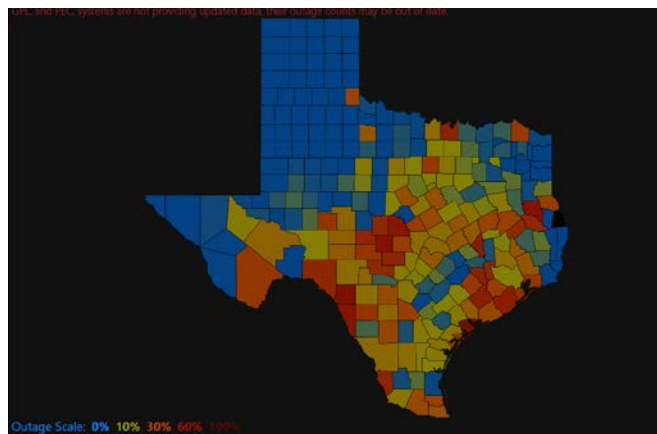


Electromagnetic Threats

20 September 2025



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Andrew R. Scott, K5ERA



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“Concept Check”

Overview

- **Introduction**
- **JBSA-EDI / SA-EMD; Lessons Learned**
- **Threats to the Power Grid**
- **Electromagnetic Threat Specifics**
- **Practical EMP Countermeasures**
- **Family Emergency Readiness Planning**
- **Information Resources**

Lt Col Eddie Stamper, USAF (ret)

"Thumper" (KJ5AYH)



F-4G Wild Weasel EWO

F-117A EWO / Mission Planner



**Wing Senior Intelligence Officer
C-130H3 / F-16CJ**



**Air Liaison Officer / Joint
Terminal Air Controller**

Intel Officer School Instructor



Squadron / Group Command



Wing Inspector General



**Founder JBSA-Electromagnetic
Defense Initiative (JBSA-EDI)**





Joint Base San Antonio

Electromagnetic Defense Initiative (JBSA-EDI)



One Team, One Mission

“Ensure JBSA continues military operations in a post Electromagnetic Pulse (EMP) environment”

- ✓ Create EMP Resiliency Model to Replicate Across DoD
- Support Dissuasion Strategy to Preclude EMP as a Weapon
- 5G Network Risks, Opportunities & Augmented Reality / Artificial Intelligence



High Altitude EMP



Solar EMP (GMD)



Physical Threats



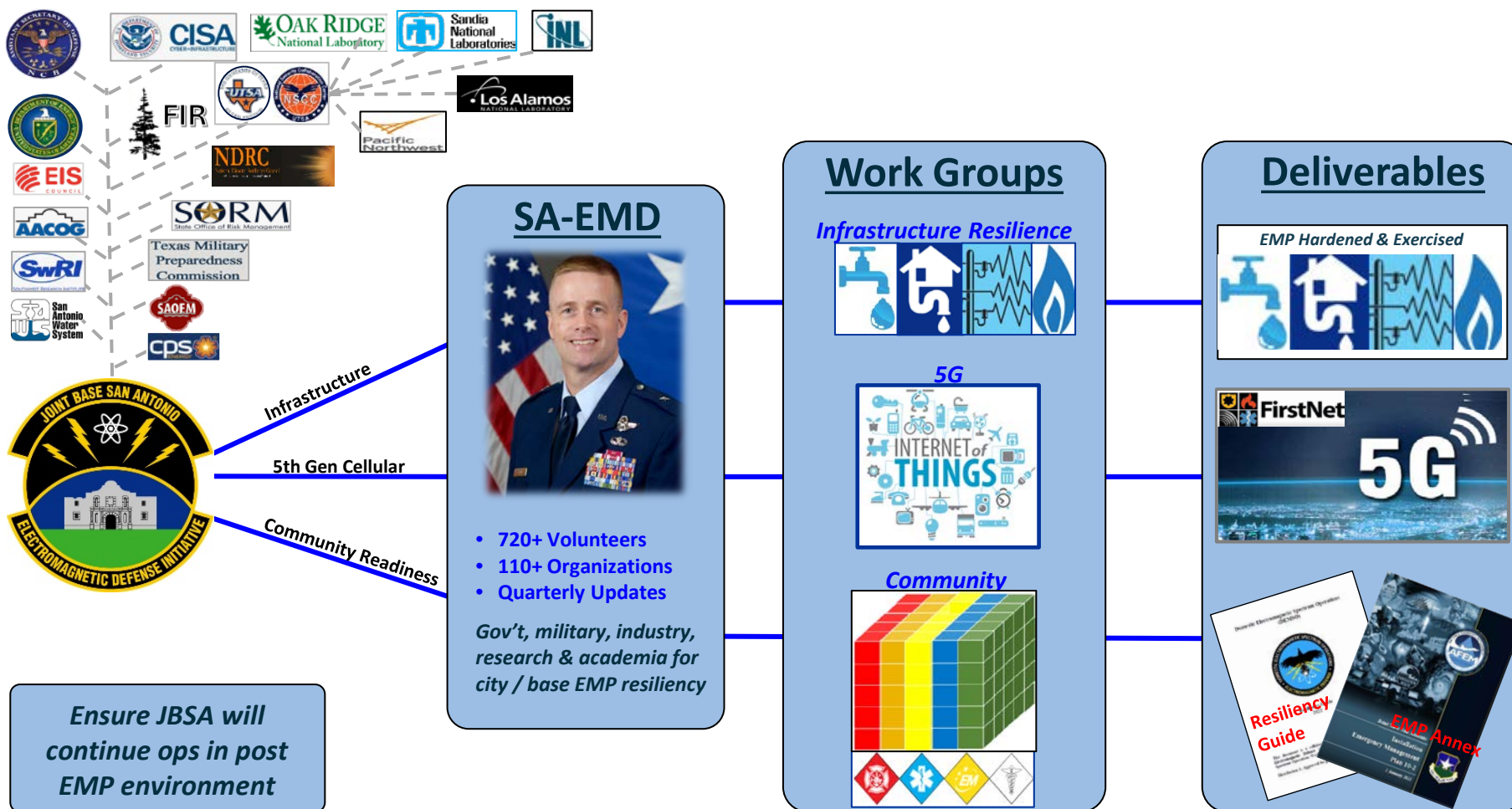
Cyber Threats



San Antonio Electromagnetic Defense (SA-EMD)



One Team, One Mission



Military Readiness Enabled by Community Resilience

Assessed Risk – Probability Ordered



Coronal Mass Ejection / Solar Geomagnetic Disturbance (CME / GMD)

- Similar in effect to HEMP E-3, but lasting Hours / Days vs Minutes
- Ground Induced Current (GIC) - Overload / Collapse Power Grids
- Rare - Potentially Catastrophic (Carrington Event – Aug 1859)
- 100% Chance of Occurring – Unknown who's lifetime



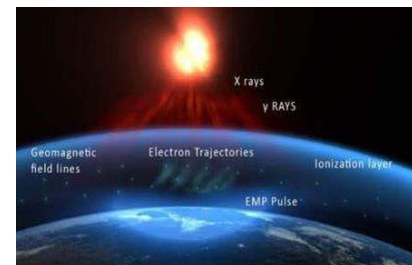
Cyber Attack

- Malicious Manipulation of Controls & Code
 - Can Result in physical destruction of critical components
- Maximize other attacks (think Combined Arms Campaign)
- Extremely hard to “effectively” conduct or defend nationwide



Physical Threats – Sniper, Bombing, Sabotage

- Physically destroy hard to replace components (Transformers)
- Potential for Insider Threats (disgruntled employees)
- Outsized Impact Potential – 11 Coordinated Substation Attacks
- Technologically Simple – Operationally & Logistically Complex



High Altitude Electromagnetic Pulse (HEMP)

- E-1 – Microcircuits, Controls, Communications
- E-2 – Similar to Lightning; Somewhat Mitigated
- E-3 – Transformer overload, Conducted via power lines, pipes & rails
- Adversaries consider HEMP Information Warfare, not Nuclear War



JBSA Substation Hardening



One Team, One Mission



- **11 Off-base Substations**
- **Critical Component Armor**
- **Ballistic Wrap “Castled”**
- **Intrusion Warning**
- **Undisclosed Aspects**



JBSA Lackland POL EMP Hardening



One Team, One Mission

- ✓ **1st Task: ID and Quantify potential EMP Vulnerabilities**
- ✓ **Results used for Active EMP Vulnerability Assessment**
- ✓ **Results used to Design & Implement EMP Countermeasures**
- **Lessons learned apply DoW wide, airline, shipping, etc.**





POL EMP Hardening Lessons Learned



One Team, One Mission

ISO POTUS EO 13865, Coordinating National Resilience to EMP:

- ✓ EMP Survey, Engineering Assessments & Design Complete; Procurement underway
- EMP hardening for existing facilities with disruption tolerance of hours (vs. seconds) using non-traditional methods typically applied in deployed operations
 - **MIL-STD 188-125 hardening cost prohibitive**
 - CISA Level 2 guidelines for facilities able to tolerate hours of mission interruptions
 - Manual capability available within hours
- **Bottom Line** – In this case, more efficient and cost effective to invest in recovery readiness instead of damage resistance (retroactive hardening)



Manual backup replaces SCADA controls/components to eliminate EMP risks



City / Base Power Outage TTX Results / Impact



One Team, One Mission

- **August 2020 – LTRPO* Exercise to “Stress Test” Existing Plans**
- **Revised JBSA 10-2**
- **Highlights**
 - **New Space Weather / LTRPO Annex**
 - **Refined Pre / Post-Event Coordination with Key Partners (CPS Energy, SAWS, etc)**
 - **Planning Considerations for Leaders / Emergency Managers**
 - **Fuel Resupply**
 - **Loss of Network Based Communications**
 - **Family Care Consideration**

JBSA IEMP 10-2

Installation Emergency Management Plan



* LTRPO – Long Term Regional Power Outage

The Threat is Real

(Man-made)

- **Scenarios:**

- High Altitude Nuclear EMP (HEMP)
- Cyber Attack on Power Grid / Critical Infrastructure Controls
- Sabotage—Physical Attack on Key Power Grid Components
 - Apr 16, 2013 – PG&E Substation Attack – Near Coyote, CA

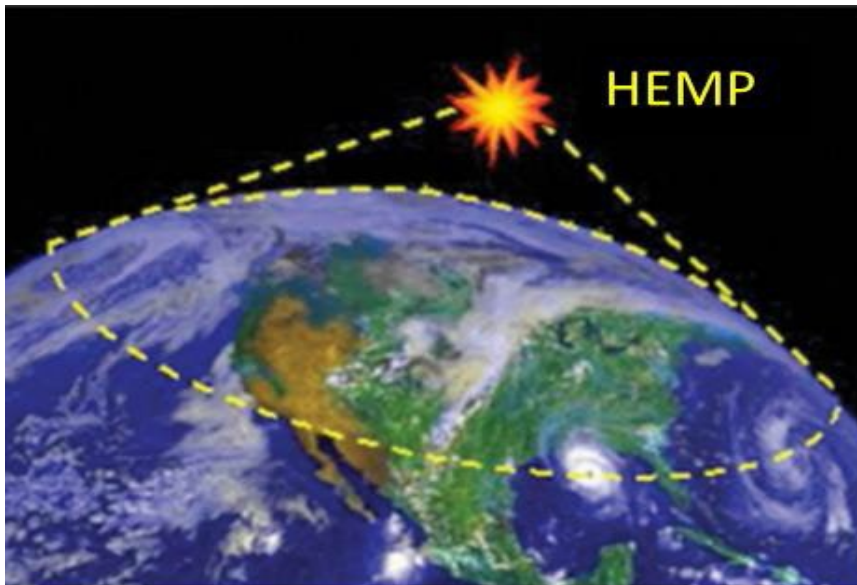


The Three HEMP Components: E1

Early-Time HEMP

UNCLASSIFIED

- E1 is caused by the interaction of gamma rays with air molecules
- E1 waveform is very fast (Nanoseconds) – “speed of light”
 - Eye Blink = 100 milliseconds
- Even small nuclear weapon can create intense fields covering large geographic areas



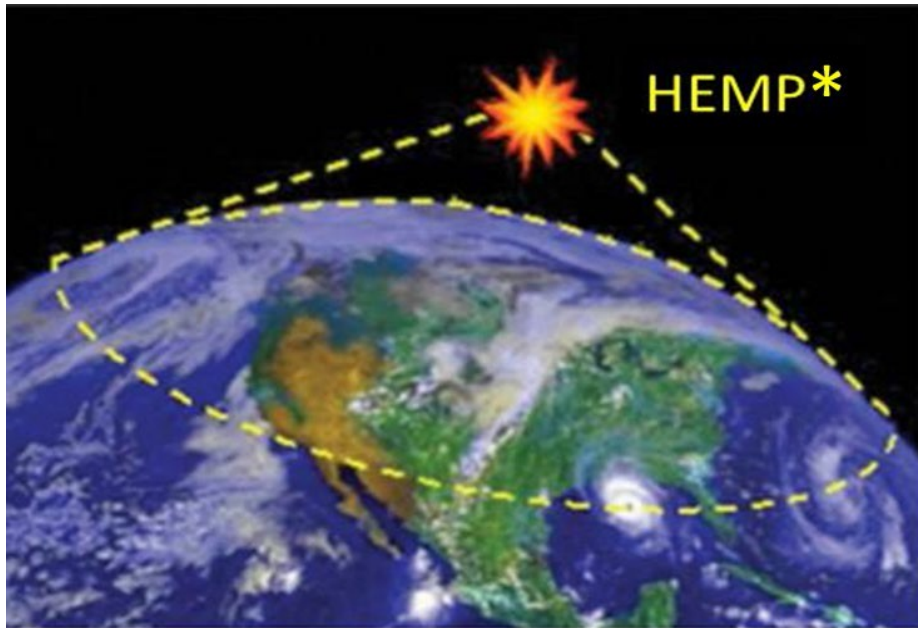
- The “smile” is caused by the influence of the earth’s magnetic field and curve of the Earth on electrons
- Typically line of sight - Radiated
- Extreme Threat to unprotected microcircuits and electronics
- Most damage within first 11ns

UNCLASSIFIED

The Three HEMP Components: E2

Intermediate-Time HEMP

- Similar to effects created by Lightning
- Modern building codes and UL ratings negate most impacts
 - 23,000 structure fires caused by lightning annually



*HEMP detonation height exaggerated to show
LOS coverage over earth's surface



- Area coverage is similar to E1
- Lower intensity than E1
- Diffusion reduces “Smiley Face” effect
- Slower waveform development creates lower frequencies similar to the Lightning

The Three HEMP Components: E3

Late-Time HEMP

Different physics' mechanisms than E1 or E2

E3 acts much like a Geomagnetic storm:

- Long duration – 2 – 8 Minutes
- Coverage less intense, but larger than E1 (beyond line-of-sight)
- Threat to long conductors (i.e. things connected to long power lines)



Starfish Prime test nuclear detonation fireball debris stretching along Earth's magnetic field with air-glow aurora as seen at 3 minutes from an RC-135 aircraft.

STAR FISH PRIME: 9 July 1962

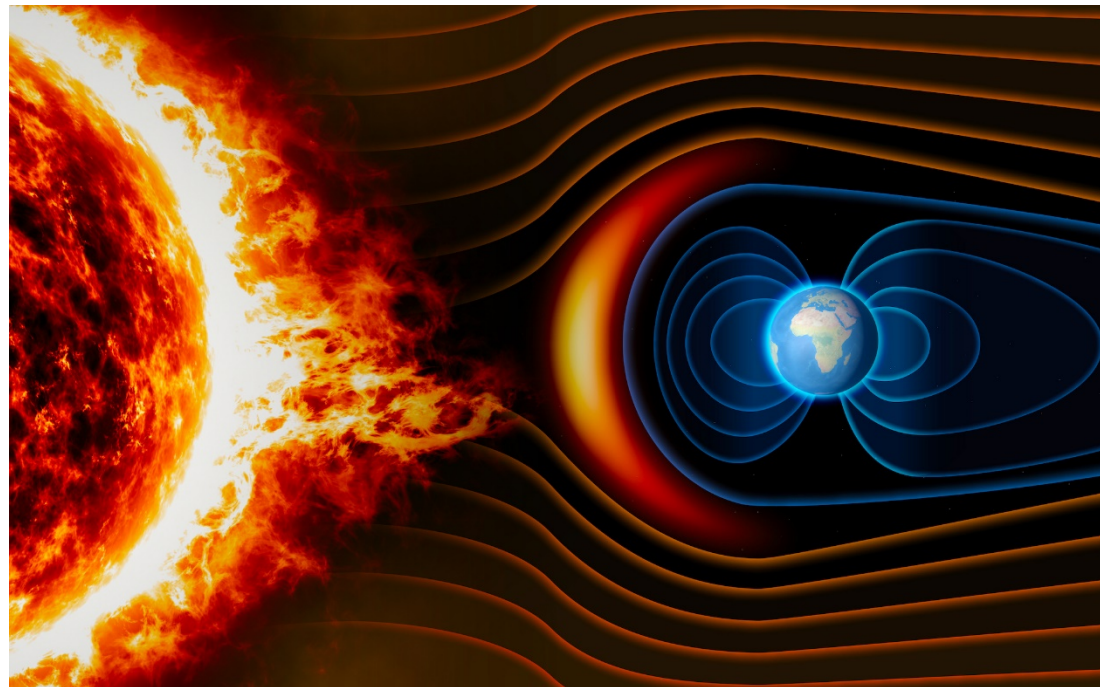
- 1.4 Megaton nuclear bomb over Johnston Atoll (900 Miles from HI)
- Detonated at high altitude – 400km (248.5 Mile)
- kV/m strength – 10-50 depending on distance from burst point
 - (commercial SCADA 8 kV/m max threshold)
- Effects:
 - Failures in 30+ residential and commercial power circuits in Hawaii
 - Some cars stalled
 - Communications disruptions for days

The Threat is Real

(Natural)

One Team, One Mission

- **Geomagnetic Disturbance (GMD) i.e. Severe Solar Storm**
 - AKA – Coronal Mass Ejection (CME)
 - 12% chance per decade (NASA)
 - 2012 Major Event missed earth by 5 days
 - 100% chance eventual occurrence
 - Similar to EMP E3
 - Measured in hours to days
 - Threatens
 - Substation Transformers
 - Power Plant Generators
 - Power Grid Controls
 - Undersea Cables
 - Could have Global Impact



Geomagnetic Disturbance (GMD)

- **Carrington Event:** Most powerful geomagnetic storm in recorded history, caused by a massive solar coronal mass ejection (CME) August 28 – September 2 1859
 - Many more have happened in unrecorded history
- **What happened:**
 - Telegraph systems worldwide failed
 - Shocked operators (hospitalized some)
 - Telegraph Stations caught Fire
 - Brand New Transatlantic Telegraph Cable Melted
 - Vivid auroras were seen across the globe, as far south as Cuba and Hawaii, so bright that people could read a newspaper at night
- **Key Takeaway:** In 1859, reliance on electricity was minimal
 - Today, we are vastly more dependent on technology and the power grid



The Modern Threat

- **Cascading failures:** A severe geomagnetic storm will induce powerful electrical currents into long conductors
 - High Tension Power Lines
 - Metal Gas Transfer Pipes
 - Railroads
 - Conductive Communication Lines (less impactful to fiber)



Impact on the Power Grid

- **Critical infrastructure at risk:** Primary danger to Substation High-voltage Transformers, Digital Controls
- **Overload and meltdown:** Line Induced Currents expected to overheat, melt or significantly damage substation and power plant transformers, causing massive, cascading blackouts across large regions
 - Potentially national or global



- **Recovery time:** Replacing giant, custom-built transformers could take months, or even years (especially at scale)
 - Not produced in U.S.
 - Primary global suppliers: China, Belgium, South Korea

Impact on Communications and Satellites

- **Satellite failure:** High-energy particles from the CME may fry the electronics in thousands of satellites
 - GPS and related systems (World Wide Timing Signal – No Internet)
 - Satellite TV and Radio
 - Weather monitoring / forecasting
 - Military and national security
- **Internet blackouts:** Land and undersea internet cables that are the backbone of the global network
- **Cellular & Data Network Failures:** Expected to fail due to loss of satellites and access to atomic clocks for precise timing
 - Banking
 - Communications

Societal and Economic Consequences

- **Food, water and fuel supply disruption:** Without power; water and wastewater systems fail and fuel pumps stop working
 - Congressional EMP Commission estimated 90% fatality rate over 1 year disruption of Power Grid
 - Based largely on inability to grow and distribute food beyond 30 Million
- **Medical services:** Hospitals would be crippled, unable to run equipment or maintain sanitation
 - Lack of available employees impact all industries
- **Civil unrest:** Expected widespread social unrest, rioting, and looting due to the breakdown of fundamental services and government functions

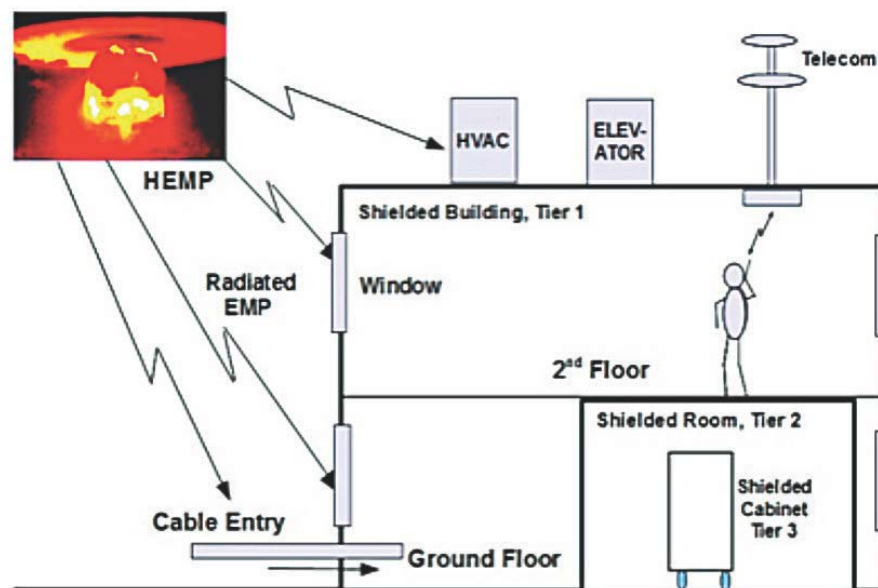


Why Are We Not Prepared?

- 3000+ U.S. Power Companies
 - 99% Corporate, Private, Municipally Owned
 - Government Oversight – Limited to Public Safety and Regulatory Fairness
 - Government Focus – Government Facilities
 - Military, Federal / State Owned Resources
- No National Champion - Only POTUS has influence over all cabinet level agencies
 - E.O. 13865 (May 2019) Highlighted EMP/GMD Threat
 - Directed all Cabinet Secretaries to study and recommend countermeasures
- Government Approach not Unified
 - EMP Considered a National Security Threat – DoW Responsibility
 - GMD Considered a Natural Disaster Threat – Homeland Security / FEMA
 - Same Critical Infrastructure Threatened either way
- Conflicting assessments of threat potential and probability
 - Industry wants to avoid expensive hardening and liability requirements

EMP / GMD Propagation

- **Radiated** - Over the Air Transmission (like a radio wave)
- **Coupled** – Attached / Induced Voltage onto long conductors (Power Lines, Gas Pipes, Railroads, Etc.)
 - AC Transformers saturated by DC voltage leads to thermal overload and internal failure over time
- **Ground Induced Current (GIC)** – Earth Energized
 - High Voltage DC can come “up” from ground into Infrastructure

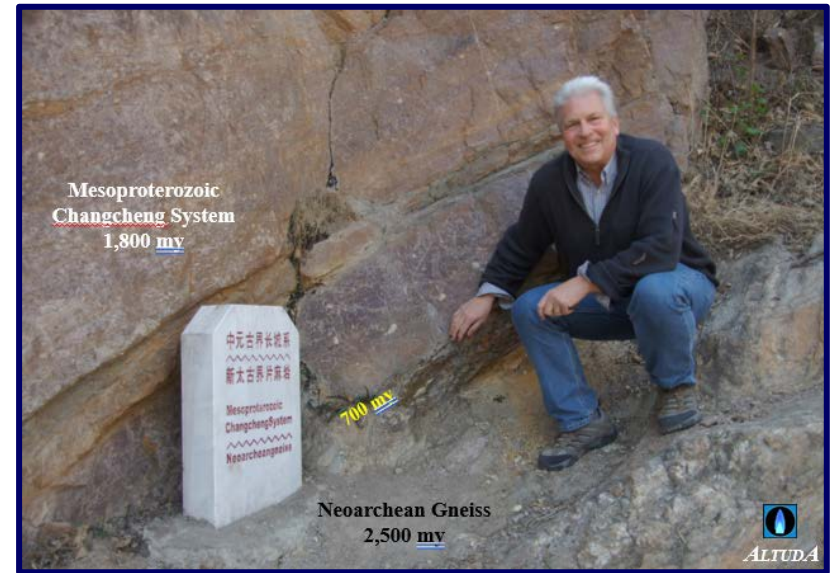


Andrew R. Scott (K5ERA)

Conducted geological research at The Bureau of Economic Geology, The University of Texas, at Austin.

Received multiple Small Business Innovative Research (SBIR) grants from the DOE.

In 2014, started investigating the science behind EMP and U.S. power grid risk just out of curiosity.

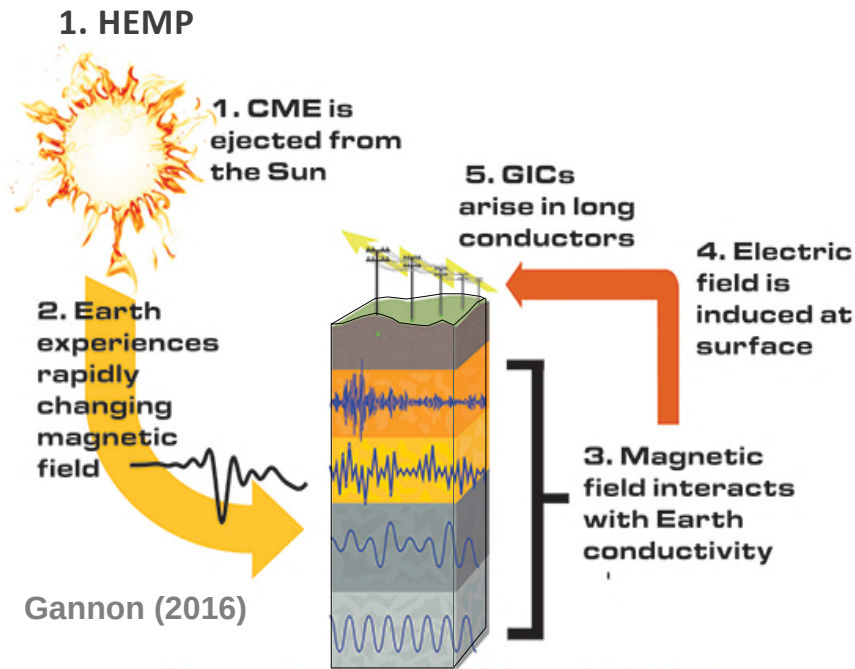


Also evaluated event timing in BSE, societal impacts, daily food (caloric) requirements, and fuel consumption rates for emergency generators based on load and fuel type.

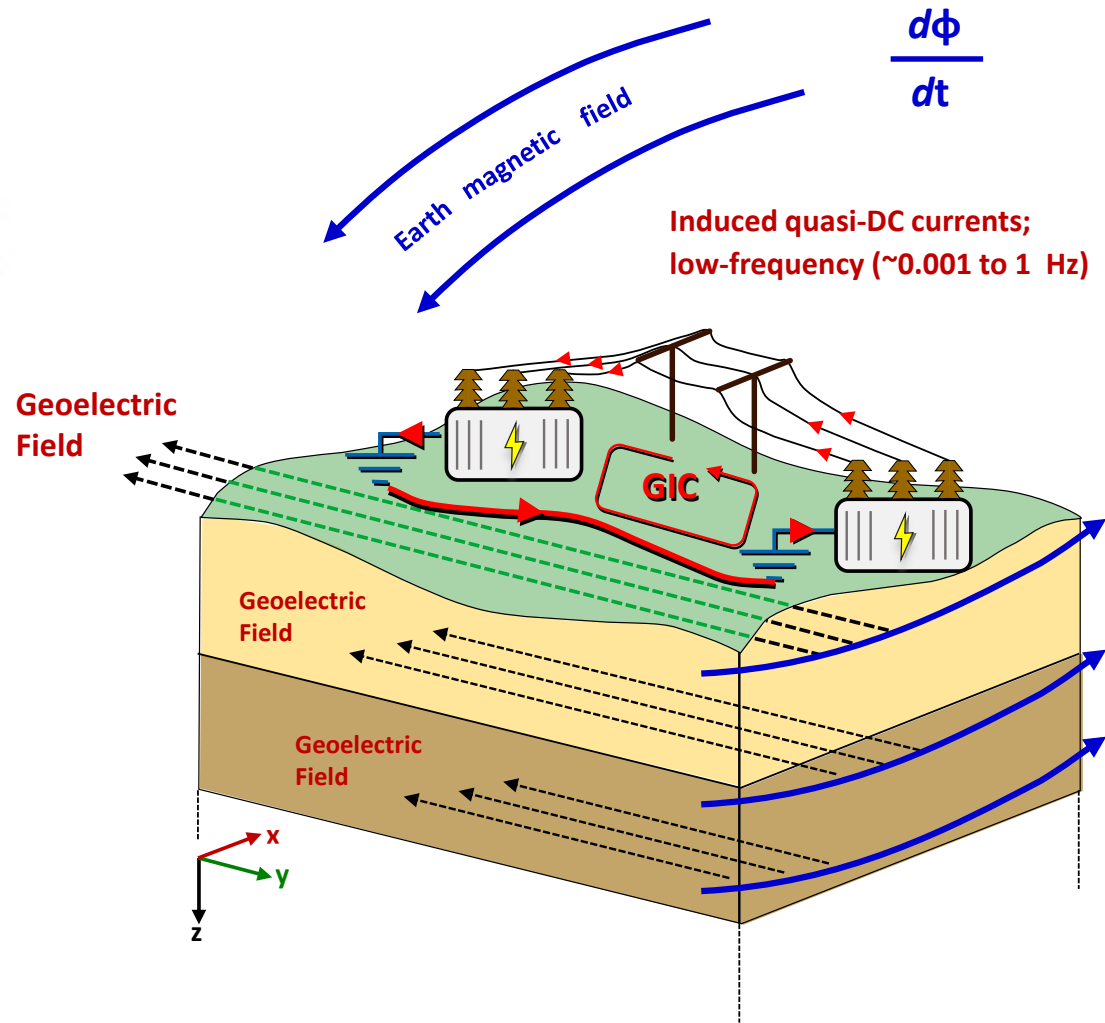
In 2022 joined Domestic Electromagnetic Spectrum Operations (DEMSO), CISA Resilient Power Workgroup, InfraGard National Disaster Resilience Council (NDRC) =>

Foundation for Infrastructure Resilience (FIR) <https://fir.foundation/>

Ground Induced Current (GIC)

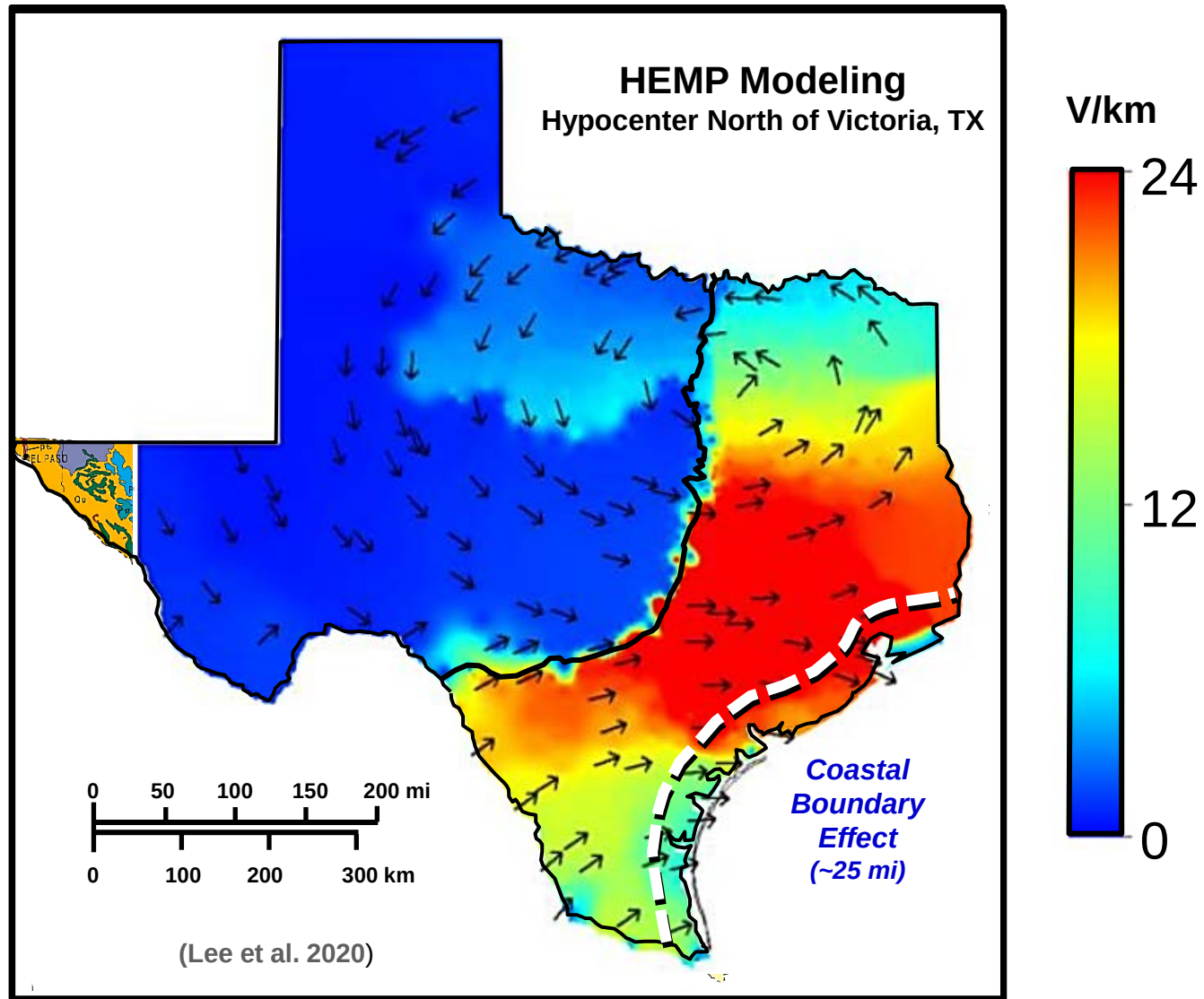


Electric Transmission Grid
Oil and Gas Pipelines
Railroad/railway circuits
Fence lines
Communication cables



After Albert et al. (2022)

Geology of Ground Induced Current (GIC)



EMP / GMD Impacts

Impact Matrix	EMP E1	EMP E2	EMP E3	GMD (Solar)
Electronics / Microcircuits	Red	Yellow	Green	Green
Cars (Electronic Ignition)	Yellow	Green	Green	Green
Power Grid (Plants & Substations)	Red	Green	Red	Red
Power Grid (Homes & Small Buildings)	Red	Green	Yellow	Red
Home Appliances (Plugged In)	Red	Yellow	Yellow	Red
Home Appliances (Unplugged)	Yellow	Green	Green	Green
Cell Phone / Comm Gear (Plugged in)	Red	Green	Red	Red
Cell Phone / Comm Gear (Unplugged)	Yellow	Green	Green	Green
Satellites	Red	Green	Yellow	Red

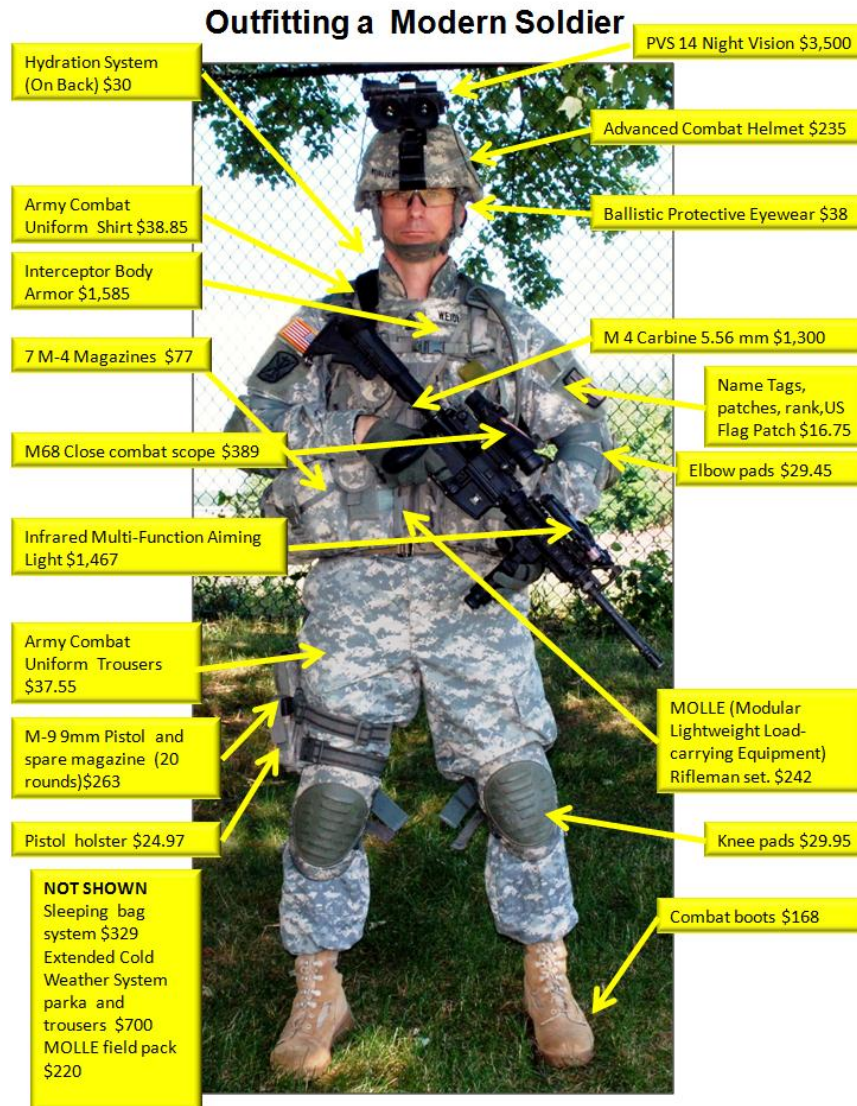
Assumptions:

- Infrastructures unprotected
- E1 Wave Primarily Radiated and Line Induced Voltage
- E2 vs Lightning Protected Infrastructure
- E3 & GMD primarily Line Coupling and Ground Induced Current

Resiliency (Soldier Example)

**Resiliency = Damage Resistance
(Hardening)**

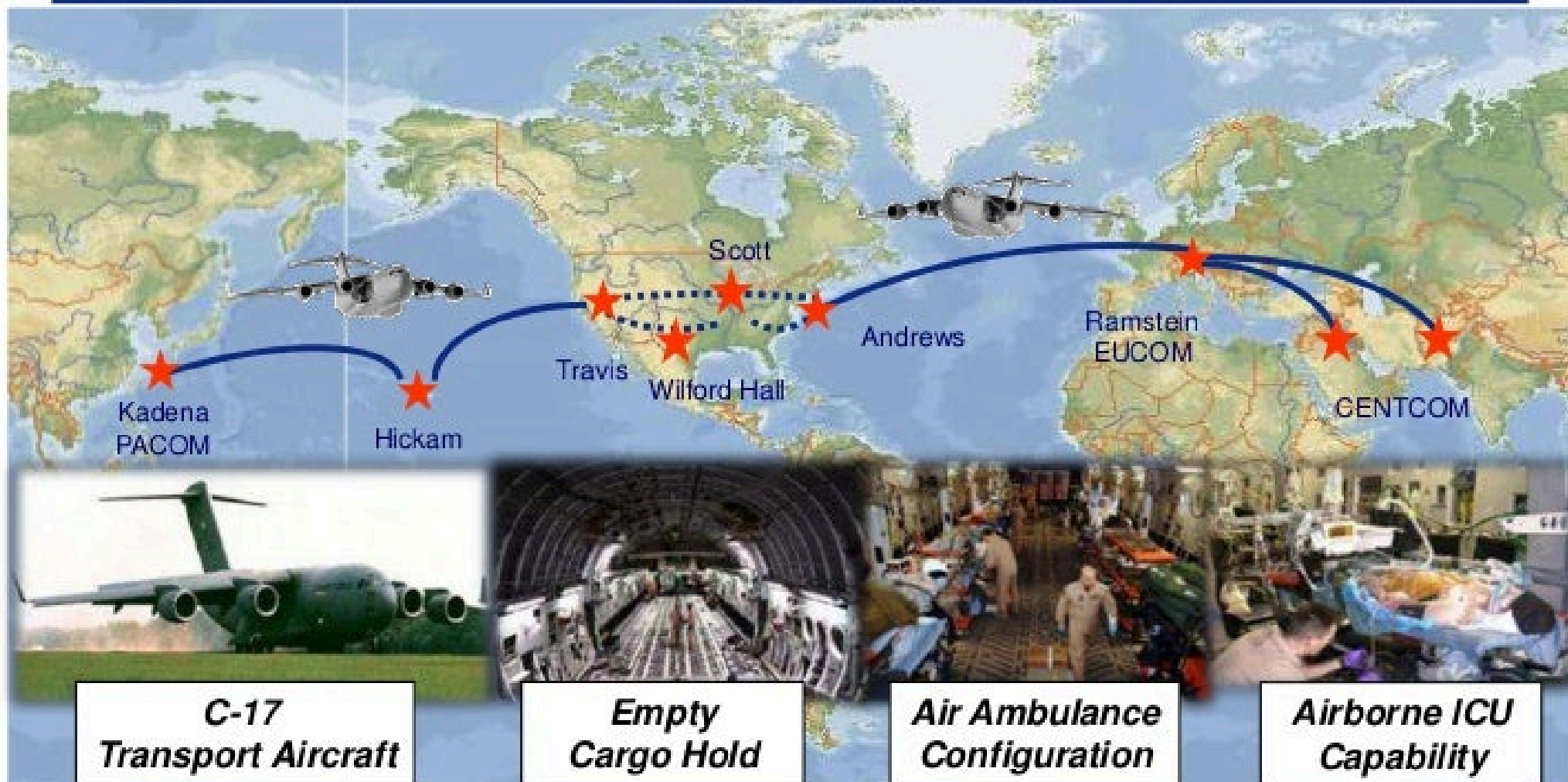
**+ Recovery Readiness
(Repair and/or Replace)**





U.S. AIR FORCE

Aeromedical Evacuation: The Lifeline Home



***Continuing or increasing levels of care...
from point of injury to resuscitation to definitive care!***

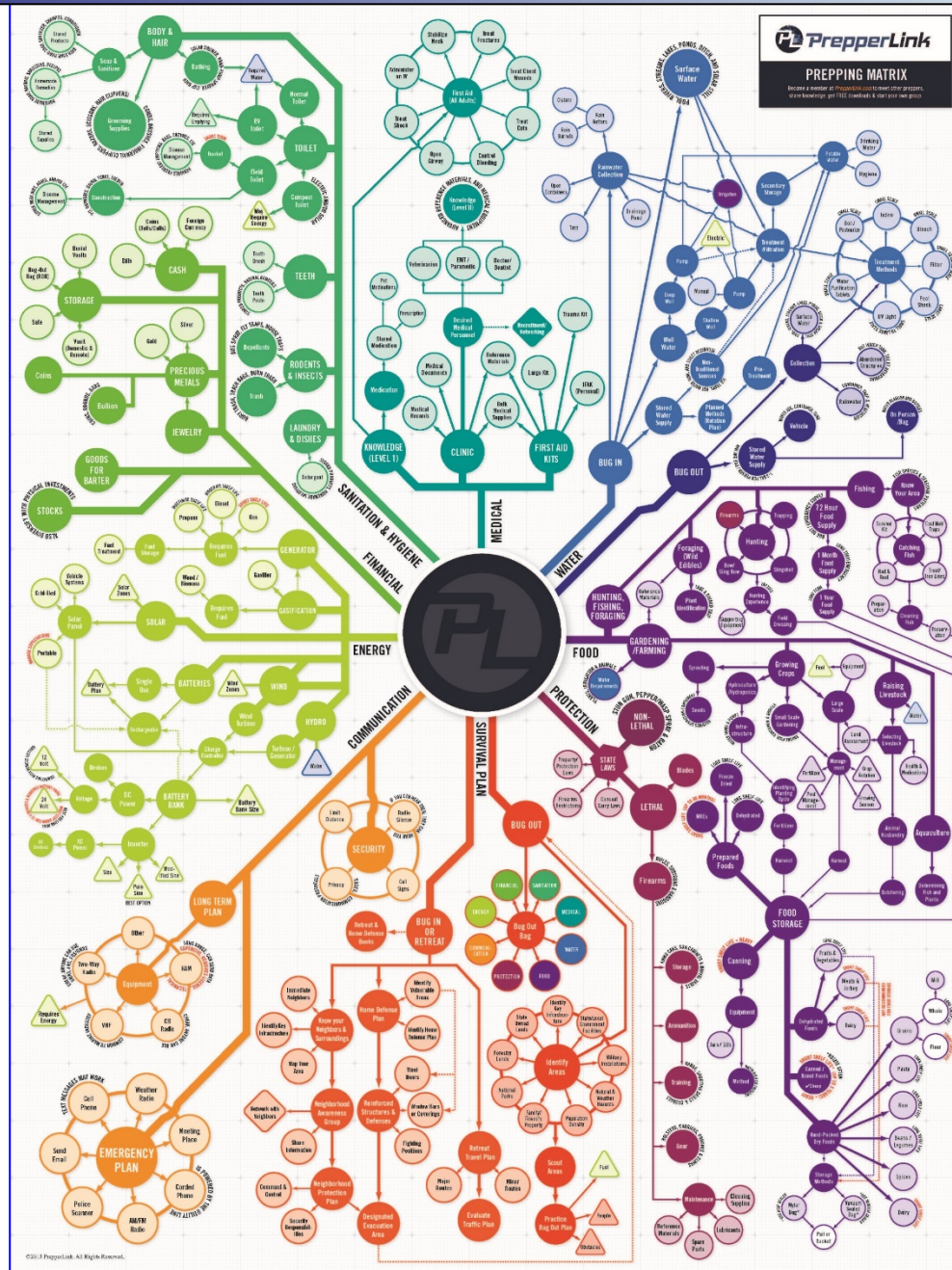
Integrity - Service - Excellence

Family Emergency Readiness Planning (FERP)

- ☐ Medical
- ☐ Water
- ☐ Food
- ☐ Protection
- ☐ Survival Plan
- ☐ Communication
- ☐ Energy
- ☐ Financial
- ☐ Sanitation & Hygiene



Family Emergency Readiness Planning (FERP)



FERP - Communication

Equipment

HAM

CB Radio

VHF (Marine)

FRS/GMRS

Other

Requires Energy

Emergency Plan

Meeting Place

Corded Phone

AM/FM Radio

Police Scanner

Email

Cell Phone – Text

Weather Radio

Security

Radio Silence

Call Signs

Privacy – Codes & Protocols

Limit Distance

FERP – Communication Short Wave Radio



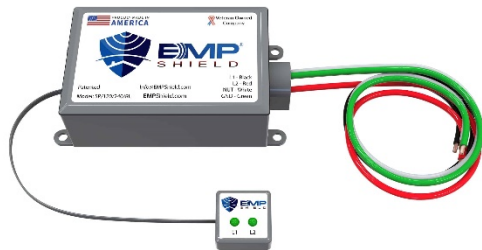
Practical EMP / GMD Countermeasures

- **Passive Defense – Filters and Shielding**

- Faraday Containers / Bags
- Unplugging Power & Antennas



- **Active Defense – EMP/GMD/Lightening Surge Protectors**



- **Preemptive Considerations**

- Food, Water, Medical, Comms
- Advanced Planning and Education
- Repair and Replacement Tools / Supplies
- Get Home Bag

Get Home Bag

Yes You Need One!



the FOUNDATION FOR
INFRASTRUCTURE RESILIENCE

<https://fir.foundation/>

Here's the backpack along with the individual bags, cookset, sleeping bag, and tent:



- **Water**
- **Hygiene**
- **Shelter**
- **Food**
- **Medical**
- **Communications**
- **Safety**

Additional Resources

Information and Reference

www.Ready.gov

www.EMPShield.com (discount code: thumper50)

Foundation for Infrastructure Resilience (FIR) : <https://fir.foundation/>

Electromagnetic Defense Task Force Reports:

2018 https://www.airuniversity.af.edu/Portals/10/AUPress/Papers/LP_0002_DeMaio_Electromagnetic_Defense_Task_Force.pdf

2019: https://www.airuniversity.af.edu/Portals/10/AUPress/Papers/LP_0004_ELECTROMAGNETIC_DEFENSE_TASK_FORCE_2_2019.PDF

Education

Video: Grid Down – Power Up: https://youtu.be/6PuR3VFtLOQ?si=r6j4jPVcq_EnpOfs

Video: 60 Minutes Grid Special: <https://www.youtube.com/watch?v=65siHaUPsRM>

“Lights Out” by Ted Koppel

“Powering Through: Building Critical Infrastructure Resilience” by NDRC



San Antonio Electromagnetic Defense



One Team, One Mission

***Next Hybrid Update – “Advanced Nuclear – Safety and Economics”
1000, 9 Jan 2026***



To receive SA-EMD updates and work group announcements, contact:
Michael.Lovell.3@us.af.mil



Questions?



One Team, One Mission

