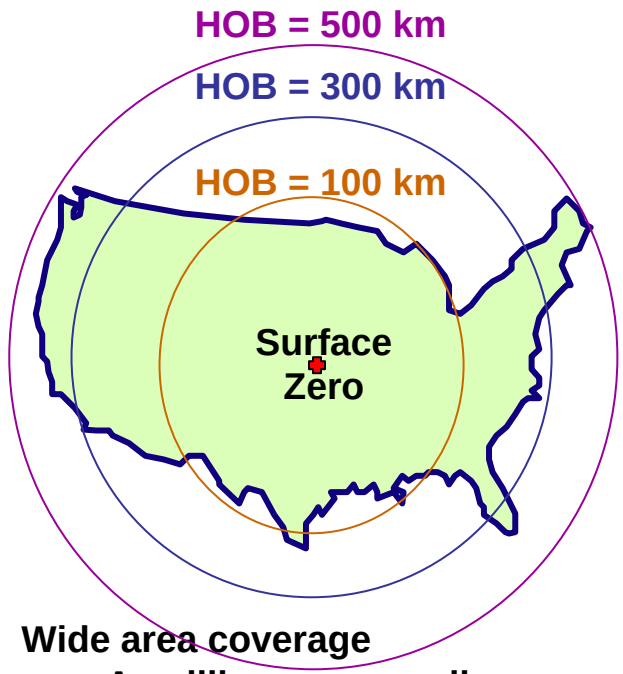


Threat: Nature and Magnitude of EMP Threats Within the Next 15 Years

- EMP is one of a small number of threats that may
  - Hold at risk the continued existence of today's US civil society
  - Disrupt our military forces and our ability to project military power
- The number of US adversaries capable of EMP attack is greater than during the Cold War
- Potential adversaries are aware of the EMP strategic attack option
- Threat not adequately addressed in US national and homeland security programs

Vulnerability may be an invitation to attack

EMP Coverage for Bursts of Various Heights



- **Wide area coverage**
  - **A million square miles**
- **Intensity depends on:**
  - **Weapon design**
  - **Height of burst**
  - **Location of burst**
- **Broad frequency range**
- **Threat to all electronics in exposure**

EMP Commission Approach

- Capabilities Based Methodology
  - Close interaction with IC
  - Consider those threats that could affect basic functioning of society
  - Not attempting to assess relative probability of EMP vs other threats
- Infrastructure Assessments
  - Power
  - Telecommunications
  - Financial
  - TransportationEnergy Distribution (Oil & Gas)
  - Emergency Services
  - Water and Food
  - Military
  - Cross cutting issues, e.g. SCADAs

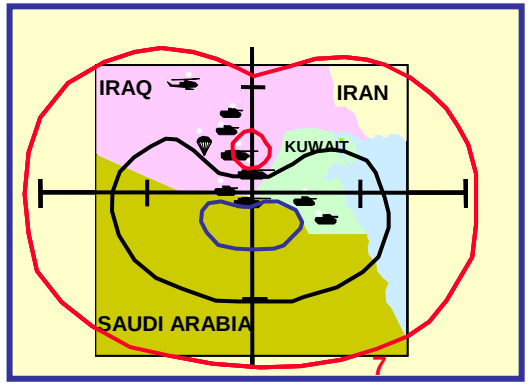
EMP Commission Approach - II

- Sponsor Workshops
  - NIO intel seminar
  - Satellite Workshop – CIA
  - Infrastructures workshop
  - Russian seminars (Sept 03, Feb 04)
- Test Program
  - Power systems, SCADA, Electronic Circuits, Telecom Systems
- Collaboration with Industry and Government
  - IC, FRB, NERC, NSTAC, NCS, OSTP

Military Forces

- **Strategic Forces**
  - EMP survivability remains a strategic necessity
    - Offensive forces, Defensive forces, Responsive Infrastructure
  - End of Cold War relaxed discipline for meeting capability for EMP hardness
- **General Purpose Forces**
  - Hardened equipment embedded in soft systems
  - Increased dependence on high reliability electronics, not just components but supporting infrastructure

General Purpose Forces (GPF)



50 kT at 100m HOB

GPF Today

- Hardened equipment embedded in soft systems and generally lacking HM/HS

Future of GPF

-Move to Digital Battlefield: *increased dependence on high reliability electronics, not just components but supporting infrastructure*

-Move to Future Combat System: *new designs, new materials, increased dependence on electronics as force multiplier*

Commercial-Off-the-Shelf (COTS) integration a concern

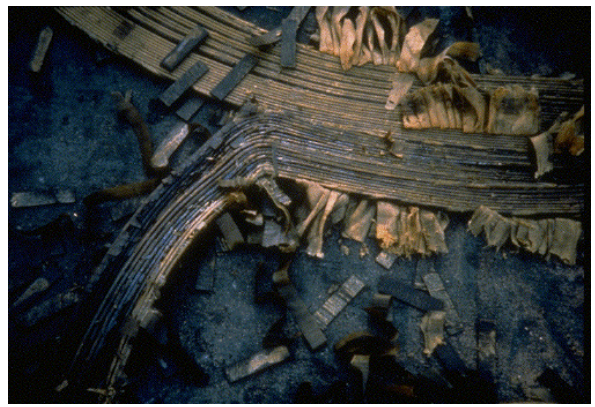
- *Most modern, unhardened electronics will fail (upset or damage) at 7-15 kV/M*

On future battlefields our small technically superior fighting force could be reduced to a small vulnerable force by EMP vulnerability

Vulnerability of US Electric Power Infrastructure

- EMP induced functional collapse of the electrical power grid risks the continued existence of US civil society
  - Immediate EM transients likely to exceed capabilities of protective safety relays
  - Late time EMP could induce currents that create significant damage throughout the grid
- National electrical grid not designed to withstand near simultaneous functional collapse
- Procedures do not exist to perform “black start”
  - Restart would depend on telecom and energy transport which depend on power
- Restoration of the National power grid could take months to years
  - Typical 500kV transformer is custom tailored to application
  - Spares are seldom available
  - Manufacturing performed offshore
  - Normal delivery time months to more than a year

Substation Transformer



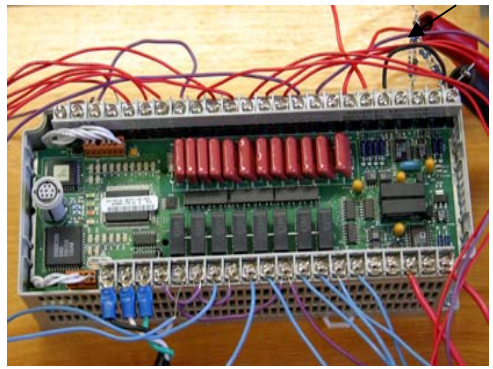
Melted 500kV transformer coil from EM induced flux creating a hot spot

Electric power is key to a functioning society and military. EMP induced destruction of power grid components could substantially delay recovery.

SCADA/Remote Controls

- **Supervisory Control Systems (SCADA) are the ubiquitous robots of modern civilization**
  - Process control
  - Environmental monitoring and control
  - Safety of operation
  - Rapid problem diagnosis
  - Real time data acquisition and remote control
- **Generic SCADA may share many component commonalities with PCs**
  - Circuit boards, I/O ports,…

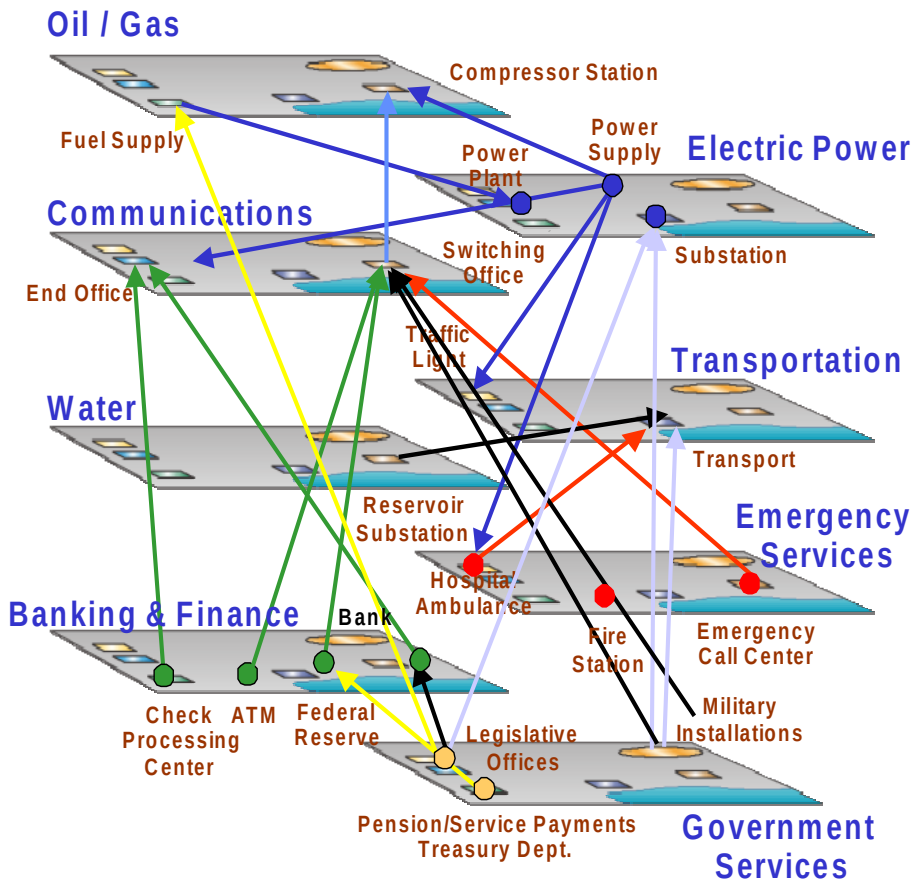
Pipeline SCADA components



PLC switch activator

The Vulnerability and Interdependence of US Military and Civilian Systems

- One or a few high-altitude nuclear detonations can produce EMP, simultaneously, over wide geographical areas
- Unprecedented cascading failure of our electronics-dependent infrastructures could result
  - Power, energy transport, telecom, and financial systems are particularly vulnerable and interdependent
  - EMP disruption pf these sectors could cause large scale infrastructure failures for all aspects of the Nation's life
- Both civilian and military capabilities depend on these infrastructures
- Without adequate protection recovery could be prolonged—months to years



Capability of the US to Repair and Recover from Damage to Civilian Systems

Other Civilian Infrastructures Dependent Upon Availability of Power

- **Telecommunications:**
  - May be significantly impacted, at least at the outset
  - Recovery will be dependent on prompt restoration of power
- **Financial system:**
  - Vulnerable to an EMP induced disruption of telecommunications and computers
- **Remote controls** in infrastructures are at risk of disruption and damage
  - **Transportation** infrastructure is vulnerable to disruption.
  - **Oil and gas supplies** likely disrupted due to failures of pump and valve controls
  - **Potable water** likely disrupted in the region affected by the EMP
  - **Distribution of food** may be degraded
- US scientific and technical capability to address EMP and other nuclear weapon effects has diminished to the point where continued viability is questionable

No credible capability exists to predict the full response of a single system (e.g., national power grid), let alone the highly interdependent US infrastructure

Danger of EMP Attack Can Be Mitigated

- Our free, modern society has inherent vulnerabilities that cannot be completely eliminated
- Catastrophe can be averted by practical and affordable steps to
  - *Prevent* attacks,
  - *Prepare* to recognize and respond to an EMP attack
  - *Protect* critical infrastructure elements and strategic military capabilities, and
  - *Recover* following attack
- National security and homeland security are Federal responsibilities that should be funded by the Federal government

In just a few years we can make significant, affordable improvements to protect society even if an EMP attack is carried out against us

We Can Do Something About it: Strategy and Recommendations

- Pursue Intelligence, Interdiction, and Deterrence to Discourage EMP Attack
  - *highest priority is to prevent attack*
  - *shape global environment to reduce incentives to create EMP weapons*
  - *make it difficult and dangerous to try*
- Protect Critical Components of Key Infrastructures
  - *especially "long lead" replacement components*
- Maintain Ability to Monitor/Evaluate Condition of Critical Infrastructures
  - *absence of information can make things worse either through inaction*
  - *or inappropriate action. Salutary example ~ Blackout of August 13, 2003*
- Recognize EMP Attack and Understand How Effects Differ from Other Disruptions

- Plan to Carry Out Systematic Recovery of Key Infrastructures
  - *demonstrate will and capacity to recover from any attack*

The Governance and Accountability Issue

- DoD has experience and structure for dealing with its own systems but is dependent on civil/commercial sector.
- DHS has responsibility for civil sectors. National Infrastructure Protection Plan addresses all sectors but does not provide discipline for resources and authorities.
- Many sectors (e.g. Electric Power, Gas, Financial, Telecom) are commercial and mitigation will cost someone.
- Commercial firms unwilling to pay for “National Security” burden.
- This is true for EMP, Cyber and physical attack, etc.

BACKUP SLIDES

Is an EMP Attack Likely?

- The Commission did not try to estimate the likelihood of an EMP event looking forward 15 years.
  - We do not think that is either practical or useful
  - The likelihood depends on our actions as well as the actions of others
  - We know that there are ways that such an attack could be mounted
  - We know there are ways to mitigate the catastrophic impact of an attack
  - We know that many of these mitigations apply to other threats as well (Cyber, Geomagnetic Storms, etc.

- We do not think it wise to leave this potentially catastrophic vulnerability in place given that it can be mitigated over time with reasonable resources

- We believe that if left unaddressed, our vulnerability becomes an invitation to attack

- If addressed, our reduced vulnerability helps deter attack, enhances infrastructure resilience and confers added protection against cyber threats and damaging geosolar storms.

I

WHY EMP?

States or terrorists may well calculate that using a nuclear weapon for EMP attack offers the greatest utility

- **EMP offers a "bigger bang for the buck" against US military forces in a regional conflict; or a means of damaging the US homeland**

- **EMP may be less provocative of US massive retaliation, compared to a nuclear attack on a US city that inflicts many prompt casualties**

- **EMP could, compared to a nuclear attack on a city, kill many more Americans in the long run, from indirect effects of collapsed infrastructures of power, communications, transportation, food and water**

- **Strategically and politically, EMP attack can: threaten entire regional or national infrastructures that are vital to US military strength and societal survival; challenge the integrity of allied regional coalitions; and pose an asymmetrical threat more dangerous to the high-tech West than to rogue states**

- **Technically and operationally, EMP attack can compensate for deficiencies in missile accuracy, fusing, range, reentry vehicle design, target location intelligence, and missile defense penetration**