High-Altitude Nuclear Explosion

EMP Protection

Yehoshua Socol

2009
Contents

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

<table>
<thead>
<tr>
<th>Type</th>
<th>Yield Range</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Atomic&quot;</td>
<td>1-20 Kton</td>
<td>~0.5 km</td>
</tr>
<tr>
<td>Hiroshima</td>
<td>~15 Kton</td>
<td></td>
</tr>
<tr>
<td>Total destruction</td>
<td>~3-5 km</td>
<td></td>
</tr>
<tr>
<td>&quot;Hydrogen&quot;</td>
<td>100-1000 Kton</td>
<td>~3-5 km</td>
</tr>
<tr>
<td></td>
<td>much more complicated;</td>
<td></td>
</tr>
</tbody>
</table>
## Nuclear Proliferation

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Country</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>1945</td>
<td>India</td>
<td>1974</td>
</tr>
<tr>
<td>Russia</td>
<td>1949</td>
<td>Pakistan</td>
<td>1998</td>
</tr>
<tr>
<td>UK</td>
<td>1952</td>
<td>North Korea</td>
<td>2006</td>
</tr>
<tr>
<td>France</td>
<td>1960</td>
<td>(South Africa)</td>
<td>1982</td>
</tr>
<tr>
<td>China</td>
<td>1964</td>
<td>...</td>
<td></td>
</tr>
</tbody>
</table>
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
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**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 ?!**
High-altitude EMP: above 30 km

High-Altitude EMP coverage

Distance to Horizon (LoS), km

Height of Burst H, km

High-altitude EMP: above 30 km
EMP

Air Force Institute of Technology
Wright-Patterson AF Base, Ohio

<table>
<thead>
<tr>
<th>Weapon</th>
<th>20</th>
<th>1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield</td>
<td>15,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Kton</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$E_{\text{max}}$ V/m</td>
<td>15,000</td>
<td>50,000</td>
</tr>
</tbody>
</table>

20 kt A-bomb 1000 kt H-bomb
## EMP wave

<table>
<thead>
<tr>
<th>E V/m</th>
<th>H A/m</th>
<th>H Oersted/Gauss</th>
<th>Energy flux S W/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>15,000</td>
<td>40</td>
<td>0.5</td>
<td>60</td>
</tr>
<tr>
<td>50,000</td>
<td>135</td>
<td>1.6</td>
<td>650</td>
</tr>
</tbody>
</table>
High-Altitude EMP Wavefront

$E(t)$, a.u.

Time, ns

Frequency, Hz

Spectrum $E(f)$

EMP wavefront

EMP wavefront
EMP vs. Lightning

**Time, µs**

- EMP - offset for clarity
- Lightning (IEC 61312 standard)

**Frequency, Hz**

- EMP
- Lightning
Radio & Radar Effects


Opaque or aberrant above 50km

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

1. Direct $\gamma$-radiation $\Rightarrow$ System-Generated EMP

2. Weapon debris $\Rightarrow$ artificial
   "trapped electron" (Van Allen) radiation belt

Satellite lifetime:
10 years $\Rightarrow$ 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;

“... 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
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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
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  Filters
Bonding  Surge Arresters
Grounding

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


*Other aspects of nuclear weapons*

Academic Forum for Nuclear Awareness

http://www.afna-forum.org

and references thereof.