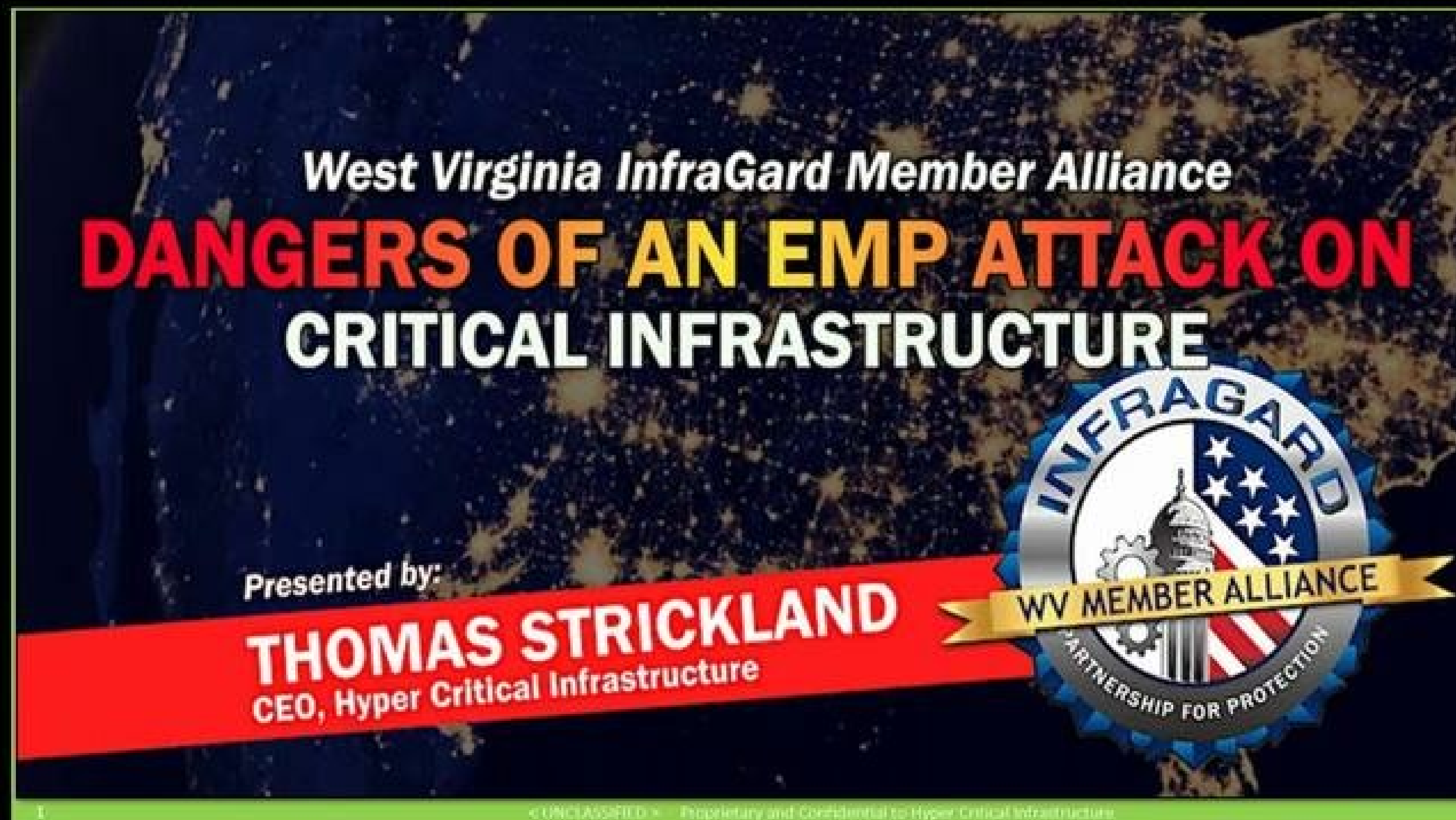
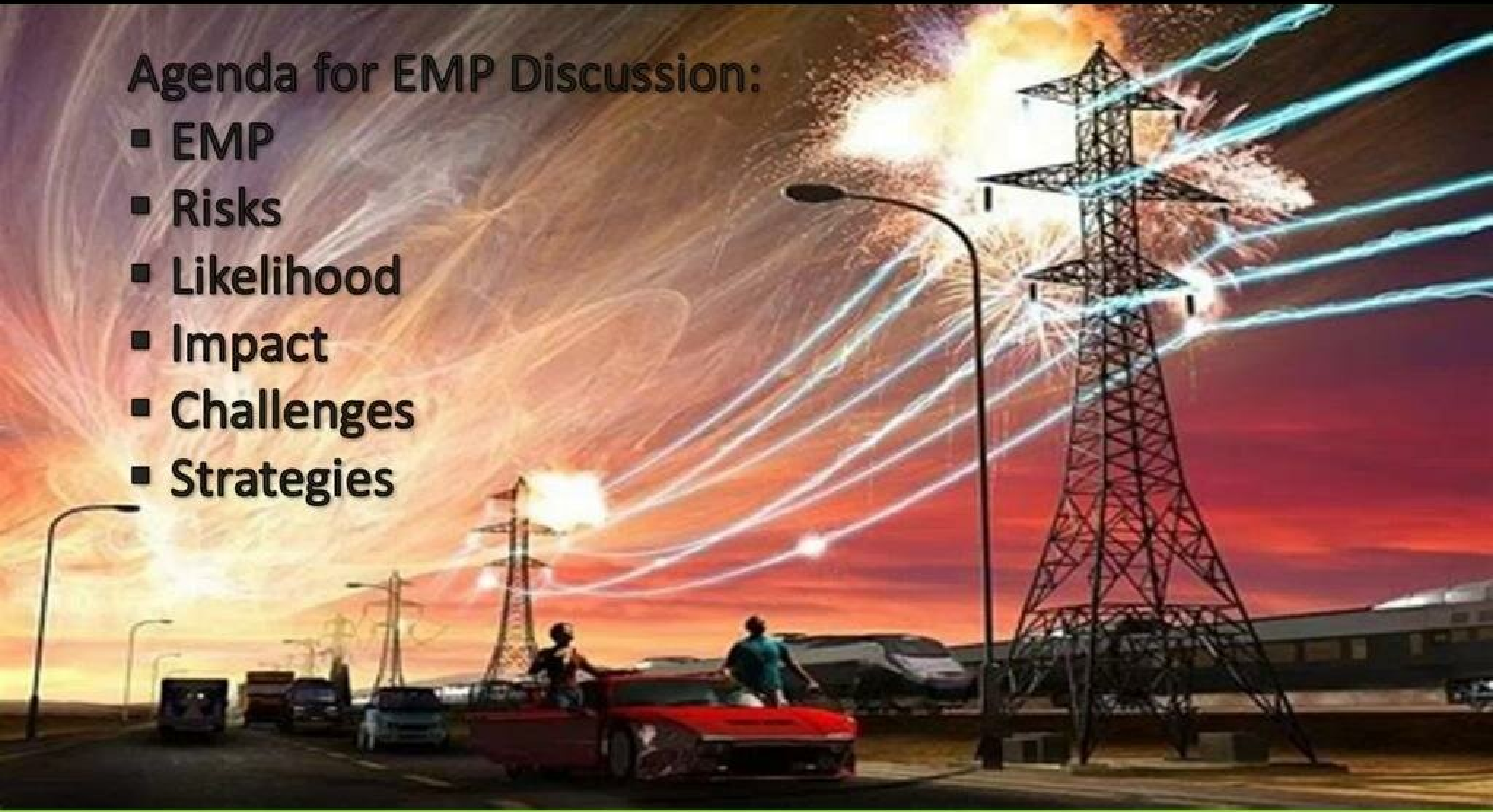

West Virginia InfraGard Member Alliance
DANGERS OF AN EMP ATTACK ON
CRITICAL INFRASTRUCTURE
Presented by:
THOMAS STRICKLAND
CEO, Hyper Critical Infrastructure
INFRAGARD
WV MEMBER ALLIANCE
PARTNERSHIP FOR PROTECTION
1
< UNCLASSIFIED > Proprietary and Confidential to Hyper Critical Infrastructure



Agenda for EMP Discussion:

- EMP
- Risks
- Likelihood
- Impact
- Challenges
- Strategies

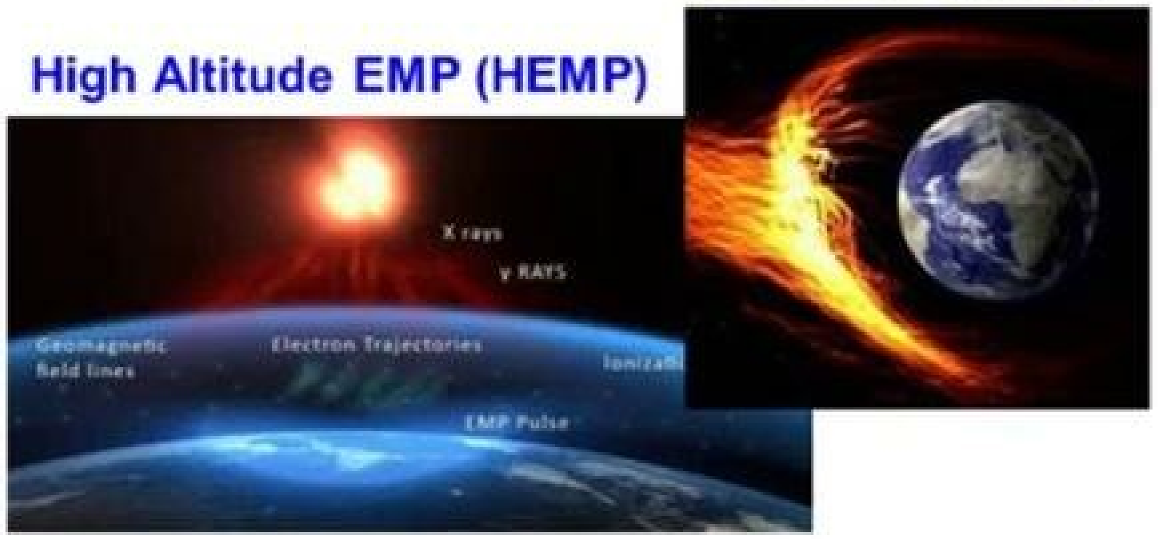

EMP

Electromagnetic Pulse (EMP)

- Sudden burst of energy caused by man-made devices or natural occurring solar flares that disperses like a wave and can travel over great distances.
  - Wave of energy creates an electro-magnetic field of electric current that can disrupt radio signals, communications, satellites and damage anything with electronic circuitry.
  - Based on the sudden dissipation of high energy or the duration of the energy discharged, an electromagnetic pulse (EMP) event can cause severe damage or a catastrophic cascading effect to interconnected critical assets.
- Solar storms, or sun flares, have the ability to disrupt strategic communications, the power grid, water and many other mission critical infrastructures.
- The EMP threat can also be a potential attack by a foreign entity to disrupt or destroy U.S. Critical Infrastructure and Mission Critical Equipment (MCE), is a clear and present threat to the nation.

Solar EMP (GMD)

High Altitude EMP (HEMP)



HEMP and GMD event examples.

HYPERCRITICAL INFRASTRUCTURE

Electromagnetic Pulse (EMP) Event Effects

- Extreme electromagnetic incidents caused by an intentional electromagnetic pulse (EMP) attack or a naturally occurring geomagnetic disturbance (GMD) could damage significant portions of the Nation's critical infrastructure, including the electrical grid, communications equipment, water and wastewater systems, and transportation modes.
- The impacts are likely to cascade, compromising one or more critical infrastructure sectors, spilling over into additional sectors, and expanding beyond the initial geographic regions.
- EMPs are associated with intentional attacks using high-altitude nuclear detonations, specialized conventional munitions, or non-nuclear directed energy devices.
- Effects vary in scale from highly local to regional to continental, depending upon the specific characteristics of the weapon and the attack profile.
- High-altitude electromagnetic pulse attacks (HEMP) using nuclear weapons are of most concern because they may permanently damage or disable large sections of the national electric grid and other critical infrastructure control systems.

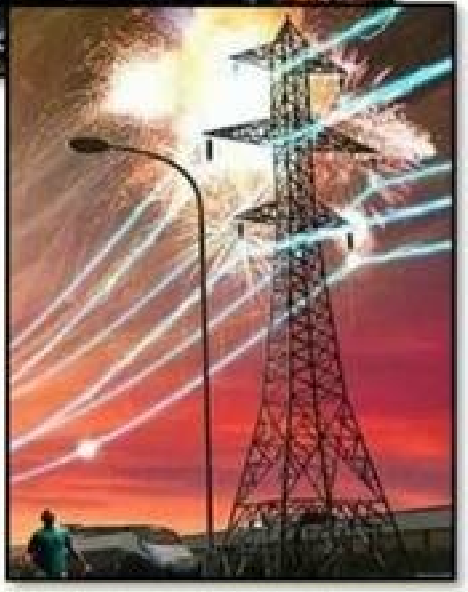
Electromagnetic Pulse (EMP) Event Effects

- Extreme geomagnetic disturbances associated with solar coronal mass ejections (plasma from the sun, with its embedded magnetic field) may cause widespread and long-lasting damage to electric power systems, satellites, electronic navigation systems, and undersea cables.
- Any electronics system that is not protected against extreme EMP or GMD events may be subject to either the direct "shock" of the blast itself or to the damage that is inflicted on the systems and controls upon which they are dependent.
- Many of the most harmful effects caused by electromagnetic incidents occur within milliseconds or seconds.
- These effects may simultaneously damage critical energy distribution nodes and industrial control systems over wide geographic areas through damage to microprocessors and power transformers.
- For these reasons, the potential severity of both the direct and indirect impacts of an EMP or GMD incident compels our national attention.


Risks

Electromagnetic Pulse (EMP) Emerging Risks

- Increasing Intensity of Lightning Strikes
- Weaponizing Substations To Create Power Surges
- Remotely Changing Taps on High Power Transformers
- Controlling Customer Equipment to Spike or Collapse Demand
- Attacking Critical Substation Transformers
- Inducing Ground Currents from Solar Storms
- Using Radio Frequency (RF) Weapons Against Infrastructure
- Creating a High-Altitude Nuclear Electromagnetic Pulse



Levels of EMP Events

The detonation of a nuclear weapon at high altitude can generate an intense electromagnetic pulse (referred to as a high-altitude electromagnetic pulse [HEMP])that can propagate to the earth's surface and impact critical electrical equipment and systems.
EMPs are divided into three waveform components that are described by their distinct characteristics and time frames:

- **E1 EMP**: An intense, short-duration EMP characterized by a rise of 2.5 nanoseconds and amplitude on the order of tens of kV/m (up to 50 kV/m at it's most severe on the ground).
- **E2 EMP**: An intermediate duration with an electric field pulse amplitude of 0.1 kV/m and duration of one microsecond to approximately ten milliseconds.
- **E3 EMP**: A low frequency (below 1 Hz) pulse with amplitude on the order of tens of V/km with duration of one second to hundreds of seconds. E3 EMP is compared to severe geomagnetic disturbances, but can be much more severe. Also, the E3 event is much shorter in duration than geomagnetic disturbance (GMD) events

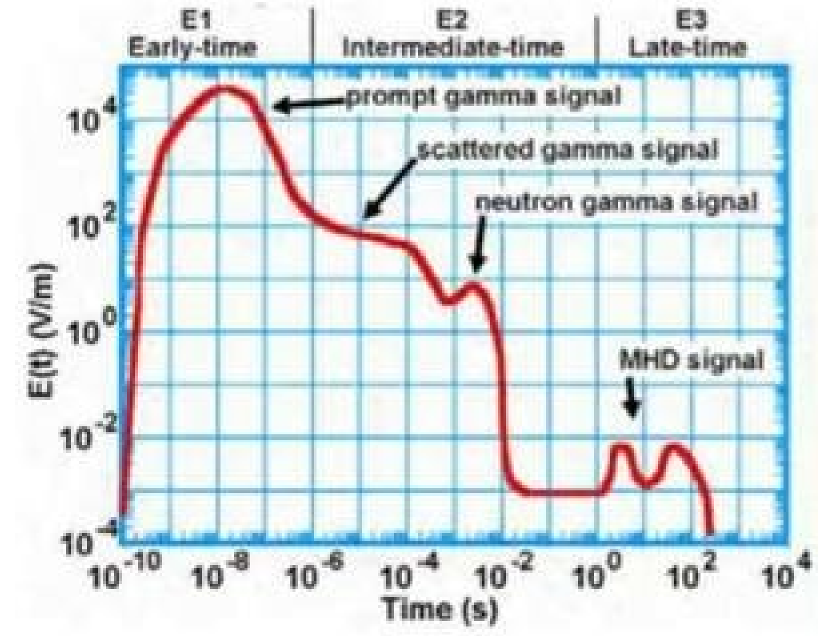


Figure 1. Generic HEMP waveform (ref. Meta-R-324)

HYPERCRITICAL INFRASTRUCTURE

Electromagnetic Disturbances

Summary of EMP and GMD characteristics, including causes, warnings, effects, risks, duration, and scope.

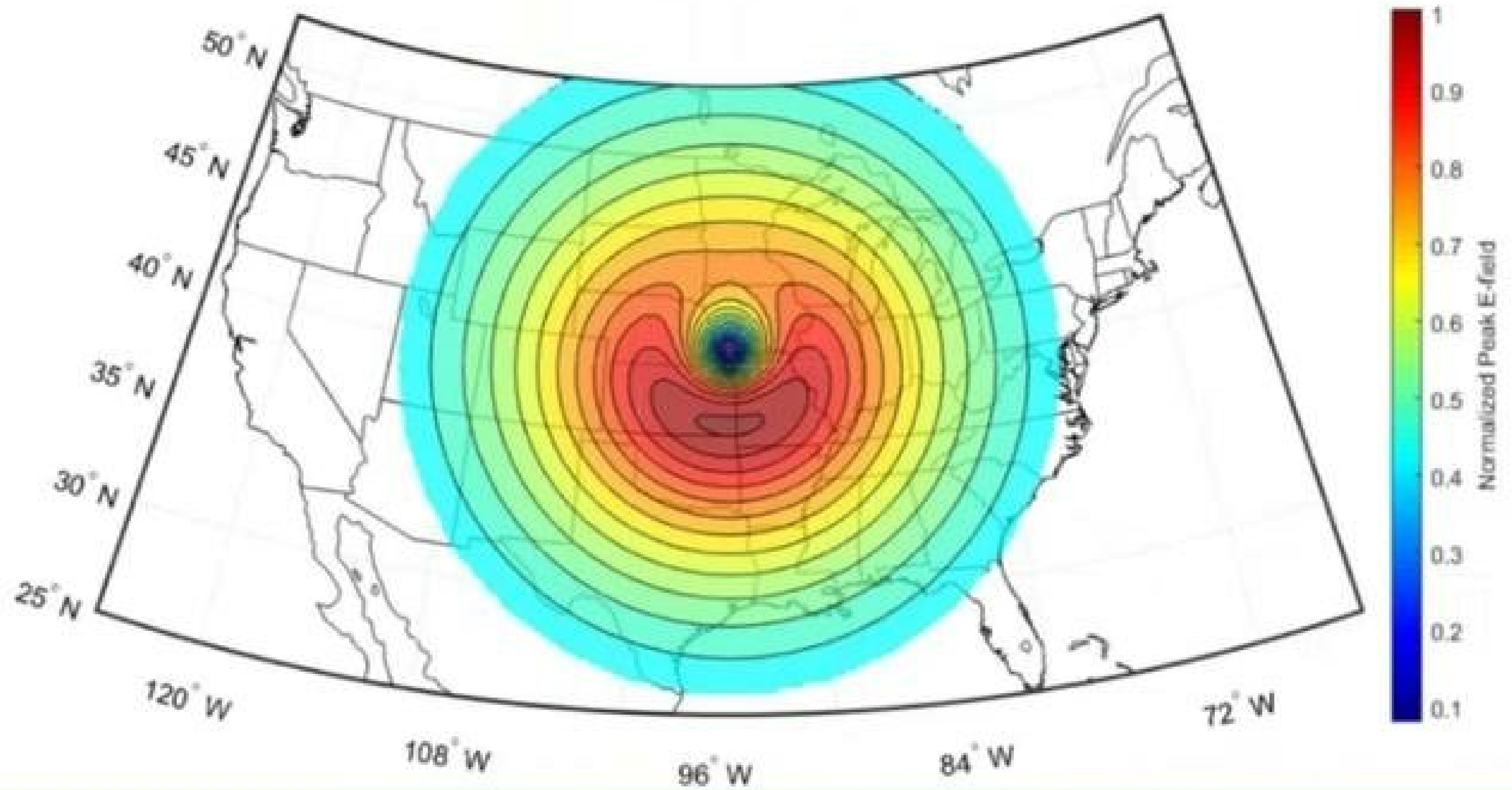
Table 1: EMP and GMD Characteristics

Attribute	EMP	GMD
Cause	Adversarial threat	Natural hazard
Warning	Strategic: unknown Tactical: none to several minutes	Strategic: 18 to 72 hours Tactical: 20 to 45 minutes
Effects	*E1*: High peak field – quick rise time *E2*: Medium peak field *E3*: low peak field, but quicker rise time and higher field than for GMD (possibly 3 times higher)	No comparable E1 wave forms No comparable E2 wave forms *E3*: low peak field – fluctuating magnitude and direction
Duration	*E1*: less than a 1 microsecond *E2*: less than 10 millisecond *E3 Blast*: ~10 seconds *E3 Heave*: ~1 – 2 minutes	No comparable E1 wave forms No comparable E2 wave forms *E3*: hours
Equipment at Risk	*E1*: telecommunications, electronics and control systems, relays, lightning arrestors *E2*: lightning: power lines and tower structures – "flashover", telecommunications, electronics, controls systems, transformers. *E3*: transformers and protective relays – long run transmission and communication - generator step-up transformers	*E3*: transformers and protective relays – long-haul transmission and communications – generator step-up transformers
Footprint	Regional to continental depending on height of burst	Regional to worldwide, depending upon magnitude
Geographic Variability	Can maximize coverage for E1 or E3 *E3*: intensity increases at the lower latitudes and as distance from ground zero is decreased or as yield is increased	*E3*: intensity increases near large bodies of water and generally at higher latitudes although events have been seen in southern latitudes

Source: U.S. Department of Energy, "Electromagnetic Pulse Resilience Action Plan," p.4

Electromagnetic Disturbances

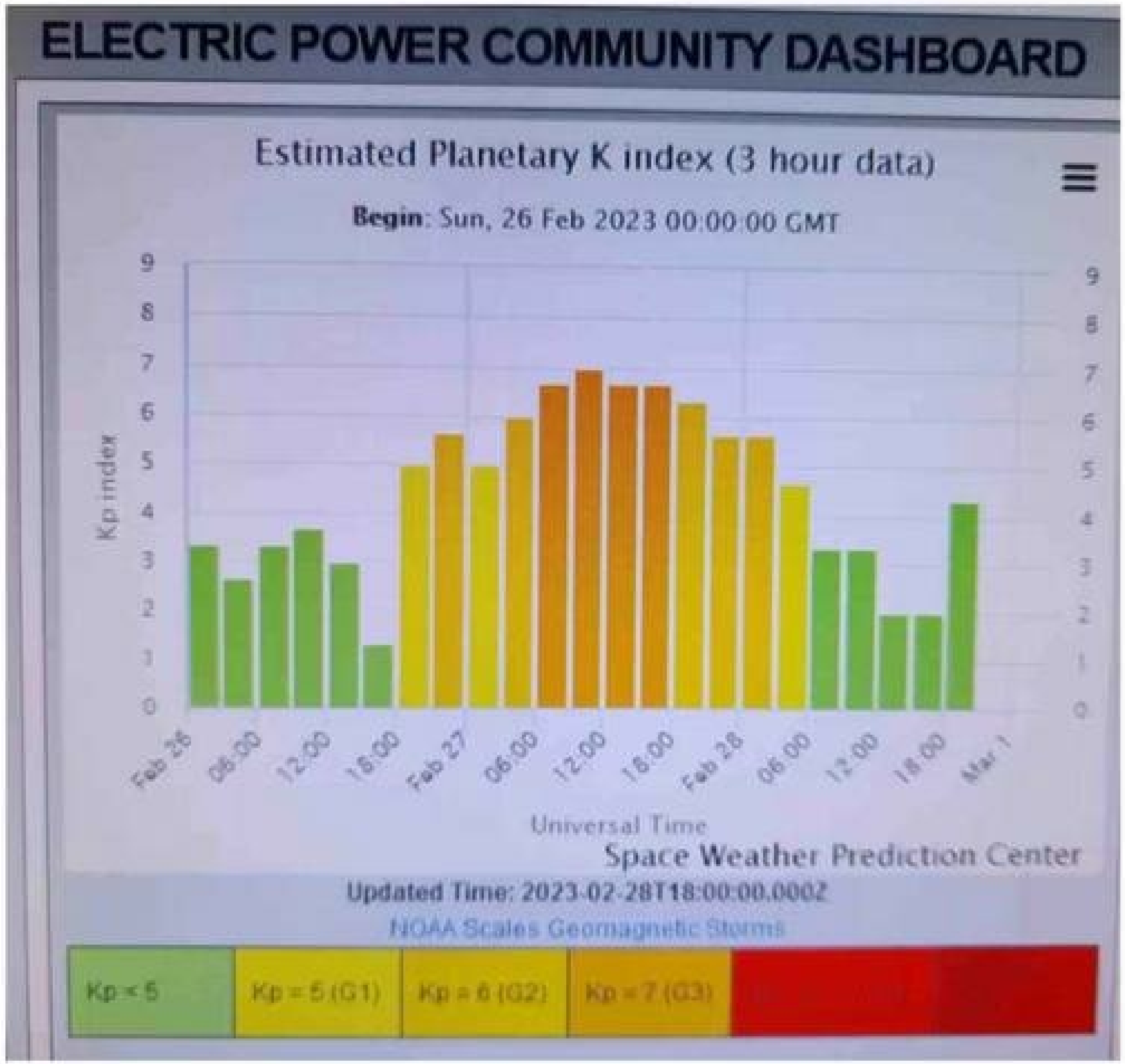
- E1 HEMP is considered a unique threat to the power grid because of its large geographic footprint. The area affected is defined by the line of sight from the point of detonation out to the horizon; E1 HEMP can affect large geographic areas, but not all areas are affected equally.
- The figure below illustrates how the incident electric field varies spatially when a notional 1-MT weapon is detonated 200 km above the central United States.



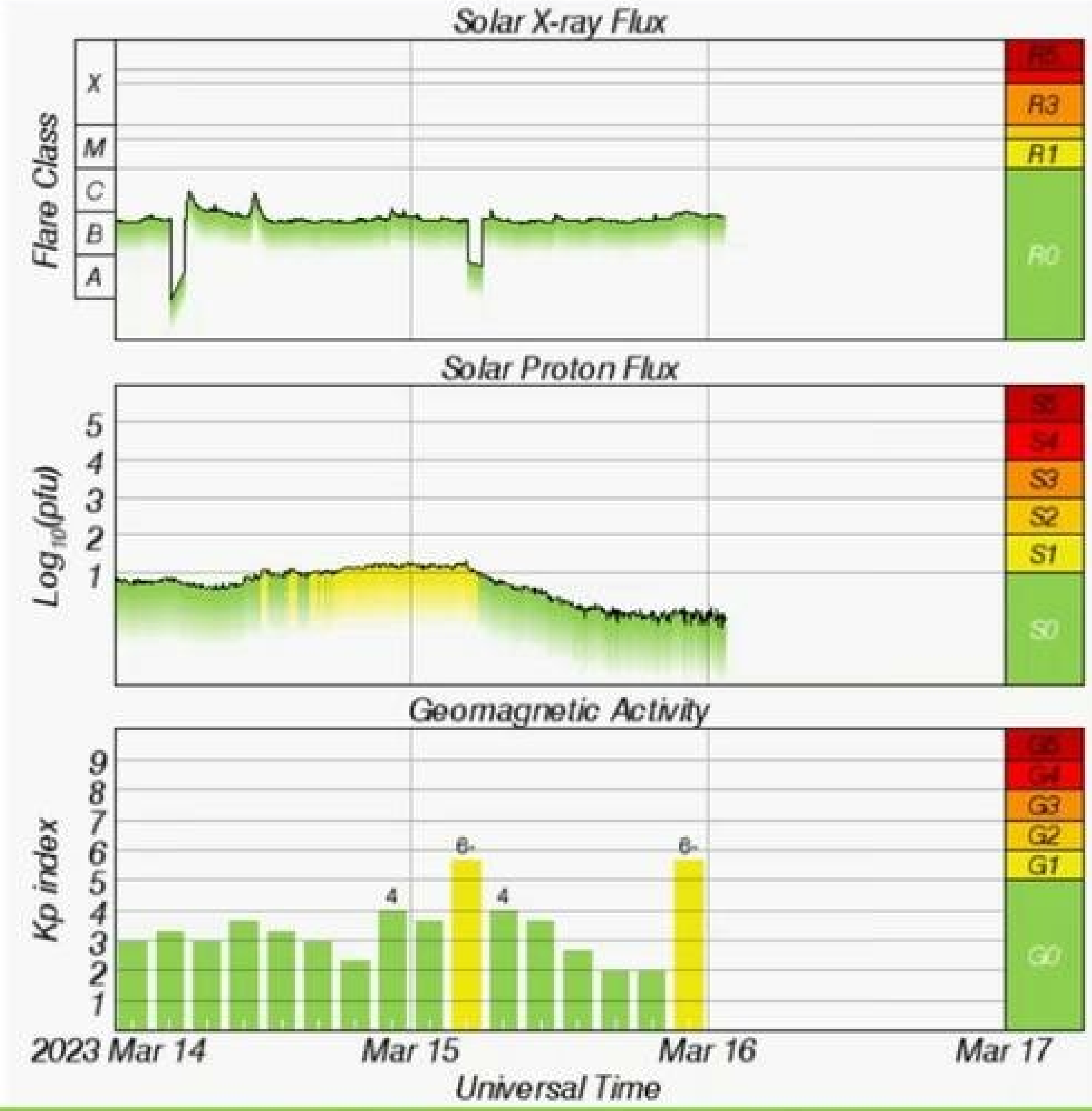

Likelihood

HYPERCRITICAL INFRASTRUCTURE

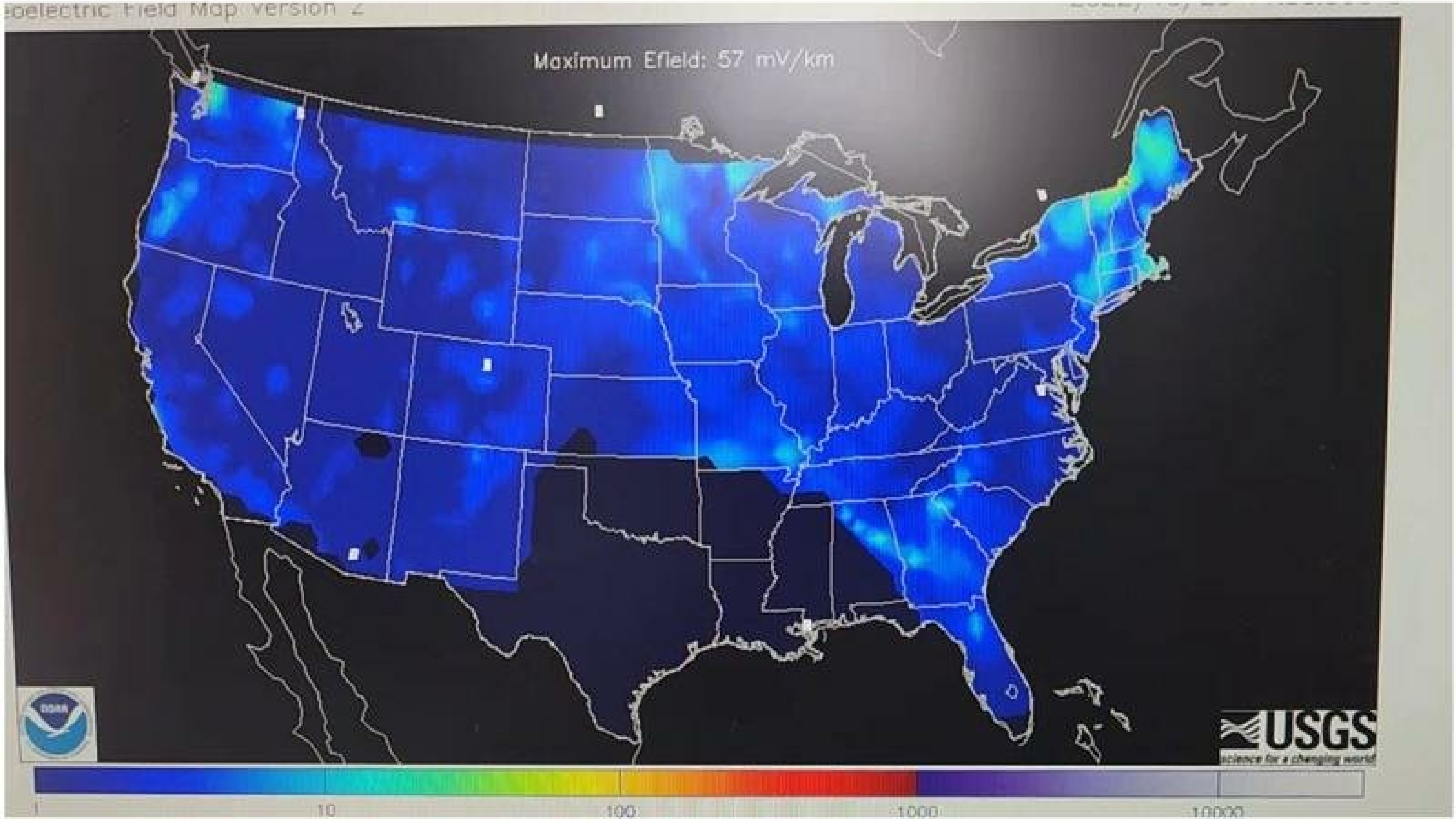
Dashboard of Events



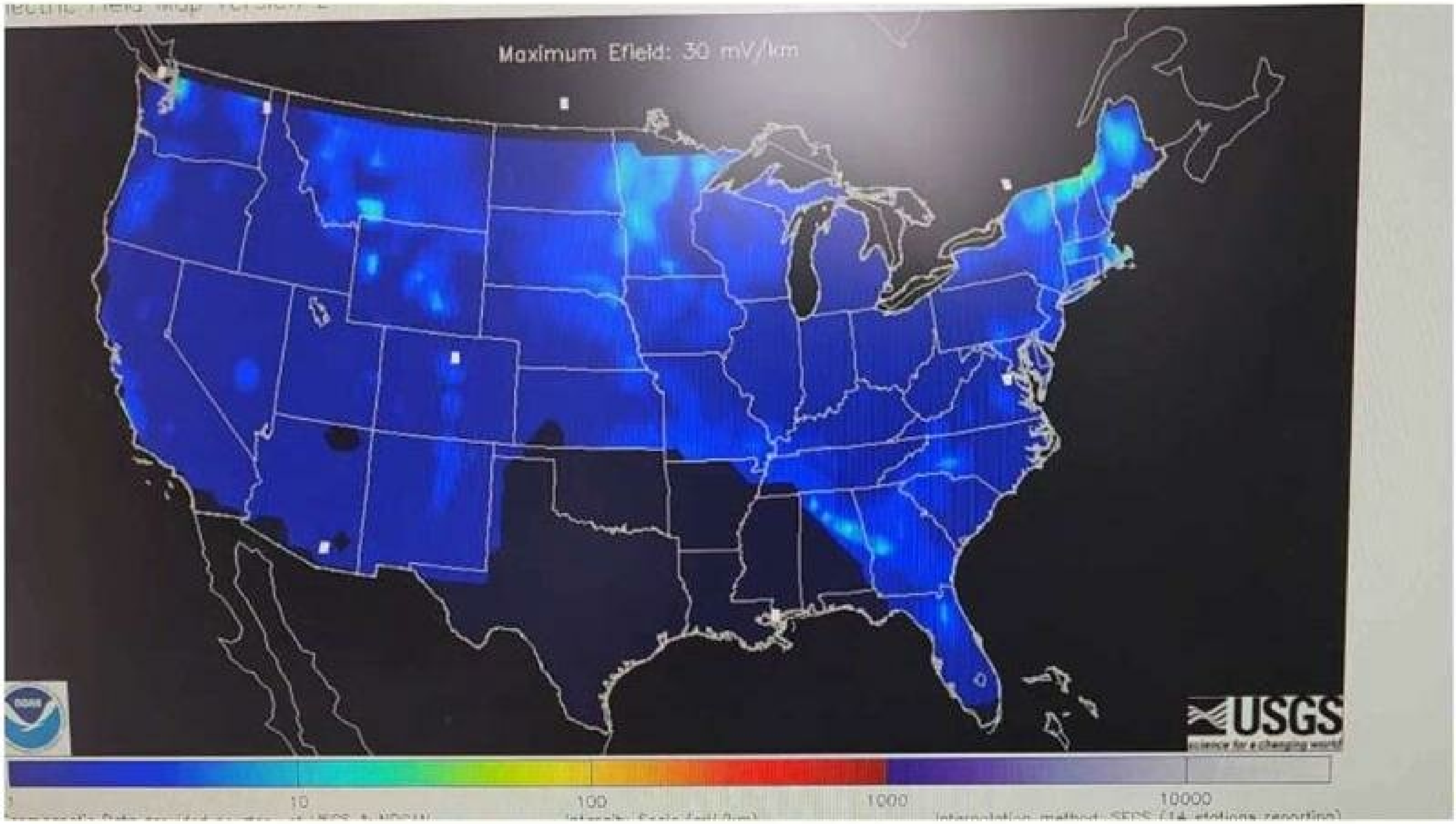
Dashboard of Events



Realtime Effects

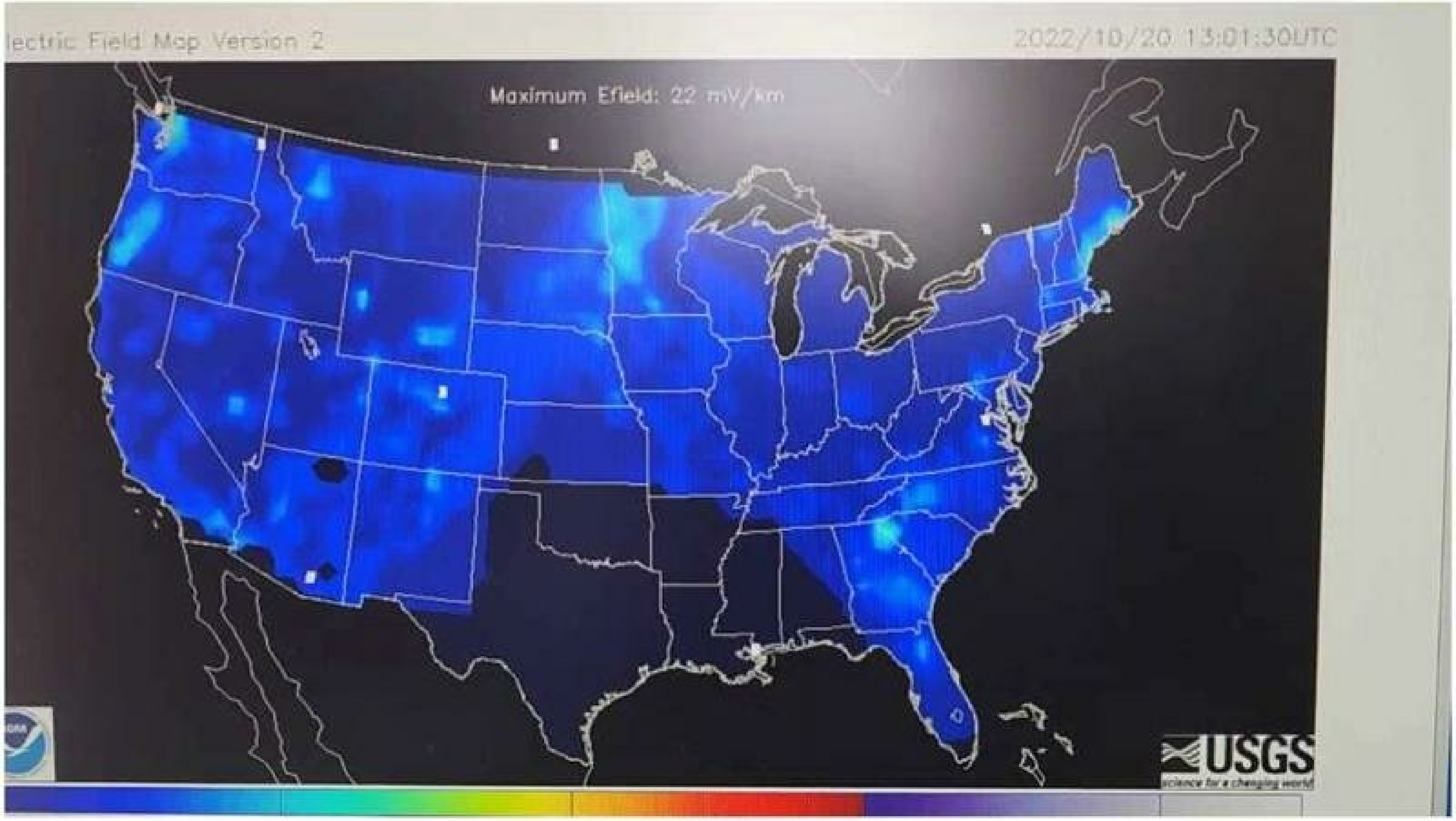


Realtime Effects

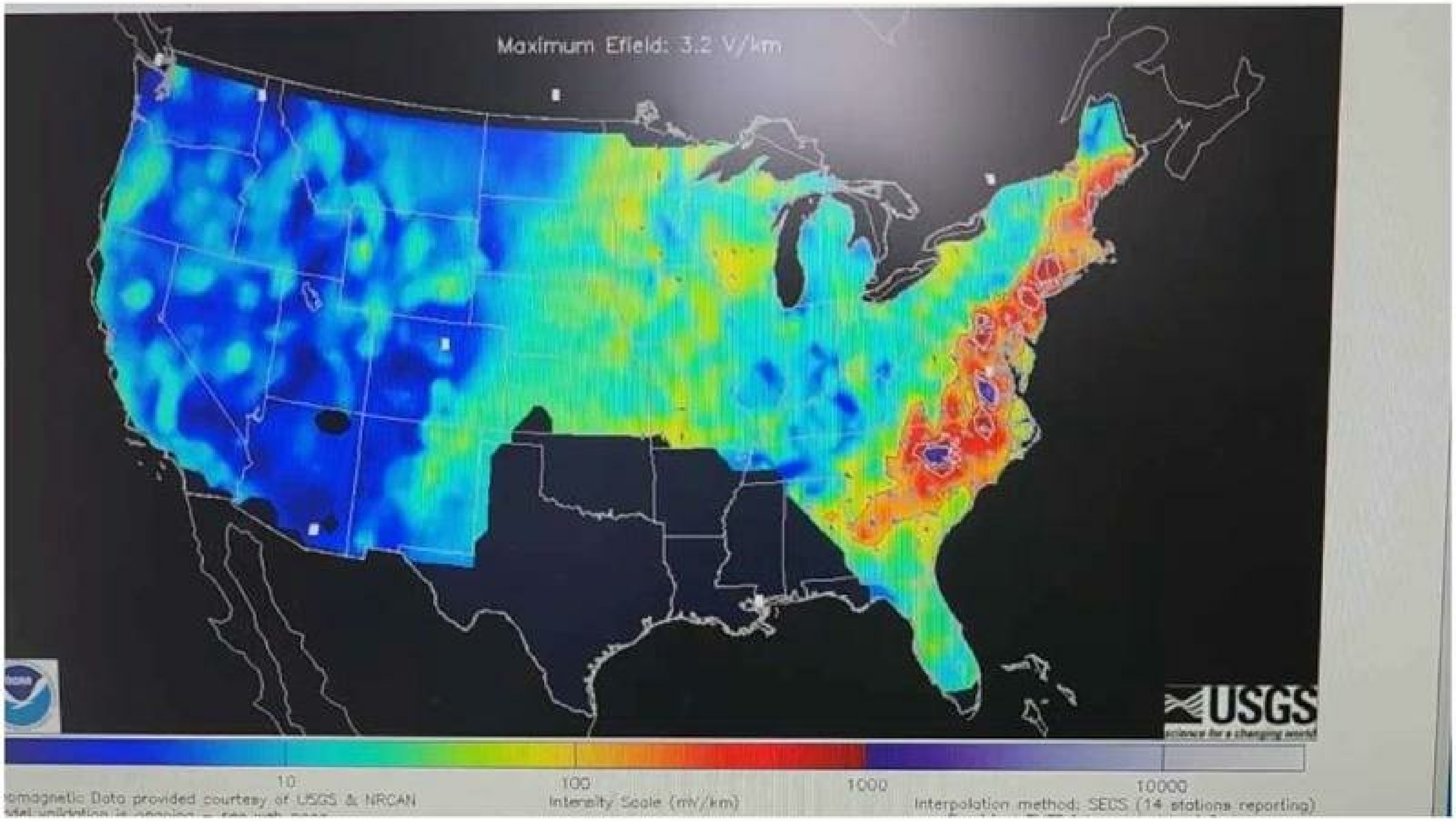


HYPERCRITICAL INFRASTRUCTURE

Realtime Effects

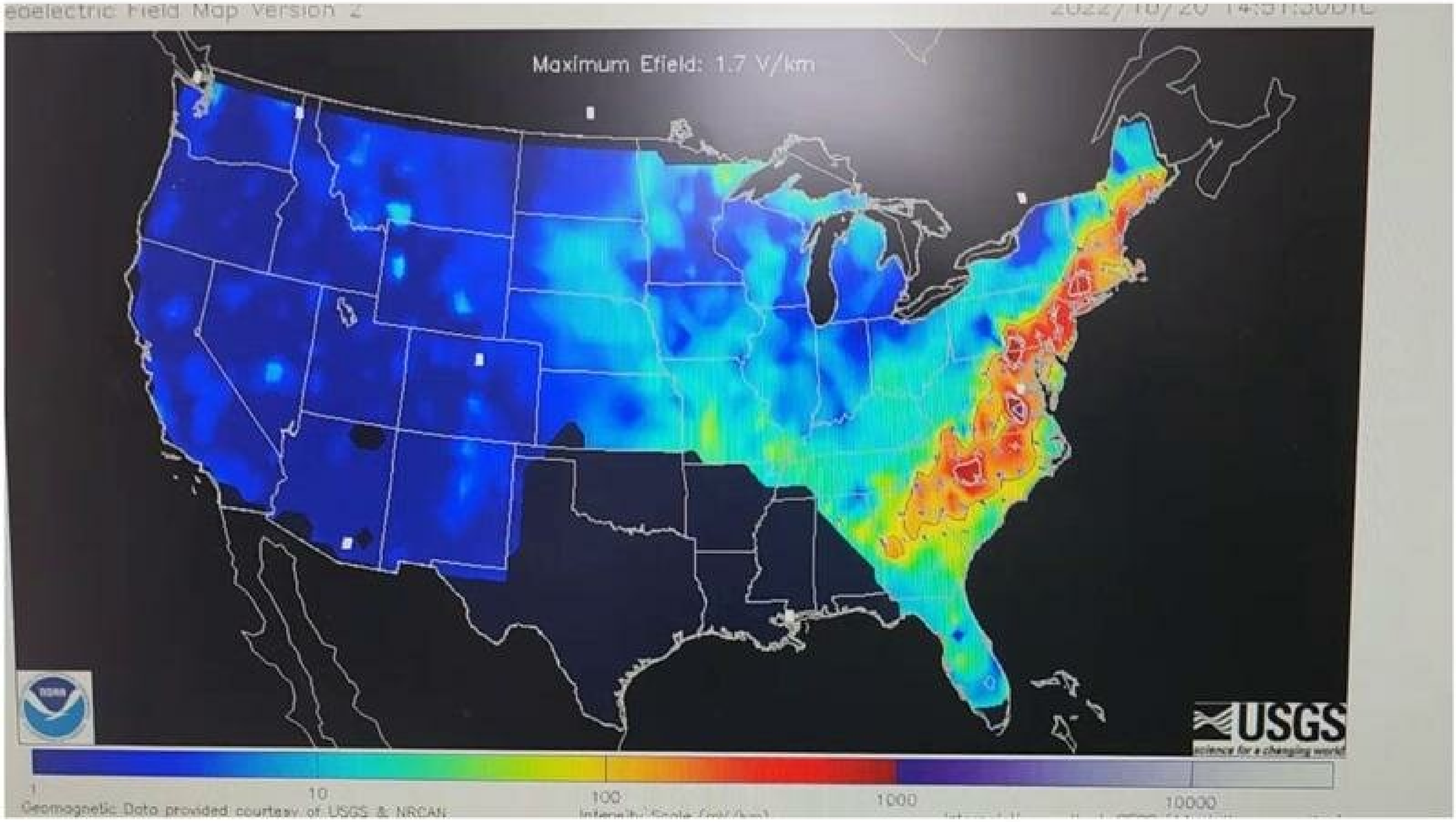


Realtime Effects



HYPERCRITICAL INFRASTRUCTURE

Realtime Effects



Historical – Has Happened and Will Again

Some significant GMD historic storms and their impacts include the following:

- **August 28–September 2, 1859** (known as the Carrington Event): One of the stronger storms recorded in the modern era, and one of the fastest moving, with only 17 hours in transit. Some telegraph systems were destroyed in Europe and North America.
- **November 18, 1882**: A GMD event caused a compass deflection of nearly two degrees.
- **June 17, 1915**: In the northeastern portion of North America, eastern-running telegraph lines were affected, allowing no transmissions. Northern-running lines were not affected.
- **May 13–15, 1921**: Railroad switching and signaling systems in New York were damaged; telephone and telegraph systems were interrupted and/or damaged across the United States and Europe; and even undersea cables were damaged.
- **March 24, 1940**: The Philadelphia Electric Company recorded strong reactive power swings and voltage surges throughout the electric grid. Telephone cables between Fargo, North Dakota, and Winnipeg, Canada, had wires fused together. More than 185,000 miles of telephone and telegraph lines were knocked out of service.

Historical – Has Happened and Will Again

- **August 4, 1972**: Solar astronomers reported three powerful solar flares. The next day, the Pioneer 9 spacecraft detected large solar waves. AT&T reported voltage surges; Bell reported service outages from Plano, Illinois, to Cascade, Iowa; and Canadian Overseas Telecommunications Corporation reported voltage surges that damaged equipment. Transoceanic communication cables also encountered problems.
- **March 13, 1989**: Hydro-Quebec power grids located in Canada and supporting approximately six million customers lost power for more than nine hours. Throughout North America, there was an increased number of failed transformers in the following months.
- **October 29, 2003**: This storm was one of the fastest moving solar storms, at only 19 hours in transit. The $450M Midori-2 research satellite was lost. South Africa experienced transformer damage and blackouts. Astronauts on the International Space Station reported radiation effects.
- **July 23, 2012**: A storm, at least the size of the Carrington Event and approximately twice the magnitude of the 1989 event, missed the Earth's path by one week. According to the National Academy of Sciences, the economic impact could have been in the trillions of dollars, and it would have taken years to recover from the damage.

Technology Old vs. New

- **So what is different since 1958, 1989 and 2001?**
  - Up until past 20 years the power grid has been a manually/physically operated infrastructure, thus solar events had minimal impact to control and protective systems.
- **Today the control/monitoring/protective infrastructure is automated with 98% SCADA, electronic, and network controlled so any number of solar (or man-made) EMP events could have catastrophic effects.**
  - To compound the problem, there are no, or at best minimal backup/replacements to these SCADA devices, resulting in some cases, projected 1+ years of power outages (if regional/national event) while waiting on replacement systems.


Impact

HYPERCRITICAL INFRASTRUCTURE

Risks to Each Industry Sector

Critical Infrastructure Sector	Catastrophic Impact/Loss
Chemical	SCADA C&C, safety, containment, monitoring
Communications	Networks, satellites, land to air, data sharing, notifications
Critical Manufacturing	Electrical and replacement equipment, medicines, machinery
Dams	Blackstart, baseload power, electrical and replacement equipment
Defense Industrial Base	Lab environmental containment, replacement equipment
Emergency Services	Life support equipment, law enforcement communications
Energy	Power/transmission/distribution, oil/gas, fuels
Financial Services	Monetary access, trading systems
Food and Agriculture	Production, processing, hot/cold food safety storage
Healthcare & Public Health	Life support equipment, medicines, healthcare, IoT devices
Information Technology	Networks, data systems/services, C&C, monitoring
Nuclear Reactors/Materials/Waste	SCADA C&C, safety, containment, monitoring
Transportation Systems	Mass transit, aviation, shipping, pipelines, automotive, fuels
Water/Wastewater Systems	Drinking water, sewage treatment

HYPERCRITICAL INFRASTRUCTURE

Impact to Critical Systems

Possible impacts to infrastructures resulting from High-altitude EMP (HEMP)

UNCLASSIFIED

Infrastructure (rating assumes not EMP protected)	Days ⟺ Months
Undersea Cable Infrastructure (main risks: E1 + E3)	Upset and damage
Satellite in space (System Generated EMP (SGEMP) + radiation belts)	Upset/degradation
Satellite terminals/support (vulnerable to HEMP E1)	Upset and damage
HF radio equipment (vulnerable to HEMP E1)	Upset and damage
HF sky wave media (heals in hours; HF groundwave not impacted	HF propagation
Computers and Ethernet Interfaces (vulnerable to HEMP E1)	Upset and damage
Desk phones (vulnerable to E1 EMP conducted on power/data cords)	Upset and damage
Cell phones (risk to towers/backhaul from E1; handsets generally OK)	Upset and damage
Routers and phone switches (vulnerable to HEMP E1)	Upset and damage
Radio and TV stations (likely to go off-air immediately due to E1)	Upset and damage
Portable battery operated radios (eventual power problem)	Battery dependent
Land mobile radios (OK if not trunked; eventual power problem)	Power dependent
Unprotected parts of the electric grid (main risks: E1 + E3)	Upset and damage

Source: NCC - Electromagnetic Pulse (EMP) Protection and Resilience Guidelines for Critical Infrastructure and Equipment

HYPERCRITICAL INFRASTRUCTURE

Impact to Critical Systems

- This chart describes the equipment status under several types of high-impact low-probability (HILP) EMP attacks.
- Non-nuclear EMP attacks have direct and permanent effects on all electric equipment including power grids and grid-dependent devices.
- Compared to physical attacks, although power grid equipment such as transformers and generators are identically vulnerable, the EMP can bring more dangerous chained effect to devices that are connected to the grid such as water supply, internet, and GPS

POTENTIAL IMPACTS OF HILP EMPS ON CRITICAL INFRASTRUCTURES

Equipment At Risk	EMP (Nuclear)	Solar Storm	Cyber	Physical Attacks	Radio Frequency Weapons
Generator Stations	DPE	DEU	DPE	DPE	DPE
SCADA/Industrial Controls	DPE	DPE	DPE	DPE	DPE
Utility Control Centers	DPE	DPE	DPE	DPE	DPE
Transformers	DPE	DPE	PPE+CE	DPE	DPE
Telecommunications Including Cellphones	DPE	DPE	DPE	CE	CE
Internet	DPE	DPE	DPE	CE	CE
Radio Emergency Communications	DPE	TE	CE	CE	CE
Emergency SATCOM Communications	DPE	TE	CE	CE	CE
GPS	DPE	TE	CE	CE	CE
Transportation	DPE	CE	CE	CE	CE
Water	DPE	CE	PPE+CE	CE	CE

DPE = Direct Permanent Effects.
DEU = Direct Effects Uncertain.
CE = Cascading Effects (if no backup power).
DPE+CE = Potential Permanent Effects plus Cascading Effects.
TE = Temporary Effect (0.5-36 hours) assuming backup power.

Source: Power Grid Resilience to Electromagnetic Pulse (EMP) Disturbances: A Literature Review


Challenges

Challenges to Moving Forward

While developing the vertical strategies with key partners, core principles need to be established:

- Expectations must be defined to the acceptable levels of performance for each vertical and their systems for a pre-defined EMP event.
- In the event of an electromagnetic incident, minimizing the loss of life and protecting and restoring critical infrastructure to pre-event levels should be the highest priority.
- Assessments of electromagnetic incident risk in the planning stage of preparedness must be based upon sound science and consensus Intelligence Community (IC) findings.
- Critical infrastructure protection activities should be prioritized based on risk management principles.
- The interdependence of critical infrastructure sectors must be accounted for when assessing risk and considering protective measures.
- Government and the private sector should share responsibility for critical infrastructure protection.
- Sharing of threat assessments and analyses among departments, critical infrastructure owners and operators, and private sector partners is critical.
- Nation approach to preparing for, and responding to, electromagnetic incidents.


Strategies

Assessments and Recommendations

Vulnerability Assessments Recommendations

- Collaboration and Coordination with Federal Government
  - Create an EMP Task Force to regularly coordinate and collaborate with governmental authorities to procure and effectively disseminate information needed by industry.
- EMP Vulnerability Assessment Methodology
  - Develop guidelines for industry planners and equipment owners to use in assessing EMP impacts on their infrastructures.
- Critical Assets Identification
  - Identify and categorize all assets and interdependencies.
  - Provide guidance to the industry on how to identify and prioritize hardening of assets that are needed to maintain and restore critical operations.

Mitigation Guidelines Recommendations

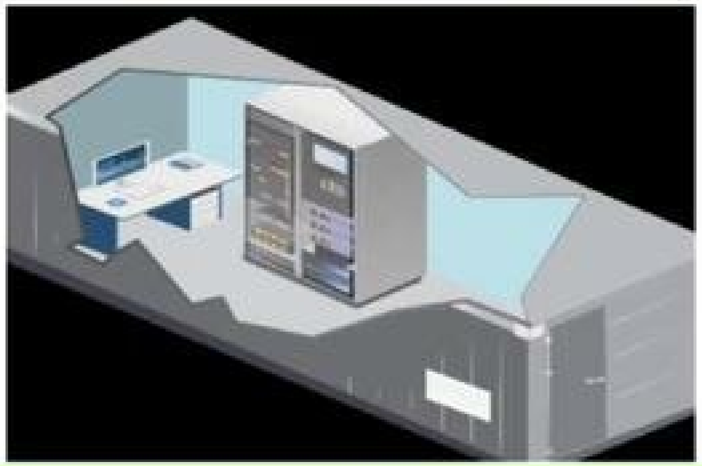
- Develop Guidance on EMP Mitigation
  - Develop guidelines for each industry to use in developing strategies for mitigating the effects of EMP (control centers/plant control, operations, supplies, manufacturing).

Assessments and Recommendations

Response and Recovery Recommendations

- Establish National EMP Notification System
  - Partnering with the appropriate agencies to develop a real-time national notification system for each vertical pertaining to an EMP event.
- **Coordinated Response Planning**
  - Develop response planning guidelines for electric utility industry members for pre and post-contingency of an EMP event that aligns with DHS and FEMA.
- **Enhance Operating Procedures**
  - Provide guidance to each industry on criteria to incorporate into operating plans and procedures and system restoration plans pertaining to EMP event.
- **Incorporate EMP Events into Industry Exercises and Training**
  - Develop training for system and operators about EMP events and what to anticipate and incorporate in industry exercises to test response planning and system restoration recovery.
- **Guidance on Supporting Systems**
  - Provide guidance to industry for supporting systems and equipment (including spare equipment strategy) needed for recovery post-EMP event.

EMP Protection Solutions



HYPERCRITICAL INFRASTRUCTURE

Q&A and Contact

Webinar Q&A

Please contact Hyper Critical for additional information

Thomas Strickland
President & CEO
tstrickland@hypercriticalinfrastructure.com
www.hypercriticalinfrastructure.com
404.323.7764

SCAN ME