High-Altitude Nuclear Explosion

EMP Protection

Yehoshua Socol

2009

Contents

- Nuclear weapons – basics
- Electromagnetic pulse (EMP) and related effects
- EMP Protection
- Conclusions

Nuclear Warheads

"Atomic"	1-20 Kton
Hiroshima	~15 Kton
Total destruction	~0.5 km
"Hydrogen"	100-1000 Kton
much more complicated;	
Total destruction	~3-5 km

Nuclear Proliferation

USA	1945
Russia	1949
UK	1952
France	1960
China	1964

India	1974
Pakistan	1998
North Korea	2006
(South Africa)	1982
…	

Nuclear Proliferation

"They'll build, buy,
borrow, burgle it –
anyhow, they'll have it"

Prof. Martin Van Creveld
author of *"The Transformation of War " and*
"The Rise and Decline of the State"
"Nota bene" No. 7, 24.02.2005

Contents

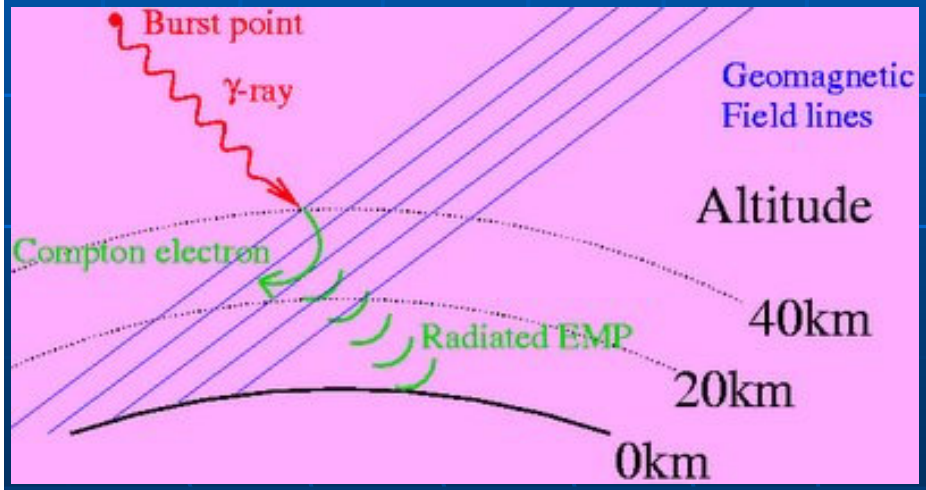
- Nuclear weapons – basics
- **Electromagnetic pulse (EMP) and related effects**
- EMP Protection
- Conclusions

HEMP – High-altitude EMP

Nuclear explosion effects

- Shock wave
- Light emission
- Penetrating radiation
- Radioactive contamination (Fallout)

- **EMP – Electro-Magnetic Pulse**



Scenario

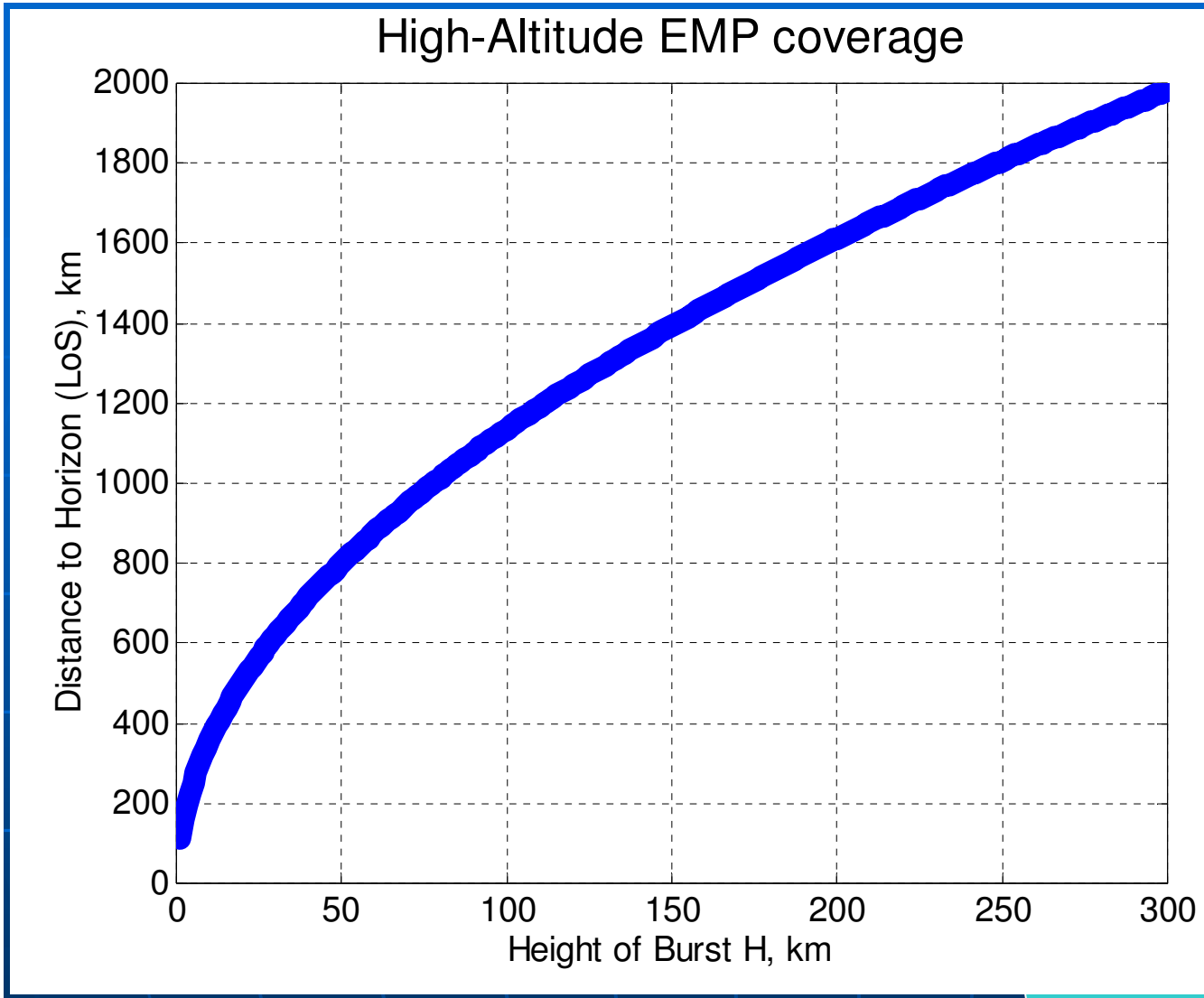
- simultaneously over the entire continental US
- no immediate casualties

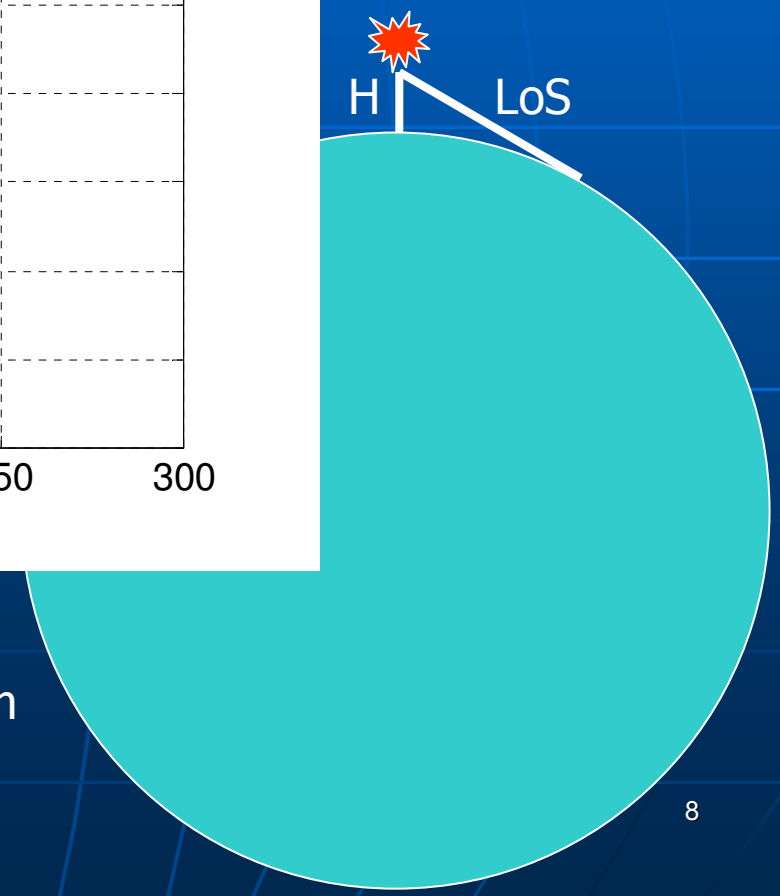
Electronic systems' shutdown

Electric grid destruction

Pilot strike ?!

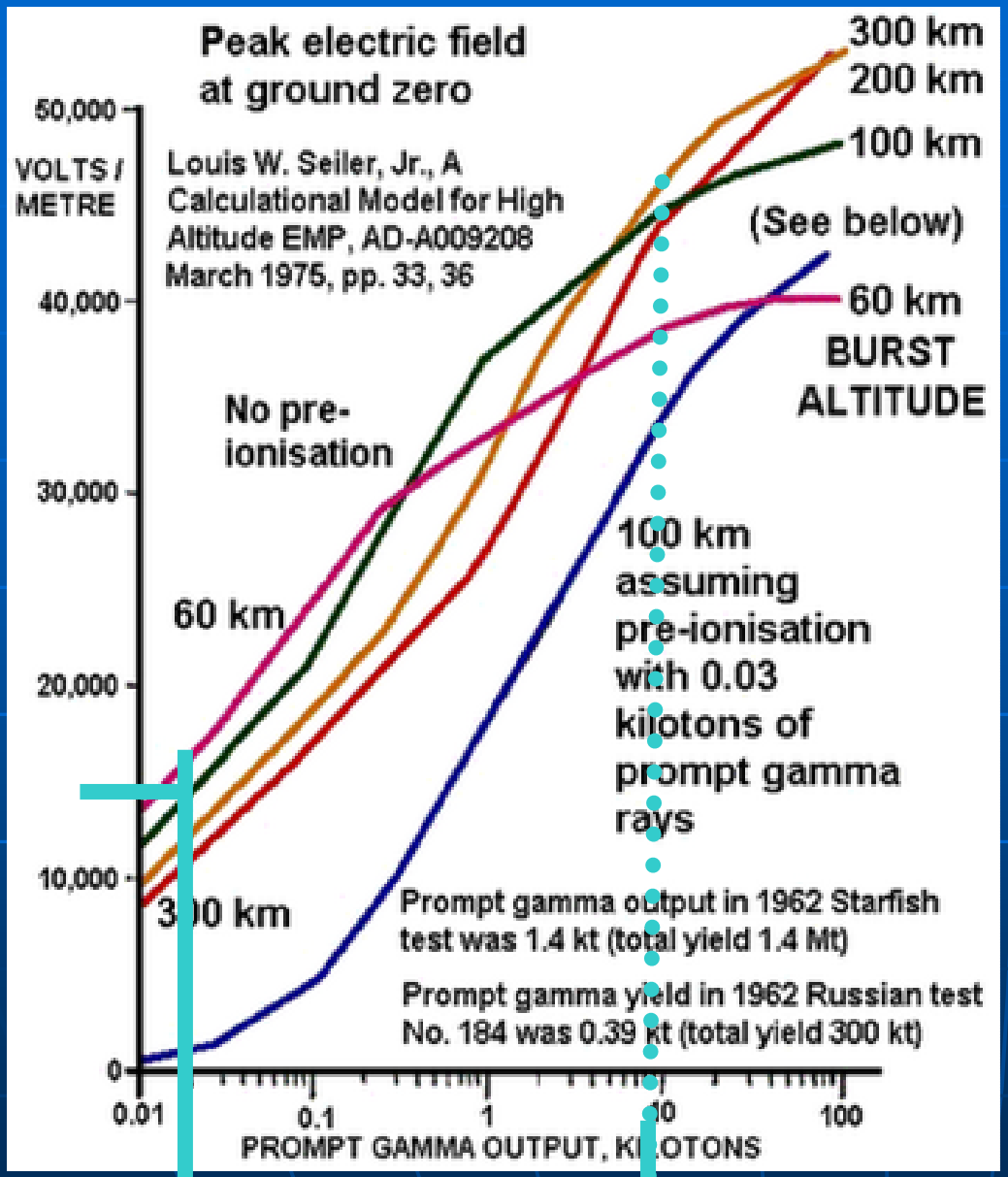
EMP





High-altitude EMP: above 30 km

EMP



Air Force Institute of Technology

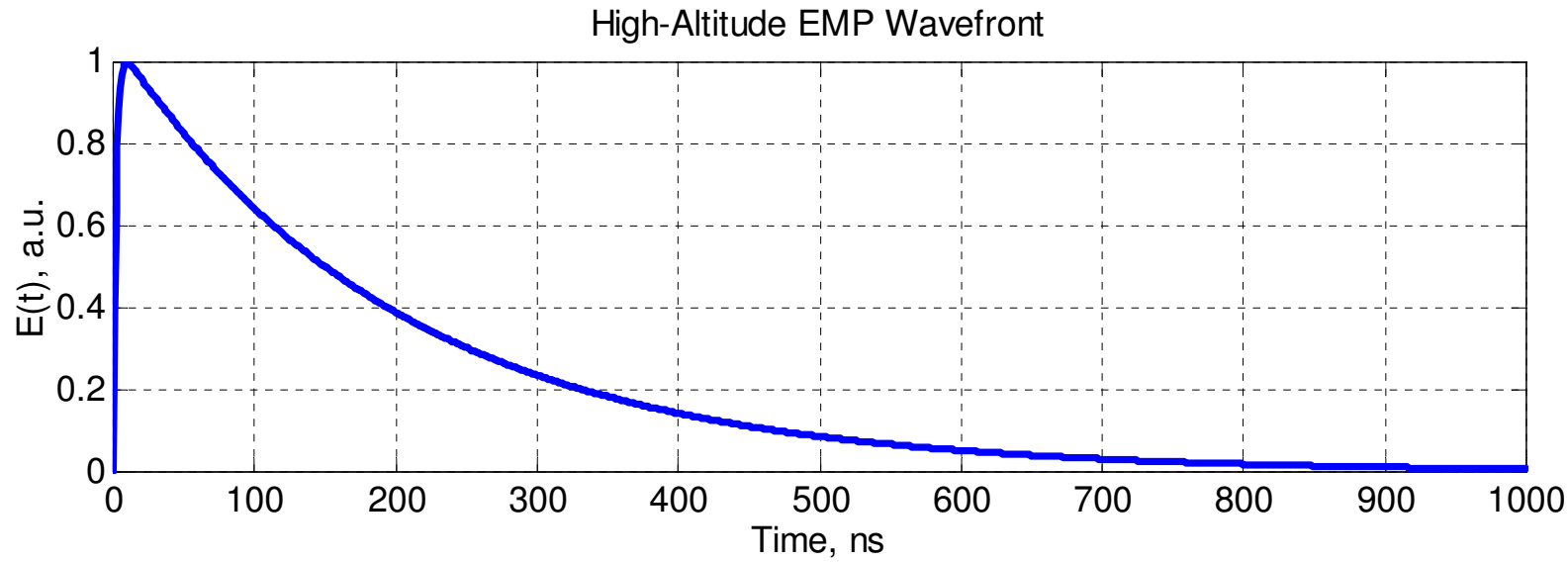
Wright-Patterson AF Base, Ohio

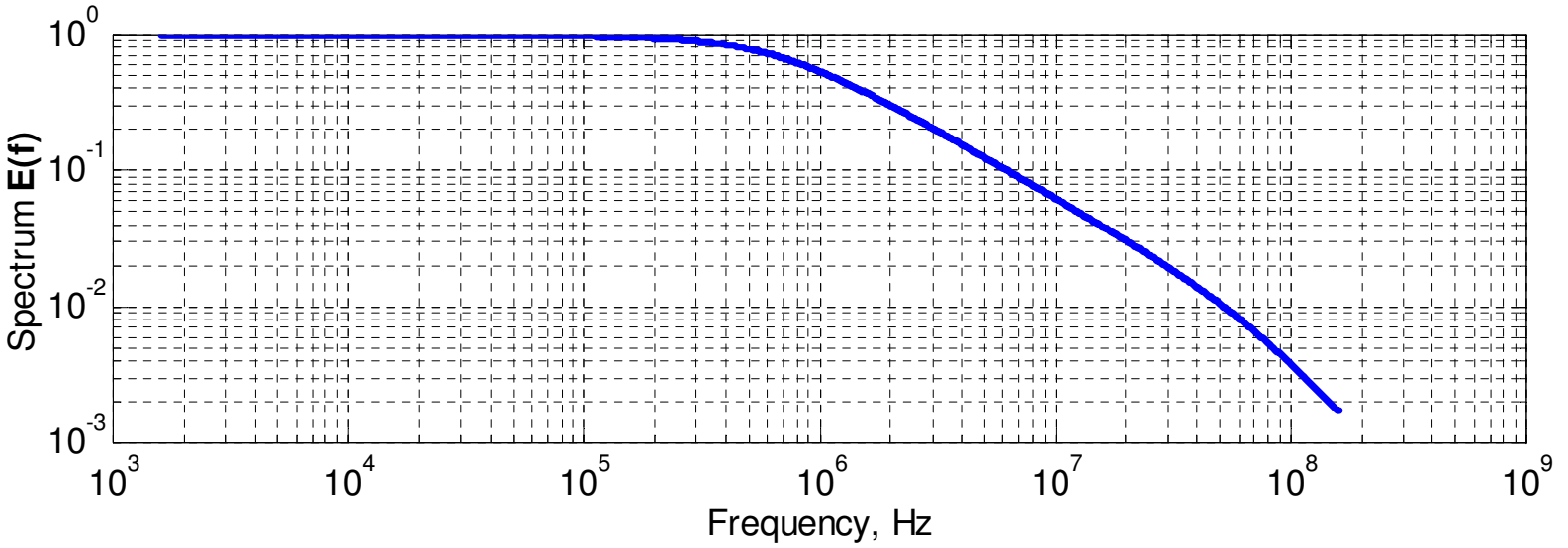
Weapon Yield Kton	20	1000
E_{max} V/m	15,000	50,000

EMP wave

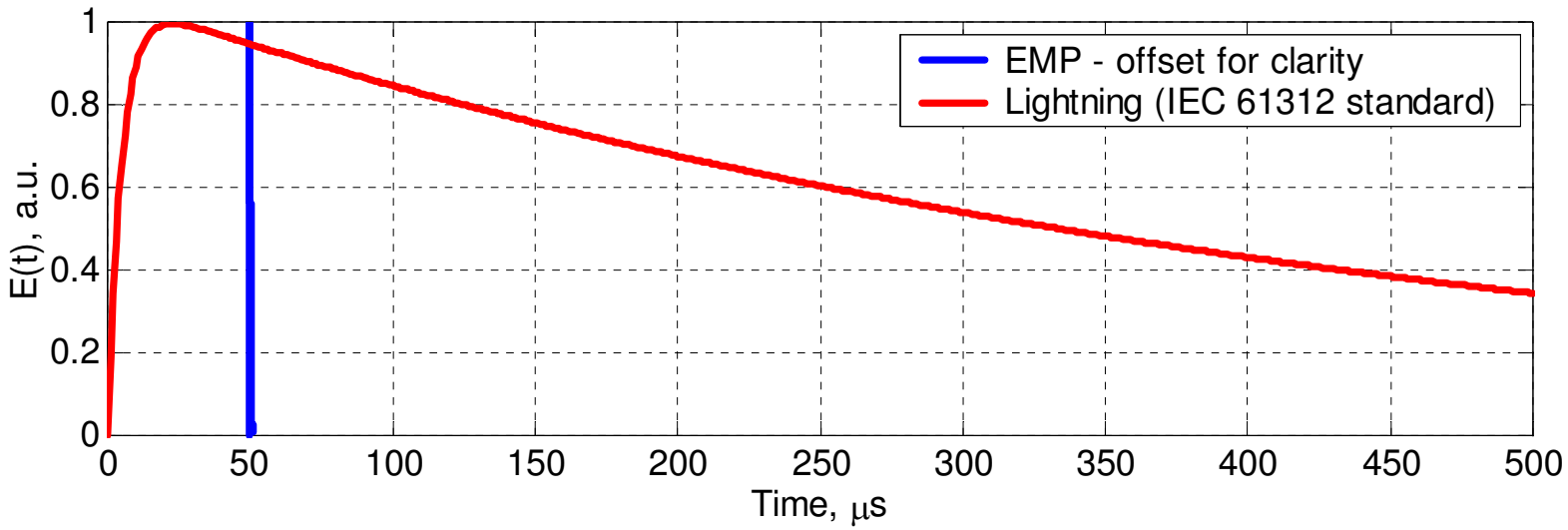
E V/m	H A/m	H Oersted/ Gauss	Energy flux S W/cm^2
15,000	40	0.5	60
50,000	135	1.6	650

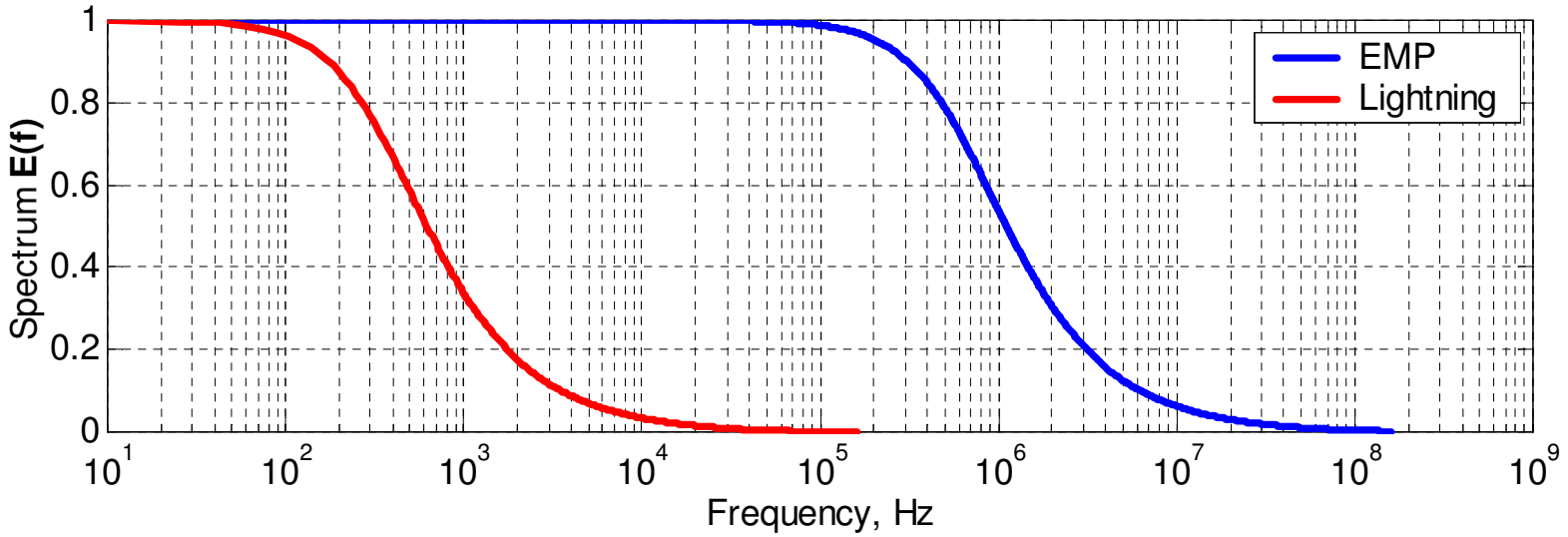
EMP wavefront





EMP vs. Lightning





Radio & Radar Effects

"The Effects of Nuclear Weapons", US DoD, 1962

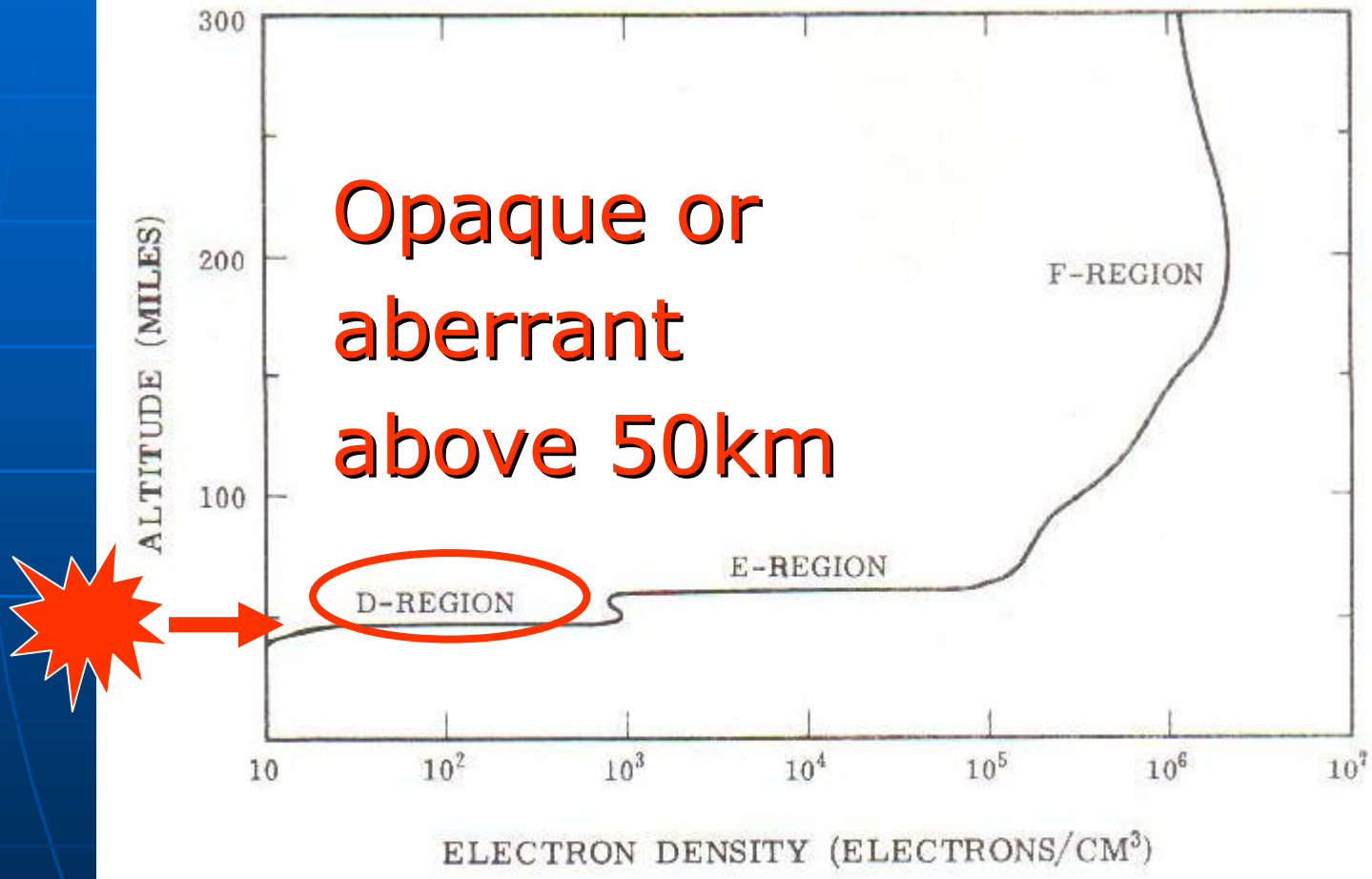


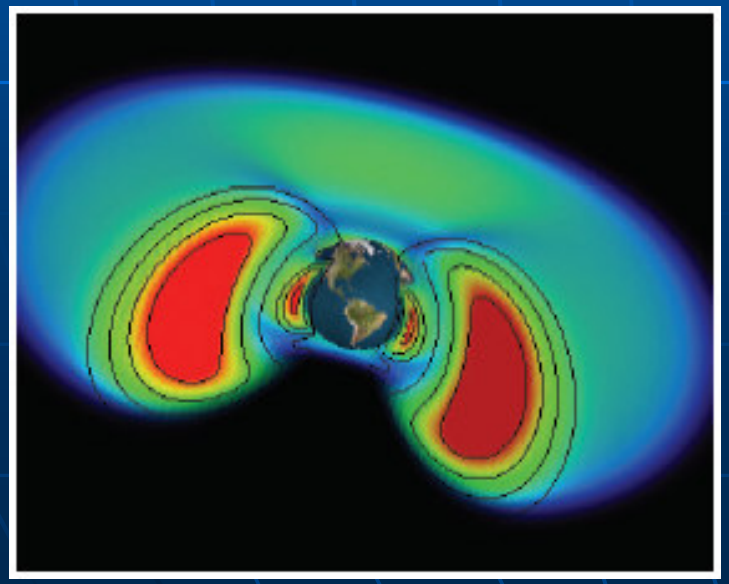
Figure 10.16. Electron densities in D-, E-, and F-regions of the ionosphere in the daytime.

Effects on Satellites

1. Direct γ-radiation => System-Generated EMP

2. Weapon debris => artificial

"trapped electron" (Van Allen) radiation belt



Satellite lifetime:

10 years => 2 months

Dr. George W. Ullrich, 1997
Deputy Director,
Defense Special Weapons Agency

EMP catastrophe?

"……. Few, if any people would die right away. But the loss of power would have a cascading effect on all aspects of U.S. society. Communication would be largely impossible. Lack of refrigeration would leave food rotting in warehouses, exacerbated by a lack of transportation as those vehicles still working simply ran out of gas (which is pumped with electricity). The inability to sanitize and distribute water would quickly threaten public health, not to mention the safety of anyone in the path of the inevitable fires, which would rage unchecked. And as we have seen in areas of natural and other disasters, such circumstances often result in a fairly rapid breakdown of social order. "

Senator Jon Kyl, Chairman;
US Senate Subcommittee on Terrorism, Technology & Homeland Security. *Washington Post* April 15 **2009**

"… whatever the target system, no indispensable industry was permanently put out of commission by a single attack. Persistent re-attack was necessary."

US Strategic Bombing Survey (European war)
Washington DC September 15 **1945**

Contents

- Nuclear weapons – basics
- Electromagnetic pulse (EMP) and related effects
- **EMP Protection**
- Conclusions

EMP Protection

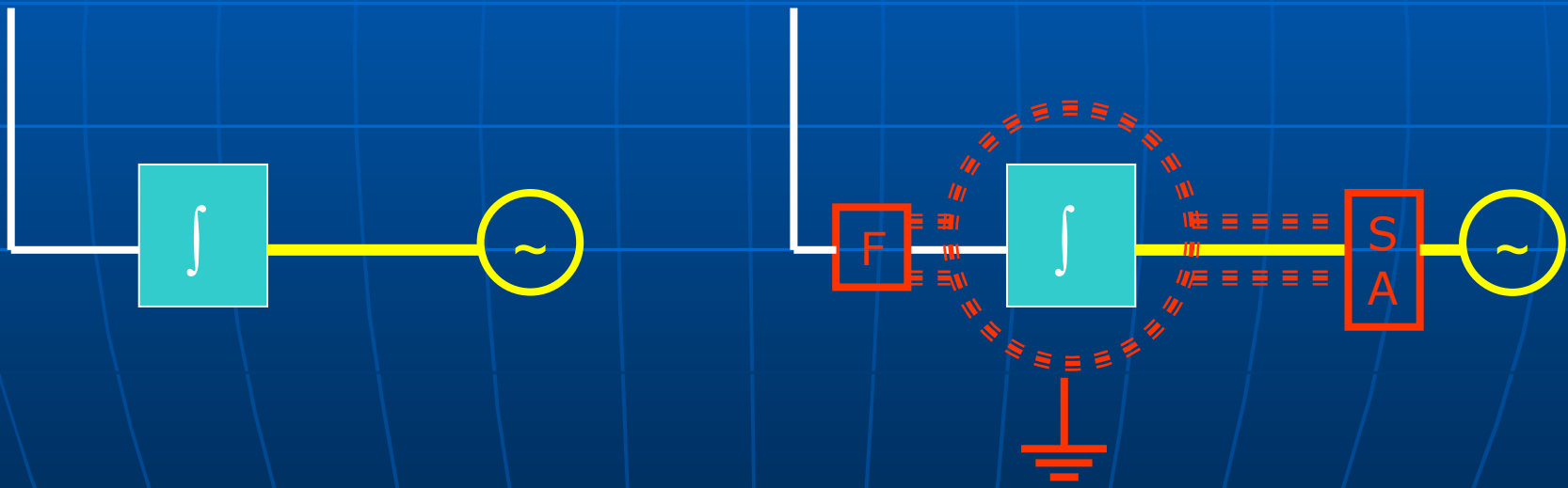
Screening

Bonding

Grounding

Filters

Surge Arresters



EMP Protection

Keep It Simple !

> "We have produced designs so complicated that we cannot possibly anticipate all the possible interactions of the inevitable failures; we add safety devices that are deceived or avoided or defeated by hidden paths in the systems." Charles Perrow, *Normal Accidents*

Cited by the US Congress

EMP Commission Report, 2008

EMP Protection

Holistic (synergetic-integrated-system) approach

> "Communicating across disciplines requires domain experts to learn one another's language to pose significant questions and usefully interpret answers," National Academy of Sciences, *Making the Nation Safer; The Role of Science and Technology in Countering Terrorism*

Cited by the US Congress

EMP Commission Report, 2008

EMP Protection

Screening
Bonding
Grounding

Filters
Surge Arresters

Hardening costs: 1%-3%
at the development stage

- ”New units can be EMP-hardened for a very small fraction of the cost of the non-hardened item, e.g., 1% to 3% of cost, if hardening is done at the time the unit is designed and manufactured. In contrast, retrofitting existing functional components is potentially an order of magnitude more expensive.“

The US Congress ***EMP Commission***
Executive Report, 2004

EMP Protection

Shared Benefits

Most of the … actions … militate against more than an EMP attack. The protection and/or rapid restoration of critical infrastructures in the civilian sector from an EMP attack also will be effective against other types of infrastructure disruptions, such as attacks aimed at directly damaging or destroying key components of the electrical system, and natural or accidental large-scale disruptions … Some of these steps also enhance reliability and quality of critical infrastructures, which is a major direct benefit to the US economy and to our way of life.

The EMP Commission
Executive Report, 2004

Conclusions

- EMP protection is **feasible**
- EMP protection is **affordable**:
  1-3% of electronics' cost
- Holistic approach is crucial
- **Time to act!**

Further Reading

The EMP Commission http://www.empcommission.org

Samuel Glasstone and Philip J. Dolan. *The Effects of Nuclear Weapons*. United States Department of Defense, 3rd edition (1977).

Philip J. Dolan. *The Capabilities of Nuclear Weapons*. Defense Nuclear Agency (1972; declassified 1989)

Other aspects of nuclear weapons

Academic Forum for Nuclear Awareness

http://www.afna-forum.org

and references thereof.