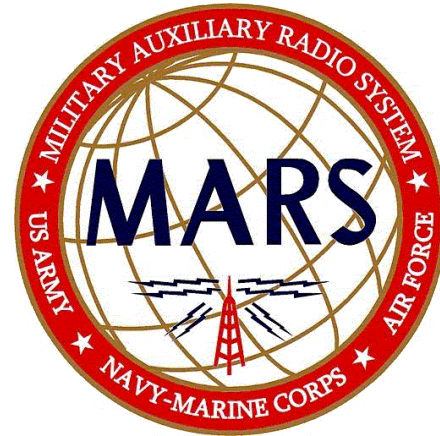


UNCLASSIFIED



U.S. AIR FORCE

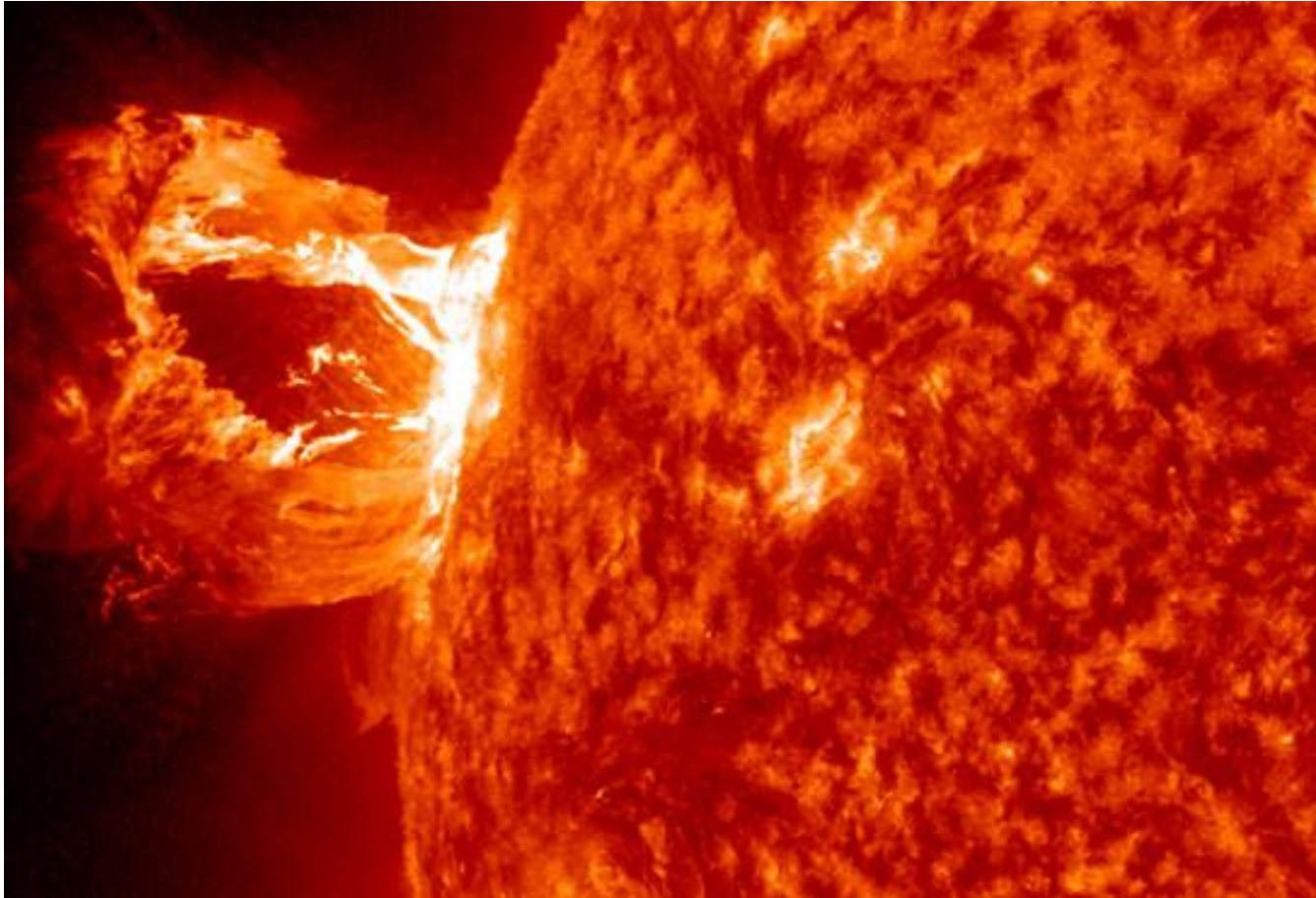


What If a Solar CME or Nuclear EMP happens?

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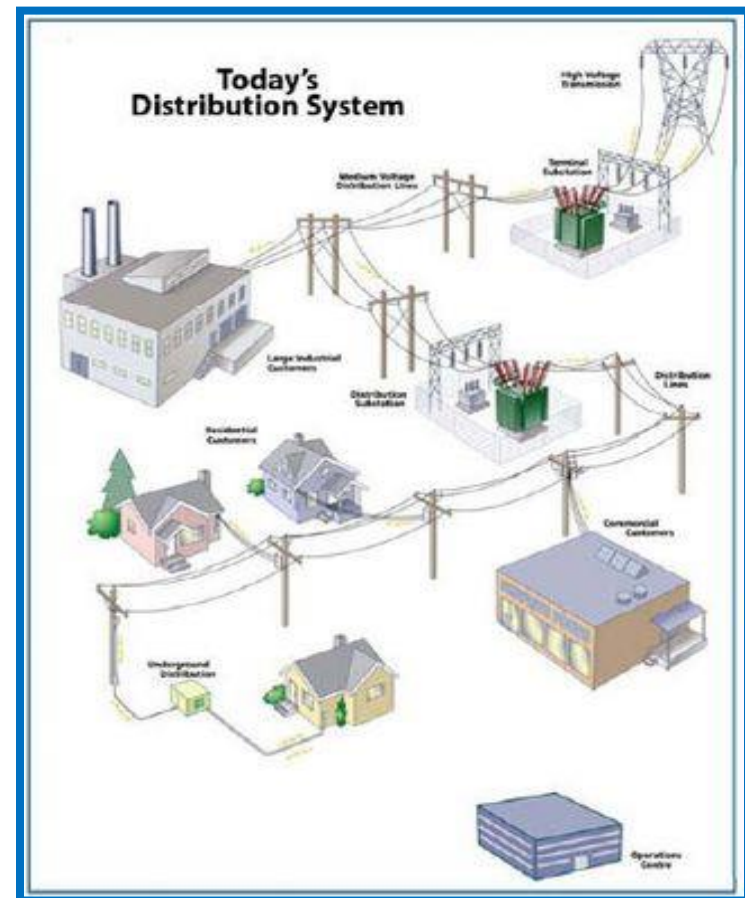
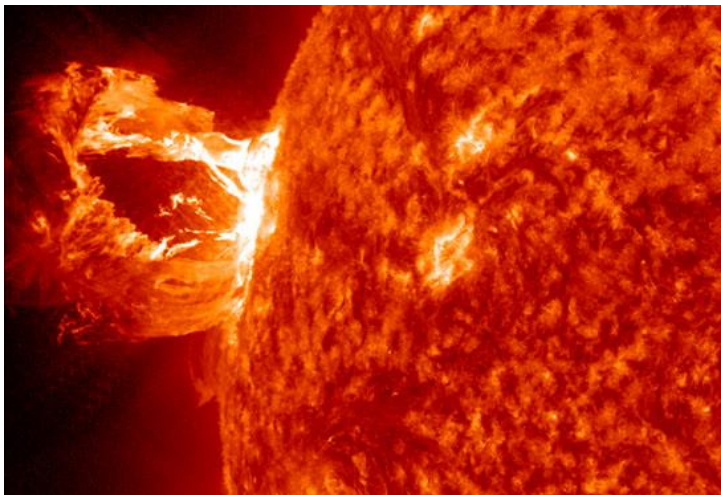


What If a Solar CME or Nuclear EMP happens?



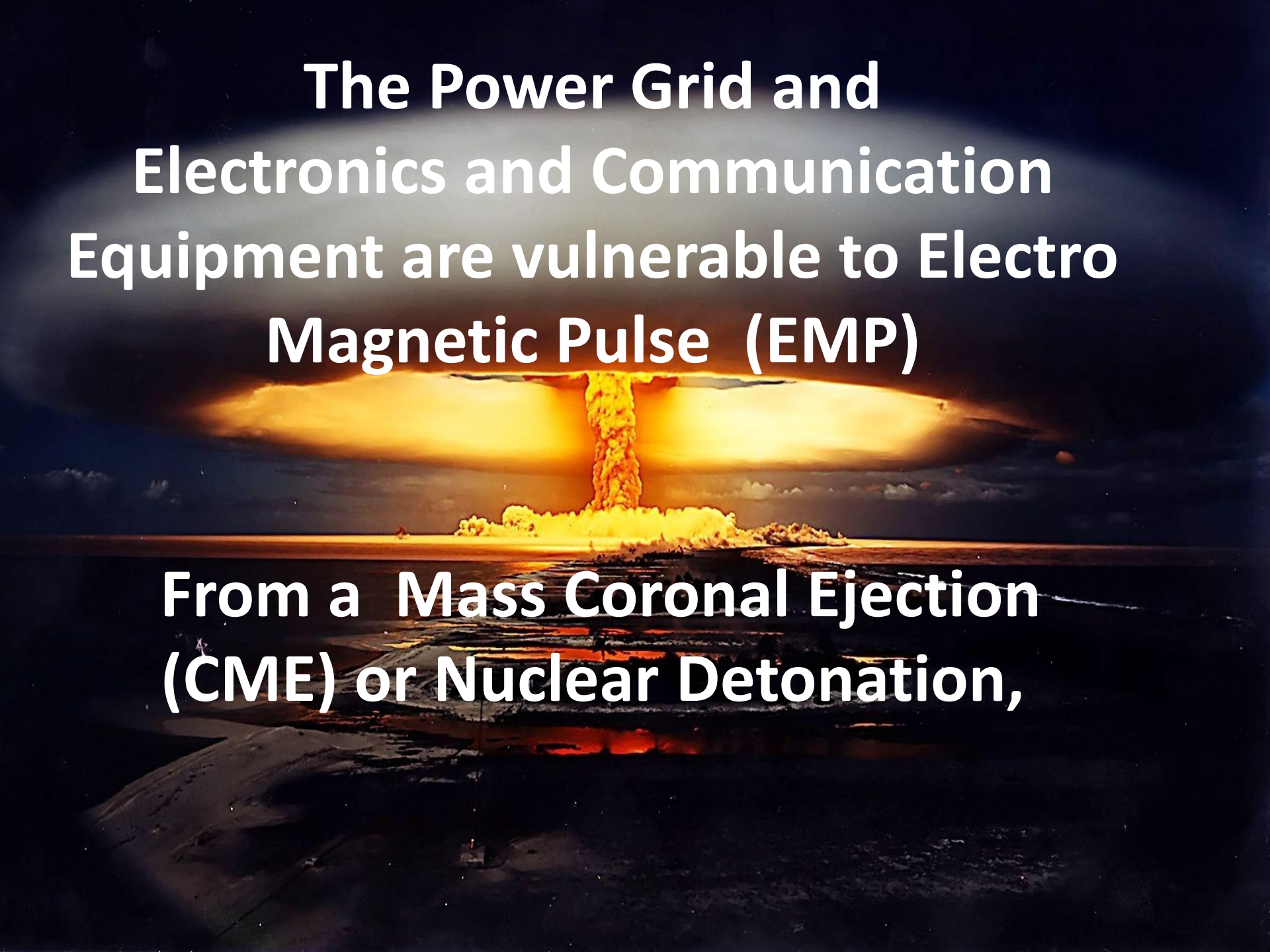
What If a Solar or Nuclear EMP happens?

Is it the end of our Electronic World?



**The Power Grid and
Electronics and Communication
Equipment are vulnerable to Electro
Magnetic Pulse (EMP)**

**From a Mass Coronal Ejection
(CME) or Nuclear Detonation,**



Monocultures

- Monocultures occur when society becomes dependent on a single crop, natural resource, network, technology, etc.
- We are at risk when one of these monocultures we are totally dependent on fails and we have no, or insufficient back up capability

The Irish Agriculture Monoculture

- The Irish Potato Famine was caused by a crop monoculture where the potato was the main food crop. When the potato crops failed, they had no alternative crop, and many died.



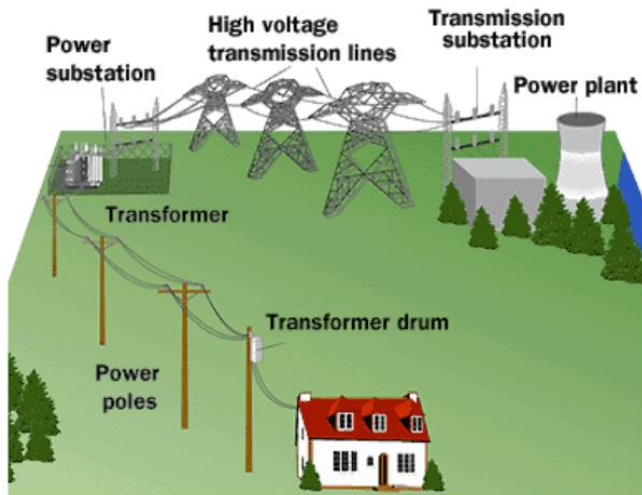
Our Electricity Monoculture



Today we are dependent on electricity
in most developed countries

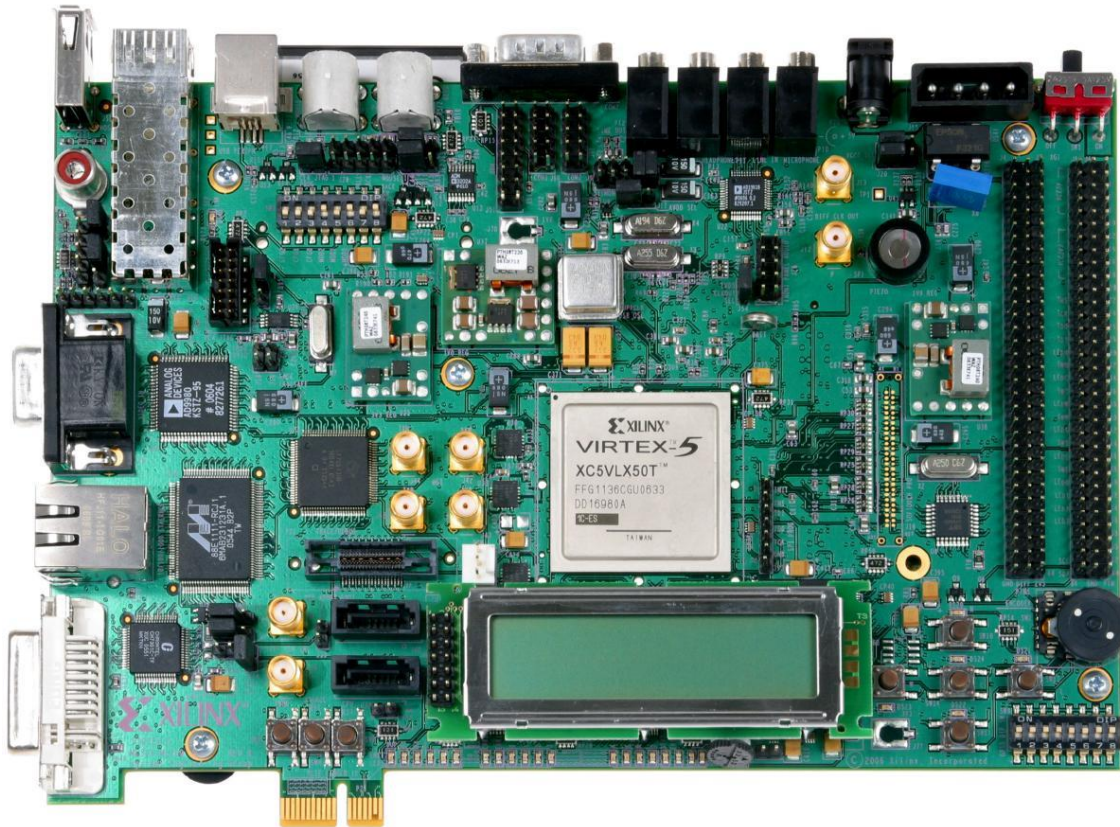
Power Distribution Networks

During a CME or Nuclear EMP Event our power distribution system would look like a giant antenna farm



Modern Electronic Devices

Typical modern electronics circuits contain many semiconductor and other fragile components.



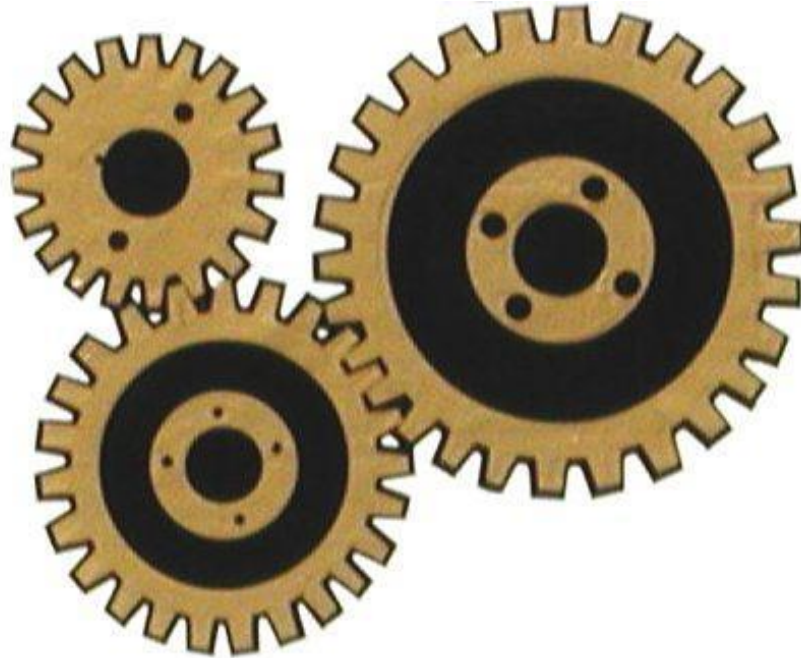
Our Civilization Wide Monoculture

- Most everything we do today relies on Electrical, Electronic and Digital technology.
- Electricity is the foundation of our Industry, Logistics, Operations, Finance and Communications.
- Public, Truck, Rail, Automobile transportation all use electronic technology and solid-state devices.



Our Civilization Wide Monoculture

(continued)

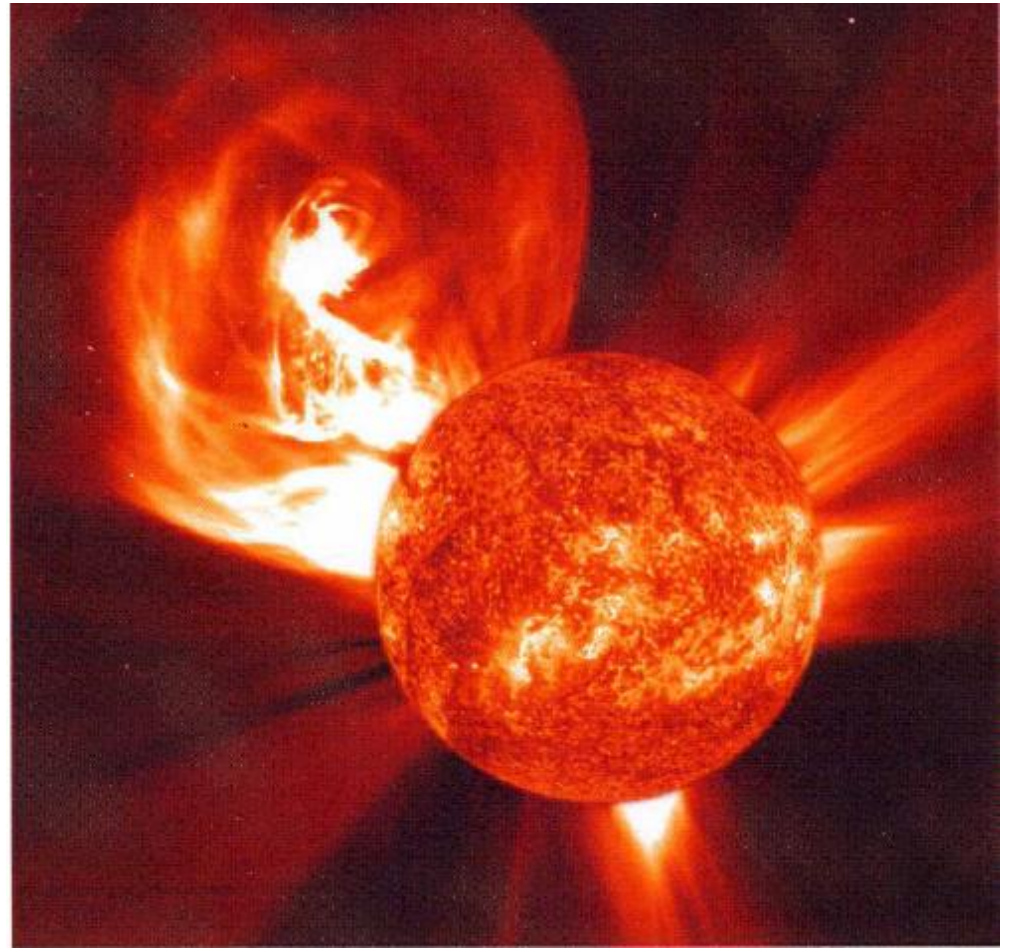


Everything is running smoothly today.

So what could possibly go wrong?

Mass Coronal Ejections and EMP

**The Sun
Could
have a
Bad Day**



Nuclear Explosion and EMP

**Mankind
Could
Also Have
a Bad Day**



Two Threats: Nature and Man

- Electro Magnetic Pulse (**EMP**) can come from the sun by way of a Mass Coronal Ejection (giant Solar Flare) referred to as a *CME*.
- Electro Magnetic Pulse (**EMP**) can also come from a high-altitude Atomic Device detonation.
- Both events are of unknown (Low?) likelihood.
- Either of these events could significantly alter our way of life because of our Electrical/Electronic dependence.

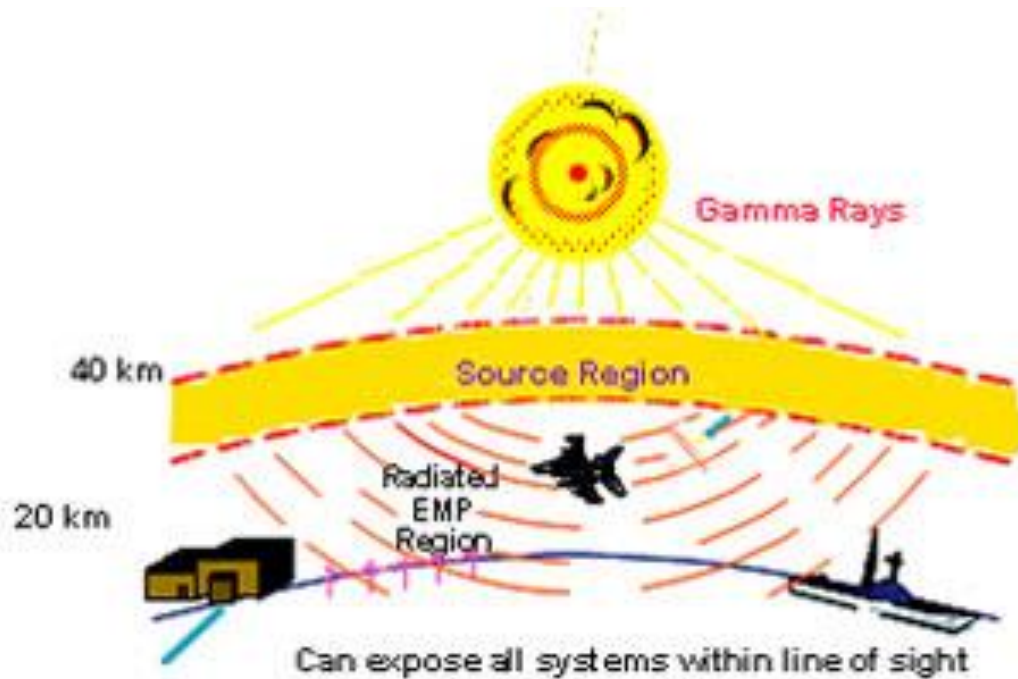
Nuclear EMP

- **Nuclear EMP is actually an electromagnetic multi-pulse.** The EMP is usually described in terms of 3 components.
- The **E1** pulse is a very fast (nanosecond) pulse that can induce very high voltages in equipment and along electrical wiring and cables. **E1** is the component that destroys computers and communications equipment and is too fast for ordinary surge and lightning protectors.

The E1 Component

- The **E1** component of the pulse is the most commonly-discussed component.
- The gamma rays from a nuclear detonation in space can travel great distances. When these gamma rays hit the upper atmosphere, they knock out electrons from atoms in the upper atmosphere, which travel in a generally downward direction.
- This forms what is essentially an extremely large coherent vertical burst of electrical current in the upper atmosphere over the entire affected area.

The E1 Component (continued)



The E1 Component (continued)

- This current interacts with the Earth's magnetic field to produce a strong electromagnetic pulse, which originates a few miles overhead, even though the nuclear detonation point may be a thousand miles away or more. Since the E1 pulse is generated locally, even though the original gamma ray energy source may be in space at a great distance away, the pulse can cover extremely large areas, and with an extremely large EMP field over the entire affected area.

The E2 Component

- The **E2** component of the pulse is the easiest to protect against and has similarities in strength and timing to the electrical pulses produced by lightning.

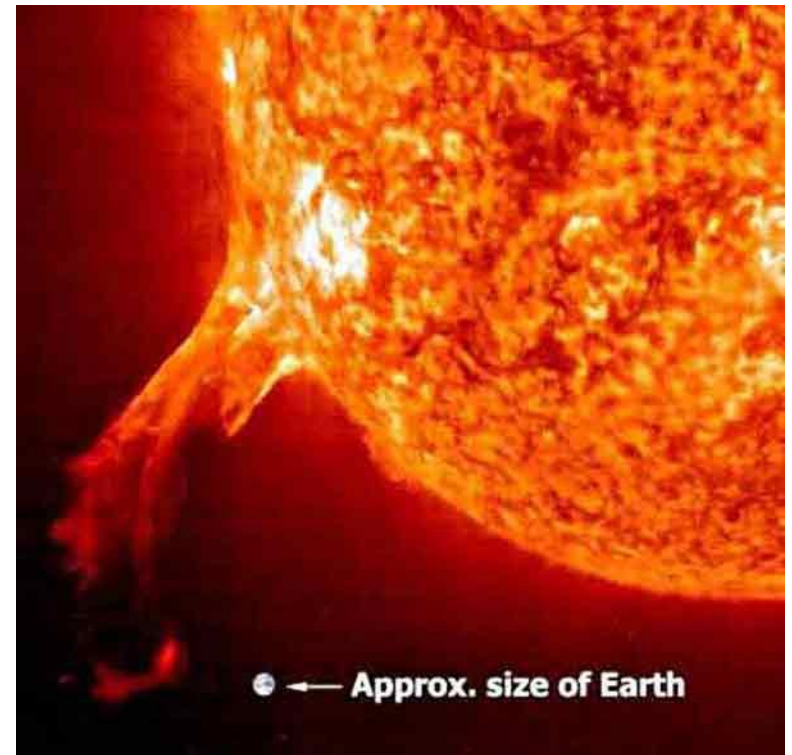


The E3 Component

- **The E3 pulse is *very* different from the E1 and E2 pulses from an EMP.** The E3 component of the pulse is a very slow pulse, lasting tens to hundreds of seconds, that is caused by the nuclear detonation heaving the Earth's magnetic field out of the way, followed by the restoration of the magnetic field to its natural place.
- **The E3 component has similarities to a geomagnetic storm caused by a very severe solar flare.**

What does a solar flare look like?

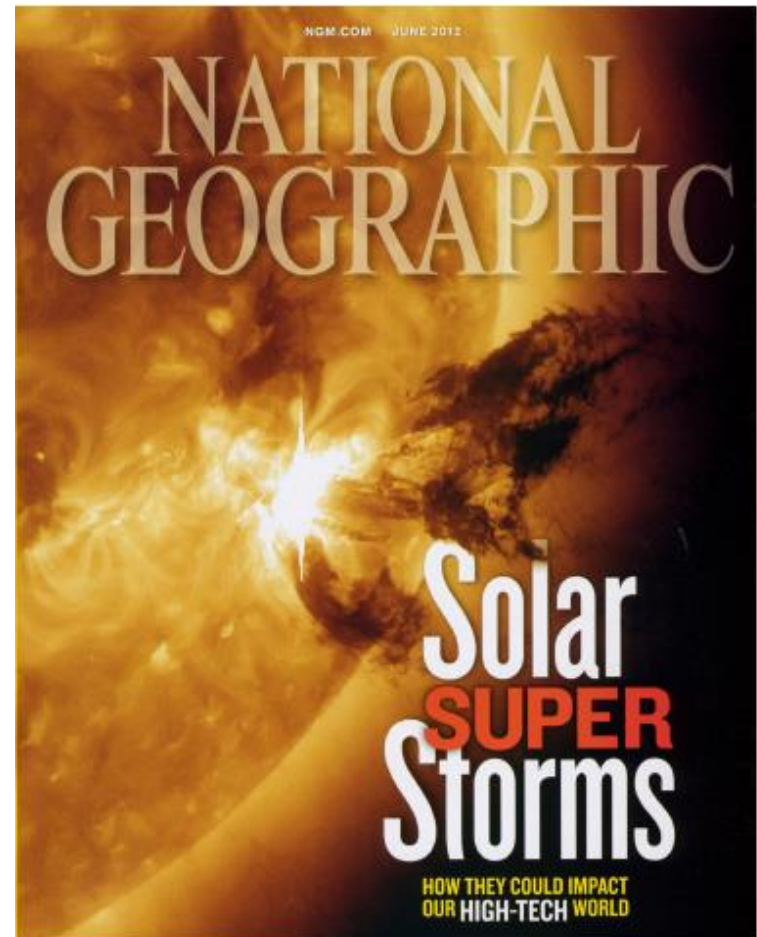
- Solar Flares can and do happen.



- Increasing solar storms and other activity on the sun's surface put the world's power grids and everything electronic at risk.

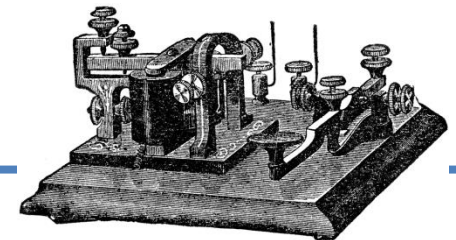
A Recent Coronal Mass Ejection

- There is a good article and photos in the June 2012 National Geographic Magazine.
- It describes some of the past major solar CME events
- There have been major solar storms reported recently.



Solar Storms Happened in the Past

- On September 1st and 2nd, 1859, “Earth’s inhabitants experienced the greatest solar storm in recorded history” known as the “Carrington Event”.
- The electrical grid was in its infancy, consisting mainly of a few telegraph wires in larger cities.
- This Solar Storm short circuited the wires in the telegraph system and caused fires.



Solar Storms are Happening Today

- In 1989 and 1994, solar storms knocked out communication satellites, shut down power plants and disrupted the electrical grid.
- These were *minor* solar flares. Imagine if a solar storm the size of 1859 Carrington Event struck our modern society?



EMP From Nuclear Blast

- According to the Washington (*DC*) Department of Health, Office of Radiation Protection, “**A 1.4 Megaton nuclear bomb detonated about 250 miles above Kansas would destroy most of the electronics that were not protected in the entire Continental United States**”.
- how would the mass population handle a prolonged event with no communication and no electricity?
- As the Commission noted, “**our society is utterly dependent on our electrical grid for everything**”.

CME Consequences

- Minor CME Events have taken out power grids, e.g. Quebec Province in 1989.
- **A major CME event could take down most, maybe all, of the US power grid by destroying the power infrastructure. It would take years to procure and replace transformers, substation components etc.**



EMP Consequences

- An Atomic weapon detonated above the ionosphere generates ionizing radiation that creates RF emissions from ionospheric electrons.
- The burst of radio frequency energy is strongest between 1 MHz and 10 MHz and can extend to 100 MHz.
- **This EMP is strong enough to destroy all electronics connected to a wire. (antenna or not, like power cords, interconnect cabling, etc.)**

What Could Fail In A Major Event?

- IF the national power grid fails, not enough reserve materials exists to bring it back up quickly.
- Communication systems will fail (cell and land line phones, the internet, GPS Navigation. Etc.).
- Transportation comes to a halt. Modern vehicles with computer controls stop operating.
- Without transportation there is cessation of material and goods flow. (fuel, food, medicine, materials) to bring back the infrastructure.

What Could Fail In A Major Event?

(Continued)

- Vehicles on the road will stop suddenly and may result in many accidents.
- Traffic control systems and traffic lights will cease operating.
- Aircraft in flight are essentially in a “Faraday Shield” protecting what’s inside the aircraft.
- Un-protected military vehicles may become disabled.



What could fail in a major EMP Event?

(Continued)

- Fuel for the older technology vehicles that are still running is not available because there is no power to dispense it, and the refineries are shut down and there are no tank trucks to deliver the fuel from their storage tanks.
- Commercial TV radio and satellite broadcasting may be off the air.
- Your TV and radio receivers do not work (your old tube radio may still operate).

What could fail in a major EMP Event?

(Continued)

- We found that a captured Russian aircraft (30 years ago) used vacuum tube technology “because vacuum tube technology was able to withstand a powerful electro-magnetic pulse (EMP), a side-effect from nuclear explosion. This radiation is harmless to humans but very damaging to modern solid-state electronics”.



What Could Fail In A Major Event?

(Continued)

- Banking and financial institutions may be unavailable and if information is not backed up some or all account information may be lost.
- On the bright side some of your credit card balances may also be lost.
- Those who have cash on hand will be fortunate, but cash may have little value and we may revert to a barter system for a while.

What Could Fail In A Major Event?

(Continued)

- Many amateur radio repeaters may have failed.
- Our unprotected base, mobile Radios may have failed.
- Communication will be critical and ham operators with working stations will be highly valued.
- If it were just a single portion of the world that is effected like the US and Canada, we would be highly vulnerable to aggressive countries

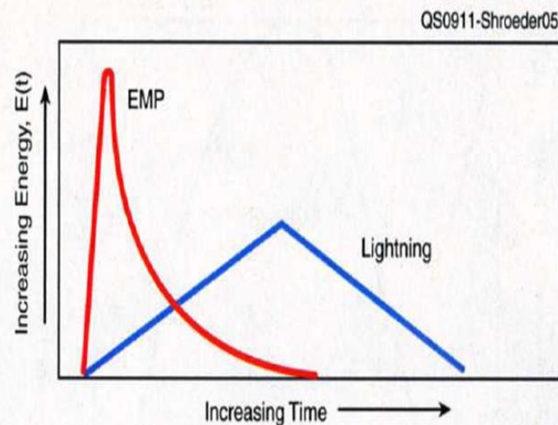
What Are The Odds This Can Happen?

- The threat is real and an EMP event can happen, especially a CME that we have no control over.
- We are at high risk because we are so dependent on our electrical based world today.
- Ignoring the possibility may not be a good bet.



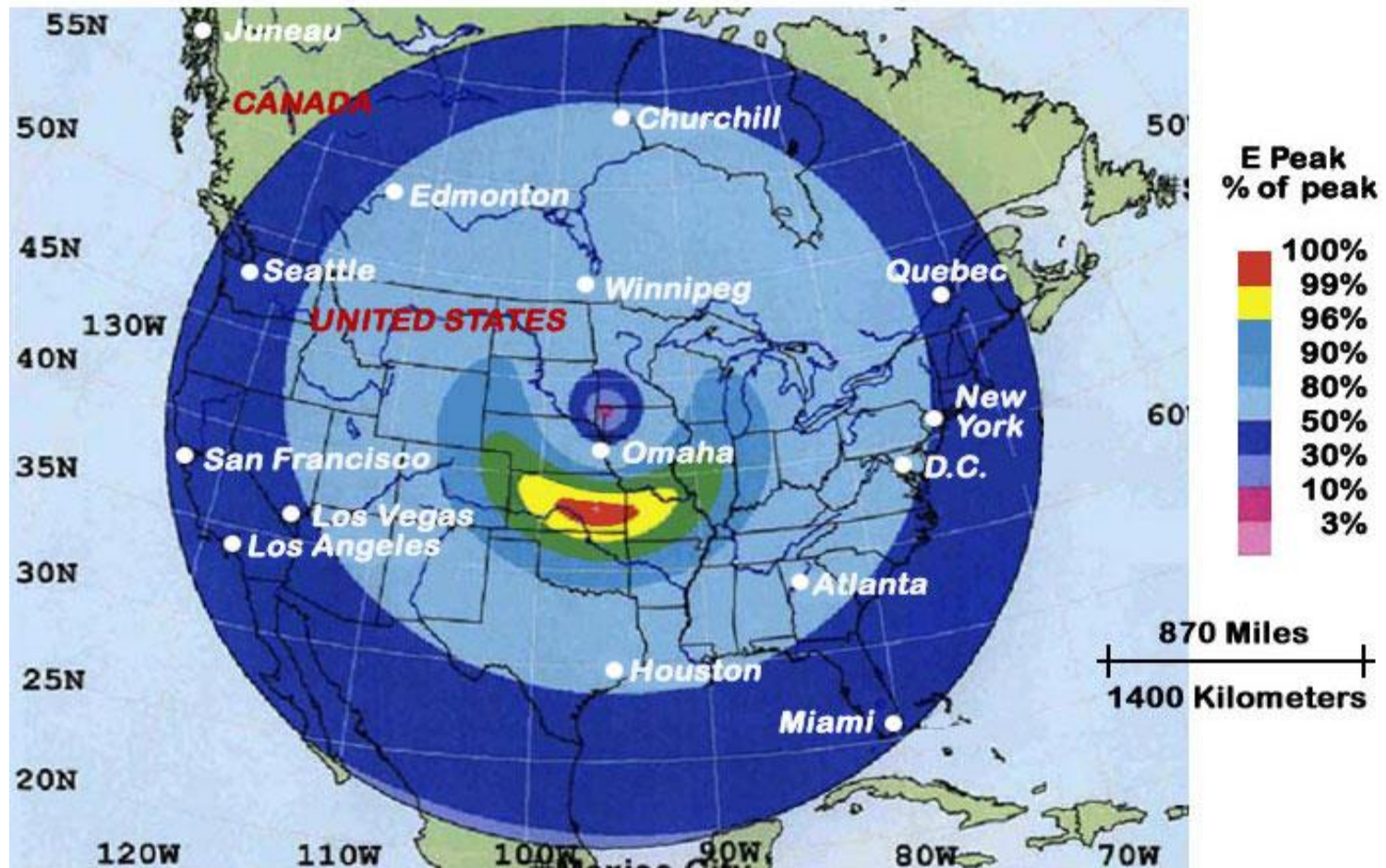
What is an EMP or CME Event?

- EMP (man made or solar) capable of traveling thousands of miles and damaging or disrupting sensitive electronics and electrical systems.
- A couple of high-altitude detonations could disable communications, defense systems and electrical infrastructure without incurring a single loss of life.



EMP Affected Region For A Nuclear Detonation

Height of Blast = 298 miles at 42.00N, 96.00W



How Much Energy Are We Talking About?

- Electric field strengths of up to 50 KV per meter.
- Magnetic field strengths of up to 120 amperes per meter.
- Exposed wiring will simply burn up with voltages and currents this high.
- The rise time of these events will be from a few nanoseconds to tens of seconds or longer.

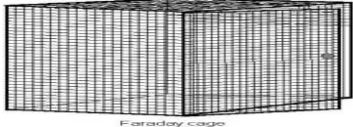
The CME or EMP Event

- Large currents are conducted into electronic devices through:
 - Antennas
 - The power grid
 - Communication lines
 - Data lines
 - Circuits will “ring” at their input resonant frequency
- Upper atmosphere ionization means:
 - Higher noise in HF signal paths
 - Increase or decrease of D layer reflectivity

Comparison Of A CME And EMP Event

- A CME event surge can eliminate electrical power for a long time, maybe years.
- Nothing powered by our power grid will work.
- All line powered devices will be at risk.
- An EMP radiation flash will create, in nanoseconds, high voltages and currents in even short wires, more in long/large antennas tuned to less than 100 MHz such as Yagis and dipoles.
- Unprotected equipment may be destroyed

Protecting Against MCE and EMP

- The problem is real
- In order to design equipment and a communications station to withstand EMP (Harden it) will be costly.
- Store back up equipment disconnected and in a “Faraday Shield” or other Metal enclosure. 
- Disconnect any radio when not in use (antenna, power Supply, external microphones, data/computer lines, external modems and interfaces).
- VHF and UHF radios for line of site communication with small antennas (rubber ducky's) will likely survive

Amateur Radio in Disaster Recovery

- Amateur Radio incurs the obligation and responsibility to be ready and to provide vital communications during all emergencies including EMP and CME events.



Amateur Radio in Disaster Recovery

- A FEMA Administrator Described the Amateur Radio operator as the ultimate communications backup.
- Disaster response personnel, because of the resiliency in all other systems, may tend to dismiss the amateur radio role as ultimate backup with their “my system can’t fail mentality”.
- Remember when other communications systems fail Amateur Radio will be there.

Have You Given Up Hope?

- Take steps to insure you have communication capability after the event.
- Protect your sensitive electronics
- Consider having Backup solar or wind power to charge your radio batteries.
- A few watts on HF may get out quite well since many other man-made noise sources may no longer be there.



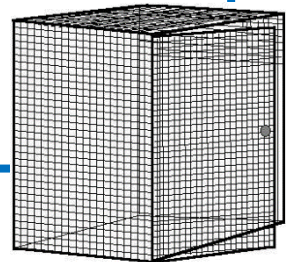
When All Else Fails

- An EMP or CME event could cause massive social disorder, starvation and disease.
- Strong local social networks such as CERT, community, church groups, etc. will promote survival.
- Man made and solar EMP can destroy communications equipment radio amateurs rely on. Communications readiness will be extremely valuable and communicators valued
- Your equipment must be protected.



EMP Protection-The Faraday Shield

- A “Faraday Shield” can protect radio and electrical equipment.
- A “Faraday Shield” is enough metal around an object to keep radio frequency out. It can be solid or mesh material.
- Aluminum foil wrapping works, a galvanized trash can, ammo can or file cabinet will work as well.
- A ground lead on the shield can act as an antenna.



Faraday cage

Wrap Radios In Foil And Place In Bags

- Choose the radios and gear to be protected. Consider HT's, small mobiles, accessories and a portable short-wave receiver.
- Wrap in aluminum foil. Be sure to seal joints by folding.
- Place wrapped items in plastic bags, insulated from each other.
- Place gear in a metal container with a lid.



An Ammo Case Faraday Shield

- An Ammo case can provide electrical as well as environmental protection for you sensitive electronics.
- Other metal storage containers like a metal file cabinet, or galvanized trash can (with a tight metal lid) for larger items.



Using The Ammo Case

Install insulation/padding material on the inside.

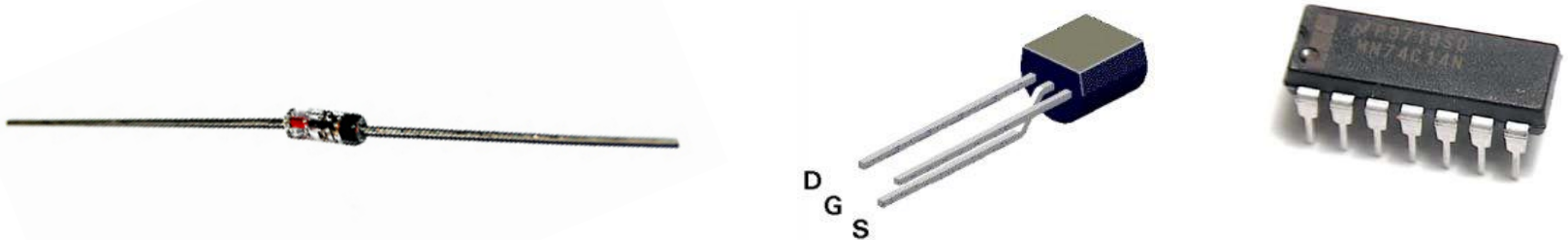


The ammo box can hold a lot of your gear



EMP And Vacuum Tube Gear

- An EMP flash will fry any un-protected solid-state equipment because solid devices are so sensitive.
- Vacuum tubes are generally unaffected.
- Vacuum tube transmitters and receivers are substantially unaffected, but receivers may lose front end coils and components.
- Anything with a power cord is at risk



Dig Out That Old Heathkit

- Vacuum tube amateur radio receivers and transmitters will likely survive EMP, as long as there are no leads connected.
- Keeping spare parts for Vacuum tube receiver front ends etc. would be prudent.
- Powering vacuum tube equipment will quickly drain batteries (you will need an inverter for 115V power).
- Solar power will keep them going.

EMP And Lightning Protection

- Grounding protects against lightning but acts like an antenna for EMP.
- Lightning and electrical safety grounds are required for safety and often by law.
- EMP protection must supplement but not defeat lightning or electrical protections.
- Most lightning damage comes from power line surges, therefore EMP/CME protections are similar to lightning protection.

EMP Antenna Protection

- **E1** EMP is a nanosecond voltage pulse. Lightning arrestors will not stop it they are too slow (milliseconds).
- Metal oxide Varistor's (MOV's) with low clamping voltages and fast nano-second response time can prevent EMP pulse from getting into the equipment. They need to be connected across all inputs, antennas, power supply leads, microphone leads, data lines, etc.



EMP and VHF/UHF

- An EMP Flash conveys little energy above 100 MHz.
- Hand Held transceivers with rubber ducky antennas are at little risk (unless plugged into a charger).
- UHF and VHF repeaters are unlikely to survive EMP effects with their line operated power supplies antennas and towers



Post EMP/CME powering of radios

- After an EMP/CME event electrical power may be down for an extended period of time.
- Communications will depend on emergency power.
- Gasoline generators will run out of fuel, and soon none will be available.
- Batteries with solar power charging will keep you on the air.



Solar Power in a CME/EMP event

- EMP can fry solar panels, but a wire mesh “Faraday shield” can protect them (but will cost efficiency). The leads also need to be protected with shielding and MOV’s.
- An CME surge will likely destroy solar systems connected to the power grid.
- A solar power system kept in a “Faraday shield” and deployed after the event is the best emergency power source.

EMP/CME and batteries

- Rechargeable batteries will provide emergency power for communications.
- Solar power can recharge batteries as can other sources of electricity.
- Batteries can be protected in “Faraday shields” as well. Be sure the terminals are insulated from the “Faraday shield”.
- Batteries connected to a charger at the time of an EMP/CME event may be at risk.

EMP / CME & Disaster Preparedness

- Strengthen local social networks (Community, CERT and Church groups)
- Community enables survival.
- Foster family survival with stored water, food, medicine and weapons (in other words be prepared).
- Store unused equipment and back-up solar power system in faraday cages (batteries separately)
- Protect all antennas with MOV's and all power supplies with isolated UPS's (Uninterruptable Power Supplies) and MOV's.

Who Will You Talk To?

Your gear is protected but:

- Talk with your ham radio friends and get them to prepare also.
- Use your extra gear for this project.
- Rotate batteries & recharge on an appropriate schedule.
- Stage kits at various sites
- Mark kits for easy identification and location.
- Don't forget to test items in the kits periodically.

Further information and investigation

- A good single source regarding EMP and Radio is Jerry Emanuelson at <http://www.futurescience.com/emp.html>
- QST archive articles: (Available online for free to ARRL members)
 - August 1981, August 1986, September 1986, October 1986, November 1986 & November 2009
- June 2012 National Geographic Magazine

Further information and investigation

National Geographic presented An excellent hour-long television documentary program on EMP titled *Electronic Armageddon*. An Electronic Armageddon DVD-R can be purchased at the [National Geographic Video Store](#). It can also be viewed on YouTube at: <https://www.youtube.com/watch?v=3XWAY1clu6E>



THE END (Maybe not)

