



Preparing for an EMP

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Before we start

1. This is not an easy topic
2. In CARES and CCC, we prepare for the worst, and hope for the best.
3. The information available on EMP is fragmented and a mix of fact, speculation and misinformation; it requires time to find, sift through, and draw your own conclusions.
4. Given the current state of the world, this is an important topic to at least, if nothing else, raise awareness.
5. This presentation introduces EMP and then focuses on equipment protection.
6. I don't have all the answers, and we are still learning.



What keeps us up at night?

The City has listed the following as hazards of concern:

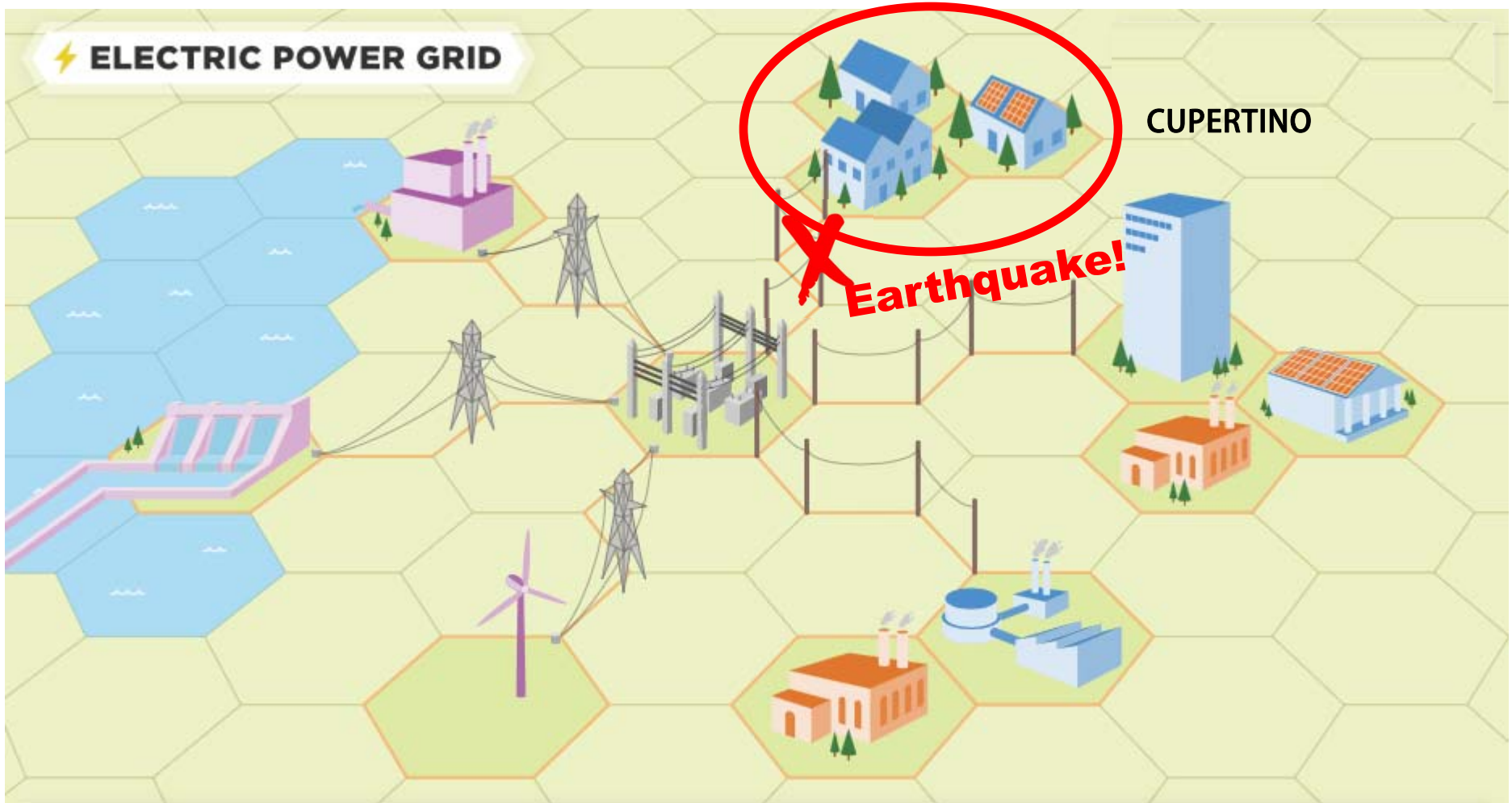
1. Major Earthquake *
2. Wildland/Urban Interface Fire *
3. Flood
4. Landslide
5. Drought/Land Subsidence
6. Climate change
7. Thunderstorms and Lightning
8. Heat
9. Public Health Emergency
10. Technological and Resource Emergency *
11. Hazardous Material Incident
12. Terrorism, Complex and Coordinated Attack, & Civil Unrest *

* Electricity Loss →
Communications Outage

Ref: Cupertino Emergency Operations Plan, 2019



Local Electricity Loss Event



U.S. Electricity Consumption by Sector (2020)

1. Residential

- Uses 40% of the electricity nationwide

2. Commercial

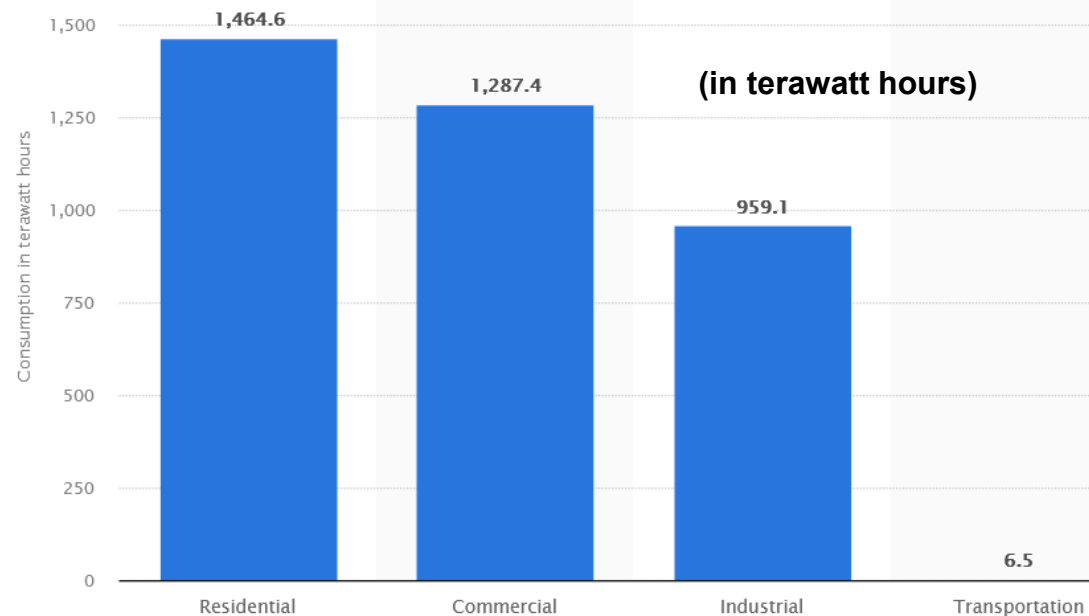
- includes government facilities, service providing facilities and equipment, and other public and private organizations

3. Industrial

- for processing, producing, or assembling goods
- more than half used in manufacturing to power various motors (machine drive)
- Other large use is heating, cooling, and electro-chemical processes where electricity is used to cause a chemical transformation.

4. Transportation

- This sector consumes most of its energy by directly burning fossil fuels such as gasoline, diesel, and jet fuel
- Some electric vehicle use



What could cause a failure?

Communications Outage

- **Loss of Power**
 - Power failures – accidental, natural, intentional
- **Loss of Connectivity**
 - Cable breaks – accidental, natural, intentional
- **System Overload**
 - Some out-of-the-ordinary event that causes a lot of people to use the phone at the same time
- **Solar Storms, Solar Flares, EMP**
 - Power failures, Communications failures – natural, intentional



What is an EMP?

Definition

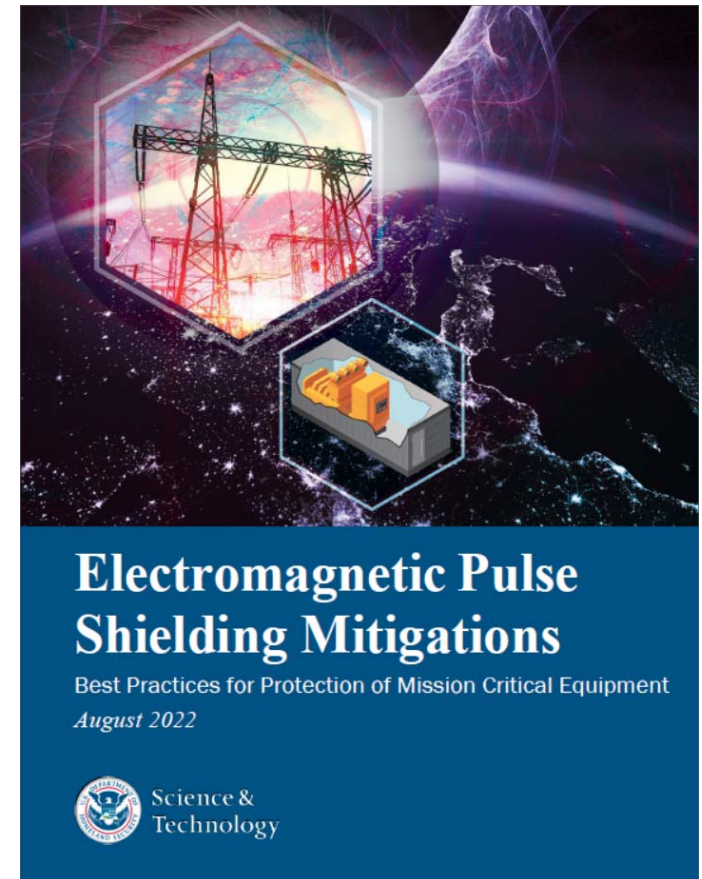
EMP – Electromagnetic Pulse

1. An EMP is a natural or human-made discharge of electromagnetic energy that can damage electronic circuitry. Such a burst of energy can be created by a solar storm or a nuclear detonation.
2. *“Electromagnetic pulses, whether caused by an intentional EMP attack or a naturally occurring geomagnetic disturbance from severe space weather, could disrupt critical infrastructure such as the electrical grid, communications equipment, water and wastewater systems, and transportation modes.”* -- DHS undersecretary for science and technology
3. The frequency range of a nuclear generated EMP is effectively from 1 KHz to 100 MHz.



Why are we talking about this now?

- **Department of Homeland Security:**
Electromagnetic Pulse Shielding Mitigations: Best Practices for Protection of Mission Critical Equipment, August 2022
- https://www.dhs.gov/sites/default/files/2022-09/22_0902_st_emp_mitigation_best_practices.pdf
- **State of California:**
Governor Signs Sen. Dodd's Electromagnetic Pulse Attack Bill, Sep 2022



Amid renewed fears of Russian nuclear aggression, Gov. Gavin Newsom signed legislation adding electromagnetic pulse (EMP) attacks to the grounds under which he could declare a state of emergency.



Causes of EMP events

Natural EMP events

1. **Lightning EMP.** The discharge is typically an initial huge current flow, at least mega-amperes, followed by a train of pulses of decreasing energy.
2. **Meteoric EMP.** The discharge of electromagnetic energy resulting from either the impact of a meteoroid with a spacecraft or the explosive breakup of a meteoroid.
3. **Coronal Mass Ejection (CME, Solar EMP).** A burst of plasma and accompanying magnetic field ejected from the sun and released into the solar wind.

Man-made EMP events

1. Electric motors; internal electrical contacts make/break as the armature rotates.
2. Gasoline engine ignition systems as the spark plugs are energized or fired.
3. Power line surges. These can be up to several kilovolts, enough to damage electronic equipment that is insufficiently protected.

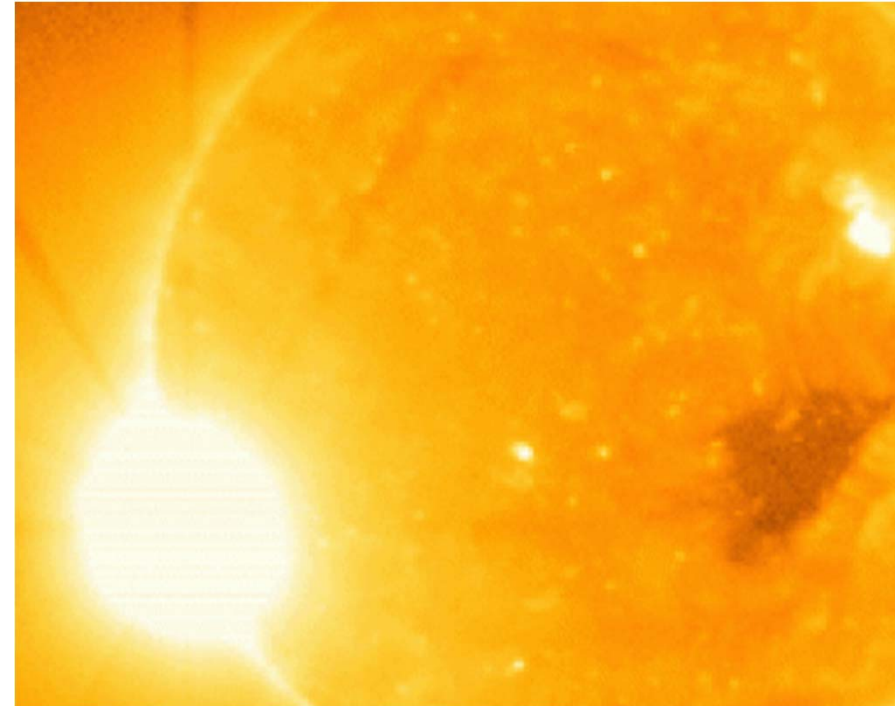
Military EMP events

1. **Nuclear EMP (NEMP),** as a result of a nuclear explosion.
2. **High altitude nuclear EMP (HEMP),** produces a secondary pulse due to particle interactions with the Earth's atmosphere and magnetic field.

Documented EMP Events – CME

Carrington Event

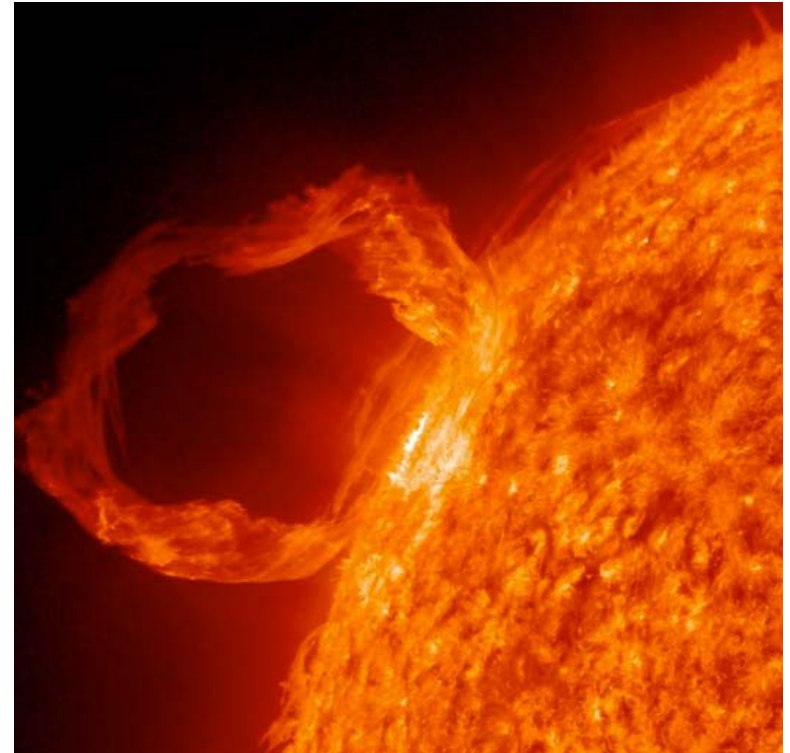
1. August 1859; A solar **Coronal Mass Ejection** (CME) that hit Earth's magnetosphere and induced one of the largest geomagnetic storms on record.
2. CME is when the sun ejects a mass of charged particles out into space.
3. This CME traveled to Earth, taking 17.6 hours to make the 93 million miles journey (typical CMEs take several days to arrive at Earth).
4. Auroras (northern lights) were seen around the world, those in the northern hemisphere as far south as the Caribbean.
5. Telegraph systems all over Europe and North America failed, in some cases giving telegraph operators electric shocks and setting fire to some telegraph offices.
6. Lloyd's of London and U.S.-based Atmospheric and Environmental Research (AER) used Carrington Event data to estimate the current cost of a similar event to the U.S. alone at \$0.6 – 2.6 trillion.



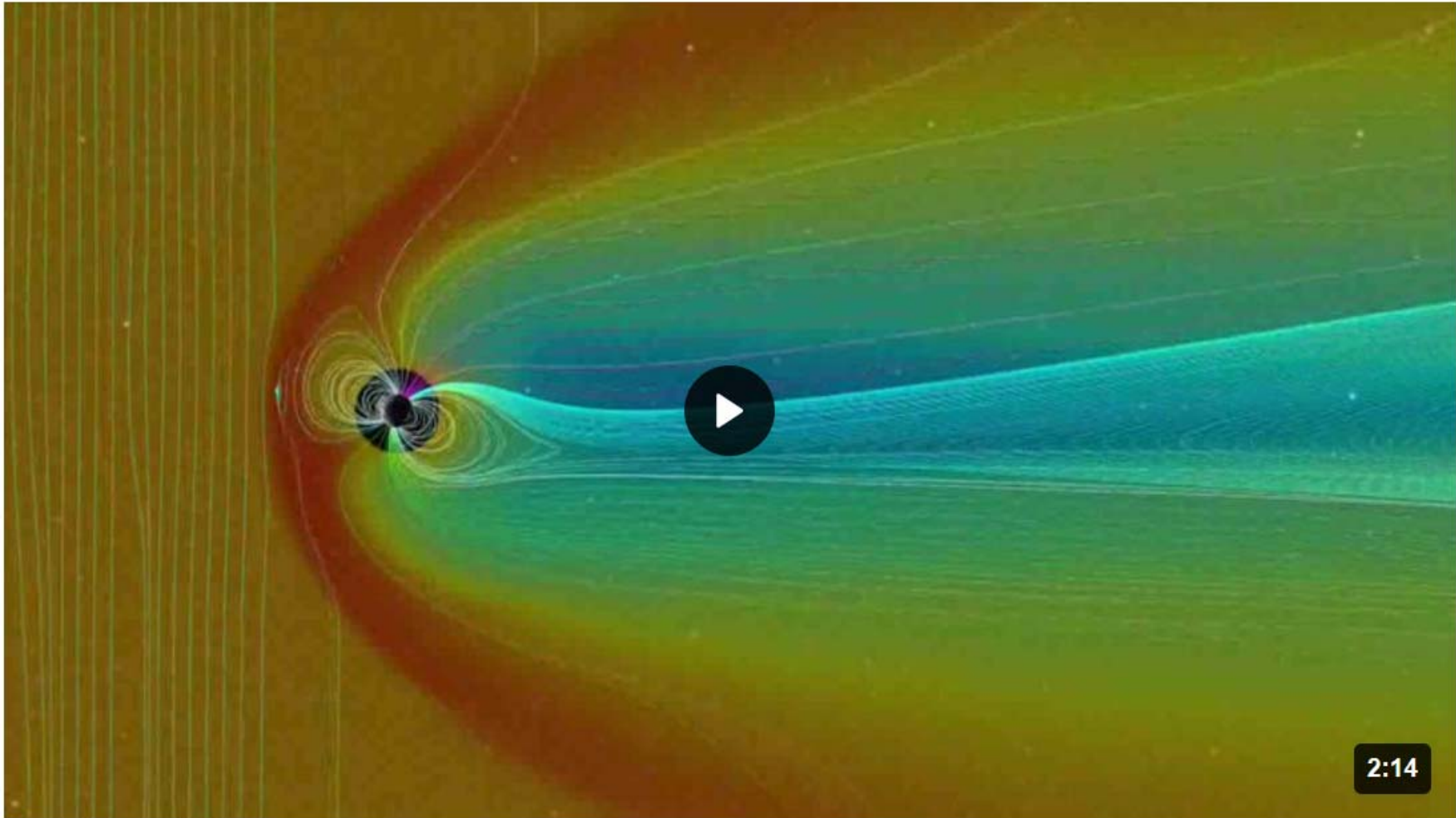
CME Event... *Near Miss*

Carrington-Class CME

1. 23 July 2012; the sun unleashed two massive clouds of plasma that *barely missed* the Earth.
2. This CME is thought to be the most powerful in at least 150 years.
3. If this event occurred a week earlier, earth would have been facing the point of eruption resulting in a potentially disastrous outcome.
4. Per NASA, “a direct hit ... would have caused widespread power blackouts, disabling everything that plugs into a wall socket. Most people wouldn’t even be able to flush their toilet because urban water supplies largely rely on electric pumps.”
5. Per the National Academy of Sciences, the total economic impact could have exceeded \$2 trillion. Multi-ton transformers damaged by such a storm might take years to repair.



CME Event... what does it look like?



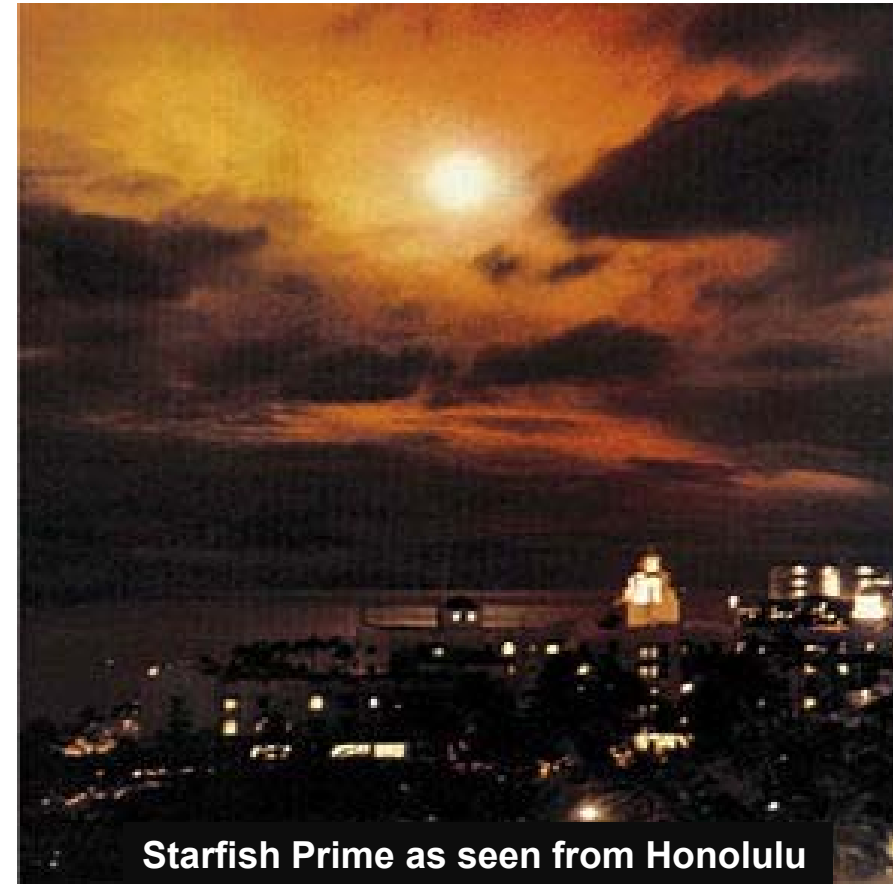
https://en.wikipedia.org/wiki/File:Comparing_CMEs.ogv



Documented EMP Events – Military

Starfish Prime

1. July 9, 1962; high-altitude nuclear test conducted by the United States.
2. The largest nuclear test conducted in outer space and one of five conducted by the U.S. in space.
3. A 1.4 megaton device detonated at an altitude of 250 miles, about 10° above the horizon as seen from Hawaii, 11pm HST.
4. EMP was far larger than expected; caused electrical damage in Hawaii about 898 mi away from the detonation point.
5. About 300 streetlights were knocked out and numerous burglar alarms were set off. The EMP damage to a microwave link shut down telephone service between Kauai and the other Hawaiian islands.



Documented EMP Events – Military

Test 184

1. 22 October 1962; one of three EMP-producing nuclear tests in space over Kazakhstan by the Soviet Union.
2. A 300 kiloton device detonated at an altitude of 180 miles over a populated, large land mass and where the Earth's magnetic field is greater.
3. The damage caused by the resulting EMP was reportedly much greater than that of Starfish Prime.
4. EMP ran to thousands of amps, damaged at least 350 miles of telephone lines, 620 miles of buried power lines, and caused the destruction of the Karaganda power station.



Types of EMP Pulses

Three Types of Pulses

- **E1 pulse:** the quickest pulse of all EMPs. It is very brief but extremely intense. This is the pulse from a nuclear blast or other EMP weapon.
 - can destroy computers and communications equipment
 - it changes too fast for ordinary lightning surge protectors to provide effective protection against it.
- **E2 pulse:** slower than an E1. similar to a bolt of lightning.
 - E2's are typically the easiest to protect against (surge protectors). But a nuclear blast or EMP weapon has the characteristics of both an E1 and an E2 pulse.
- **E3 pulse:** the slowest of the pulses; could last minutes, hours, or days.
 - This is the type of pulse found in intense CMEs from our Sun.



EMP Event Impact

How it destroys electronics

1. Direct; in the form of energy waves

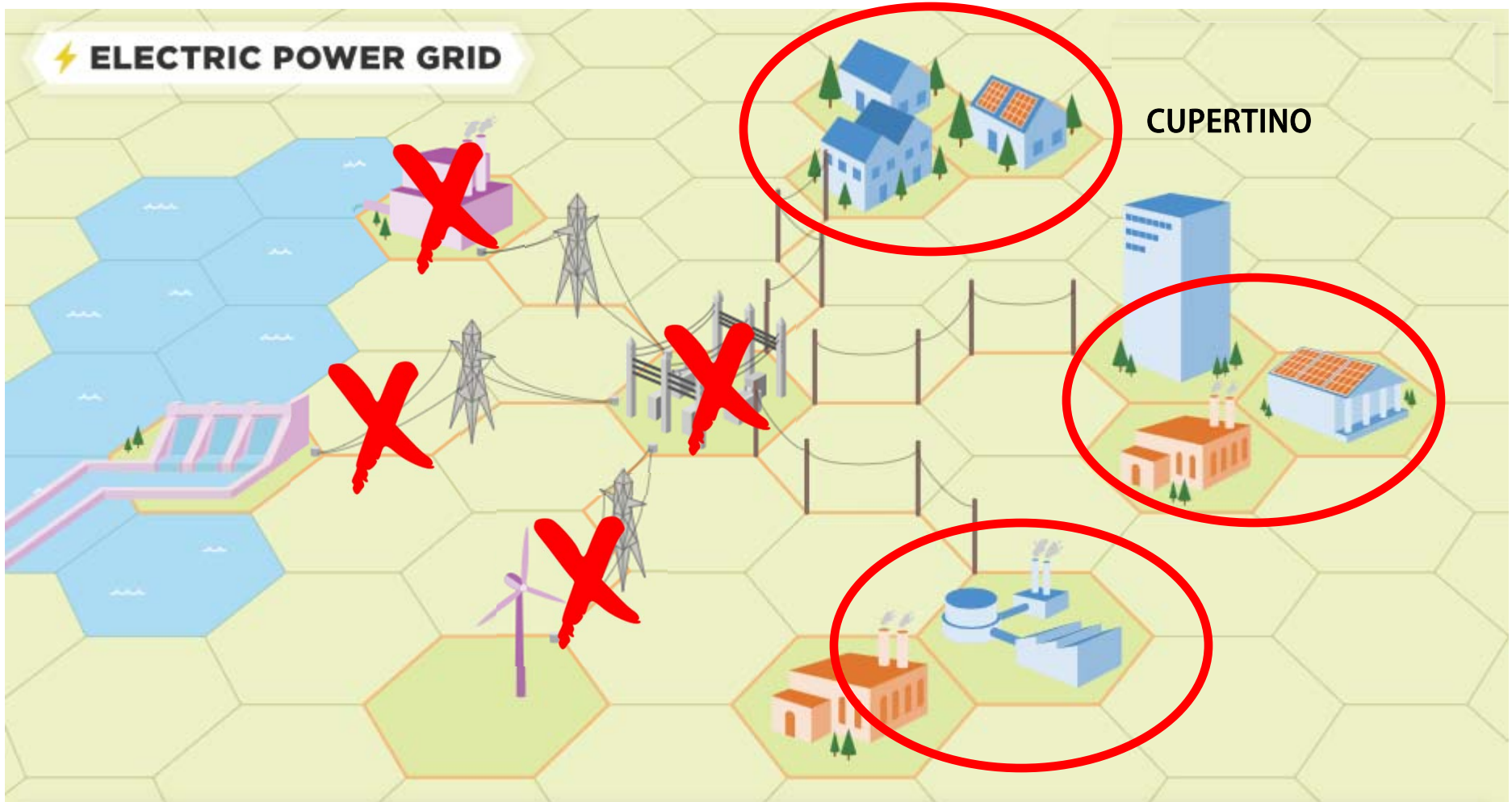
- Impacts a variety of electronic devices, especially those that have attached wires that act as antennas.

2. Via the power grid

- The millions of miles of transmission lines run across the country will act as an immense antenna. When an EMP reaches the power lines, it will induce a huge spike.
- Normal surge protectors are designed for the much slower power surge created by lightning. EMP voltage spikes are significantly faster. Surge protectors will not trip in time to block the spike.
- Devices plugged into a home outlet on the grid will be impacted.



Regional/National Electrical Loss Event



EMP Event Impact

Device winners and losers

What survives

- Electric devices that aren't controlled by solid-state electronics
- Vintage electronics, especially if it uses vacuum tubes.
- Solar panels; may see a slight degradation of their power output (5% to 10%)
- Pre-1980 automobiles (no electronic ignition)
- Items in shielded protective enclosures / Faraday Cages
- Possibly small electronics

What may not work

- Any modern electronics, like
 - SCADA¹ systems
 - computers
 - network gear
- Possibly small electronics - cell phones, tablets, etc.
- Power infrastructure
- Mass transit, freight hauling (power for the fuel pumps, the trucks themselves)
- Things plugged into an electrical outlet

¹SCADA: Supervisory Control and Data Acquisition; an industrial computer system that monitors and controls a process



EMP Event Takeaways

- Modern society is deeply dependent on some very sensitive technologies such as GPS, satellite communications, and the Internet that all that have a total reliance on the national power infrastructure.
- Per the EMP Commission report,
 - “...even a relatively modest-to-small yield weapon of particular characteristics can produce a potentially devastating E1 field strength over very large geographical regions.”
 - The impact of such an EMP-triggered outage would be severe but not catastrophic **IF** the recovery was rapid or the geographic impact sufficiently limited.
- ***The worst case:*** We lose the ***magic of technology*** that keeps us in the manner to which we are accustomed.



EMP Event Takeaways

- Without electricity, things stop.
- The consequences of lack of food, heat, water, waste disposal, medical, police, fire fighting, and effective civil authority would threaten society itself.

In short...

- A significant CME or HEMP event would totally ruin our day.

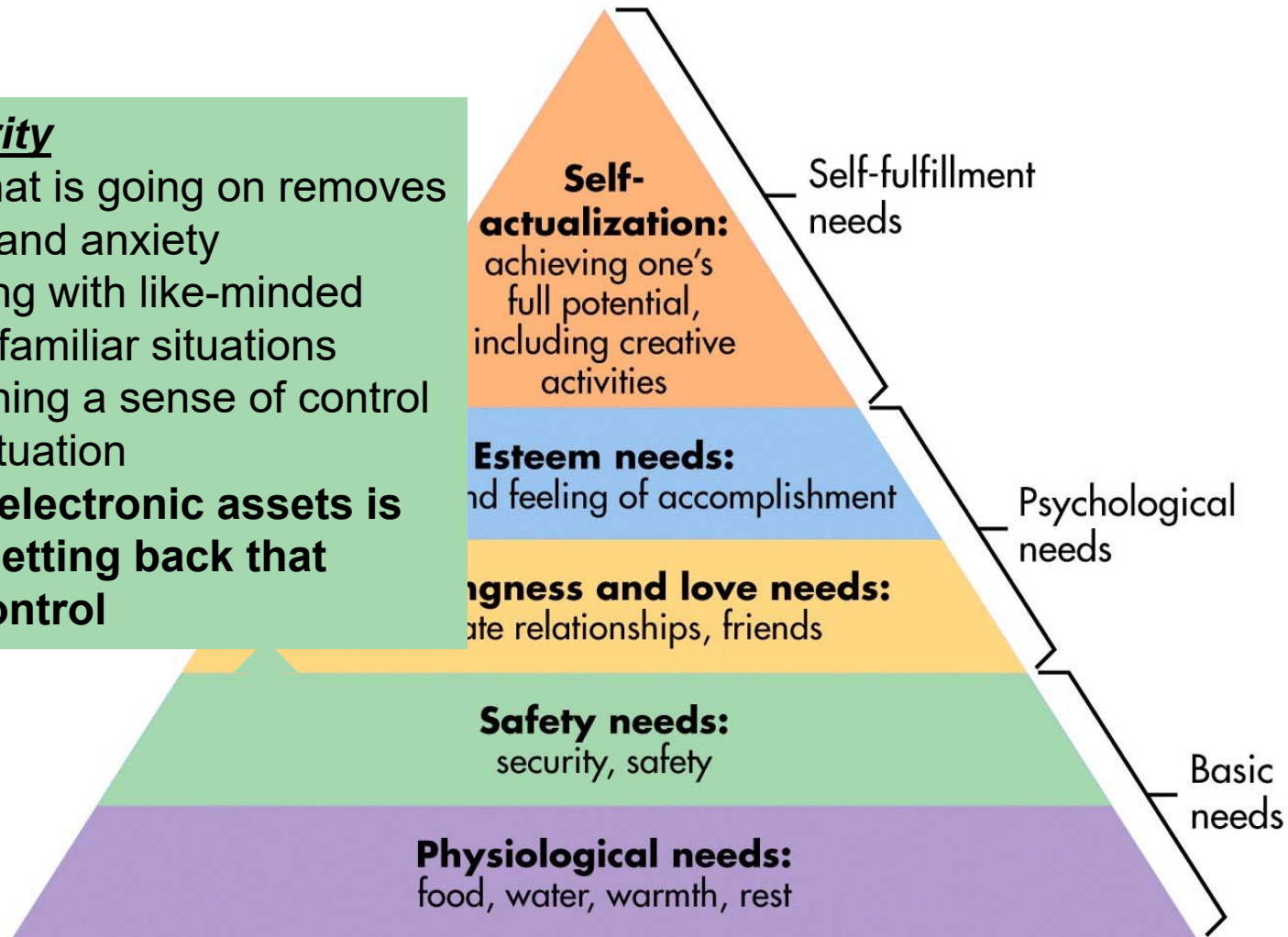


Preparing for an EMP... where to start?

Maslow's hierarchy of needs

Safety, Security

- Knowing what is going on removes uncertainty and anxiety
- Reconnecting with like-minded individuals, familiar situations
- Re-establishing a sense of control over your situation
- **Protecting electronic assets is critical to getting back that sense of control**



Preparing for an EMP

Why protect electronic assets?

1. Having the ability to communicate via radio and generate power can give you a huge advantage when trying to survive in a powerless world.
2. Having a large amount of information that you can store in digital format allows you to restart your life at a mid-1800s level.

Method

1. Faraday Cage; Michael Faraday discovered the properties for shielding against electromagnetic waves, including electricity.

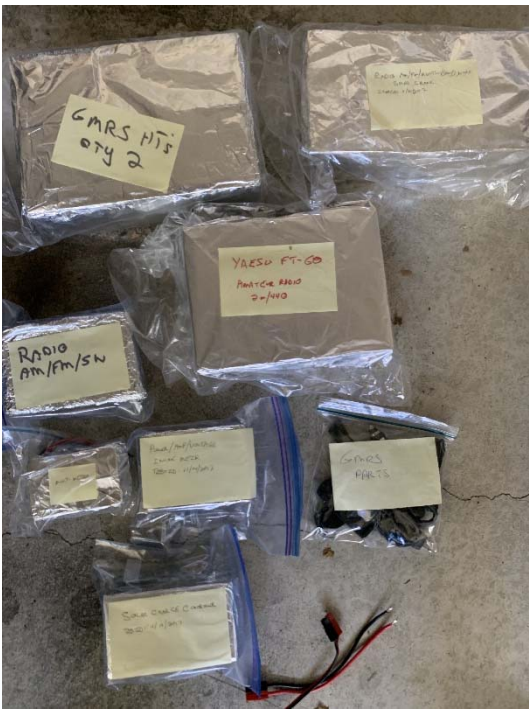


Preparing for an EMP

How-to (very high level)

1. Build your own at home using aluminum foil, a galvanized steel trash can, and aluminum foil tape.
2. Keep electronics in their original package.
3. Wrap packages in aluminum foil... 2nd shield.
4. Apply foil tape over all joints and connect points of your trash can.
5. Line the can with cardboard (insulates the contents from the walls).
6. Place packages in can, ensure the lid is on tight... 1st shield.
7. Read the USAF's EMP Handbook for a discussion on [shielding](#).





Preparing for an EMP

What should we protect (1st pass)?

1. Ham Radio equipment
2. AM/FM/SW Radio
3. A set of walkie-talkies (FRS/GMRS) that run on rechargeable batteries
4. Mp3 players filled with music; spare sets of earphones.
5. Digital cameras
6. Solar battery chargers (implies one or more solar panels available)
7. A Kindle or tablet with all kinds of references, survival books, classics, the Bible
8. One or more digital watches and clocks (pre-buy a wind-up clock / watch)
9. An old laptop computer with ebook downloads; stored personal information
10. Any and all digital photos stored on a DVD and/or a thumb drive
11. Scanned documents stored on a DVD and/or thumb drive
12. Small DVD player
13. ... what else?



How real is this threat?

1. Lightning – Infrequent, but not unheard of.
2. Significant CME – roughly every 150 years? This is based on only 2 documented data points: 1859, 2012
3. HEMP – ??



If you want to know more

Technical References

1. *EMP Handbook for Air Force Communications Service Communications-Electronics-Meteorological Engineers*, 1842 Electronics Engineering Group, USAF, October 1976; 78 pages.
<http://www.dtic.mil/dtic/tr/fulltext/u2/a060435.pdf>
2. *Comparison of the RF Frequency Spectra of HEMP and Lightning*, Defense Nuclear Agency, March 1991; 48 pages.
<http://www.dtic.mil/dtic/tr/fulltext/u2/a234306.pdf>
3. *Transient Radiation Effects on Electronics (TREE) Handbook*, Defense Nuclear Agency, December 1995; 507 pages
<http://www.dtic.mil/dtic/tr/fulltext/u2/a302734.pdf>
4. *EMP Generation Mechanism and its Destructive Effect on C³I Network*, Defence Electronics Application Laboratory, Dehradun, Published in IEEE ElectroMagnetic Interference and Compatibility 2006 Proceedings of the Int'l Conference. <http://ids.nic.in/jces/art-3.htm>
5. *The Report of the Commission to Assess the Threat to the United States from an Electromagnetic Pulse (EMP) Attack*, EMP Commission, April 2008; 208 pages
<http://www.futurescience.com/emp/A2473-EMP-Commission.pdf>
6. *Intentional Electromagnetic Interference (IEMI) and Its Impact on the U.S. Power Grid*, Metatech Corporation, January 2010, for Oak Ridge National Laboratory; 53 pages
https://www.ferc.gov/industries/electric/indus-act/reliability/cybersecurity/ferc_meta-r-323.pdf
7. *U.S. Department of Energy Electromagnetic Pulse Resilience Action Plan*, U.S. Department of Energy, January 2017; 26 pages
<https://energy.gov/sites/prod/files/2017/01/f34/DOE%20EMP%20Resilience%20Action%20Plan%20January%202017.pdf>

If you want to know more

Lite reading:

1. *One Second After*, William R Forstchen, 2009. The novel deals with an unexpected electromagnetic pulse attack on the United States and how it affects the people living in a small American town.

On-line Movie:

2. ***American Blackout 2013***, 2013, National Geographic, YouTube 1hr 27:00 min.

Interesting On-line References (this is not that is out there):

3. Google: “survival mom emp”

- <http://thesurvivalmom.com/emp-survival-first-things-to-do/>
- <http://thesurvivalmom.com/why-and-how-to-protect-your-gear-from-emp/>
- <http://thesurvivalmom.com/post-emp-survival-what-if-you-cant-get-home/>
- <http://thesurvivalmom.com/whats-in-your-faraday-cage-a-common-sense-guide-to-preparing-for-an-emp/>



Thank you

Any Questions?

