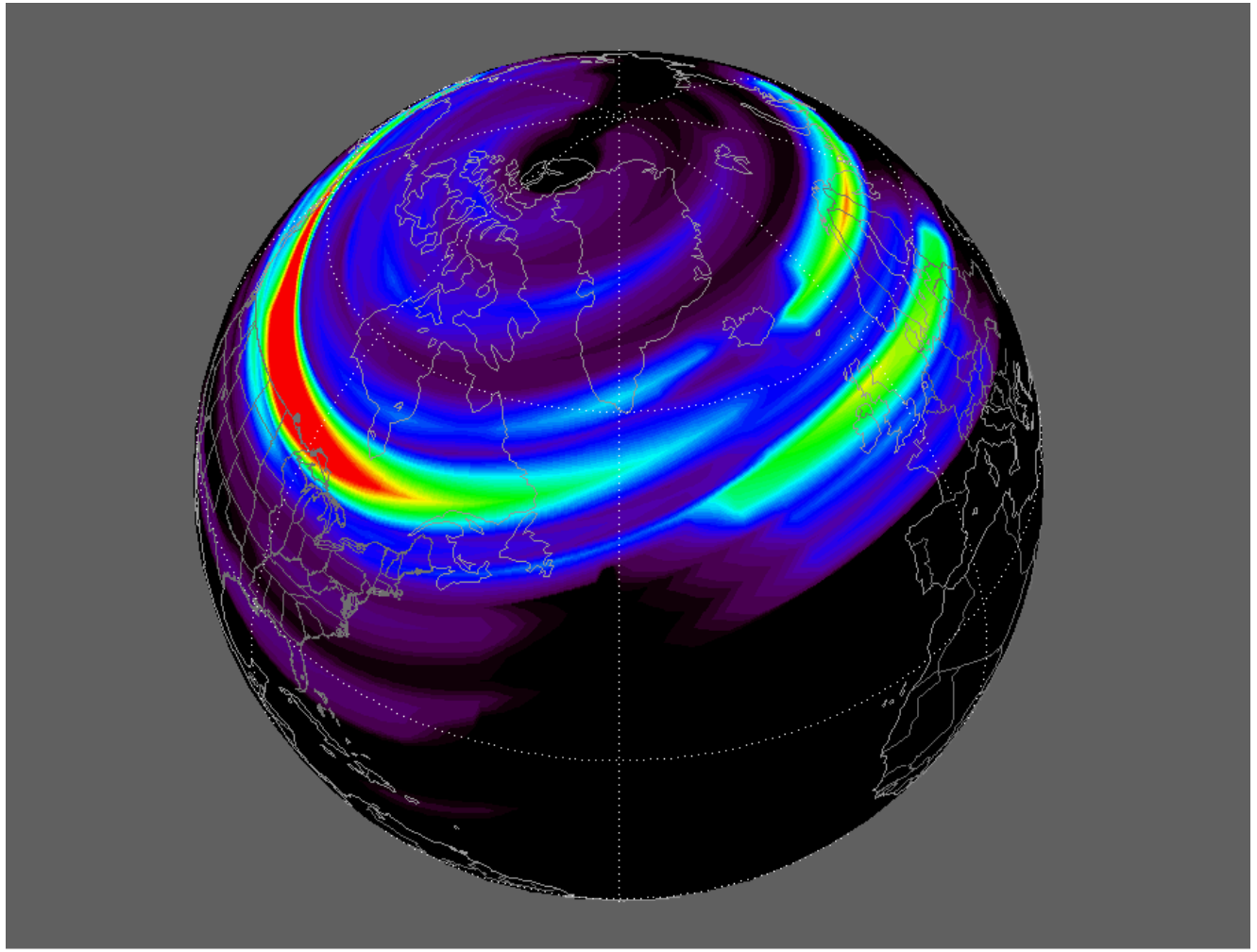
Electric Grid Vulnerability to EMP & GMD



Storm Analysis Consultants

John G. Kappenman

EMP & GMD: Perspectives on Current Status and Future Concerns

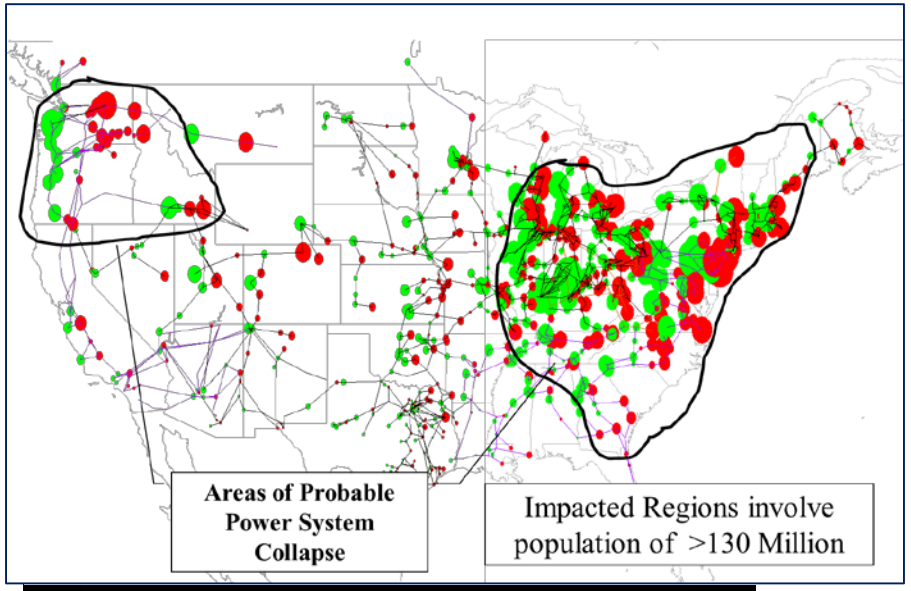
The Nation has experienced a Several Decade Long Failure to Understand how Risk has Migrated into our Electric Grid Infrastructures from GMD & EMP Threats

- Transmission Network Design Evolutions to Higher kV Rating and Single Phase Transformers have unknowingly Escalated GMD & EMP-E3 Risks and Potential Impacts
- Similar Evolution in Electric Grid for Relays, Control, Communications and IT go Electronic-Based Systems have made these important sub-systems much more vulnerable to EMP-E1
- **Un-Recognized Systemic Risk** – Changes Unchecked by Rational Design Code

US Government Report Findings

Congressional EMP Commission, FERC/DOE, National Academy of Sciences

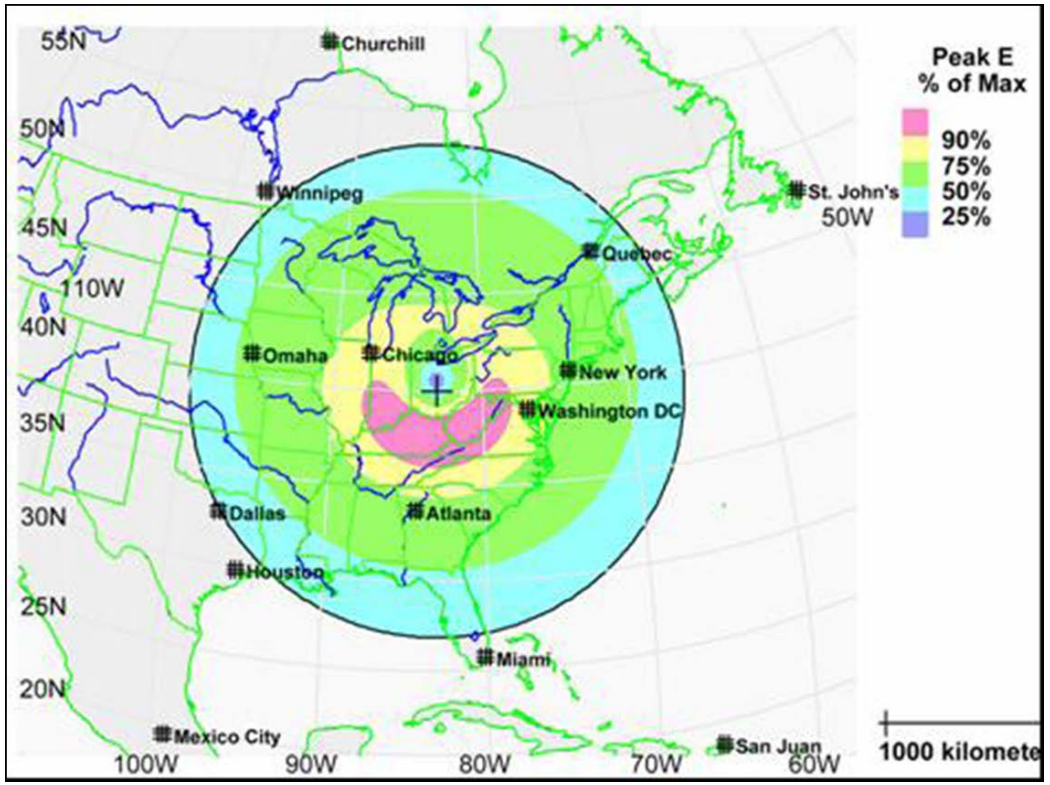
- ✓ Severe Storms ~4-10 Times Larger (~5000 nT/min) & 20-40 V/km Geo-Electric Fields
- ✓ Potential for GIC Flows ->1000 Amps/phase
- ✓ Potential for Grid Blackouts of Unprecedented Scale
- ? Damage Issue Questions
  - ? Transformers
  - ? Generators
  - ? Circuit Breakers
  - ? Arresters
  - ? SCADA, Controls & Sensitive Customers



EMP E1 (Fast Pulse) – Threat Perspectives

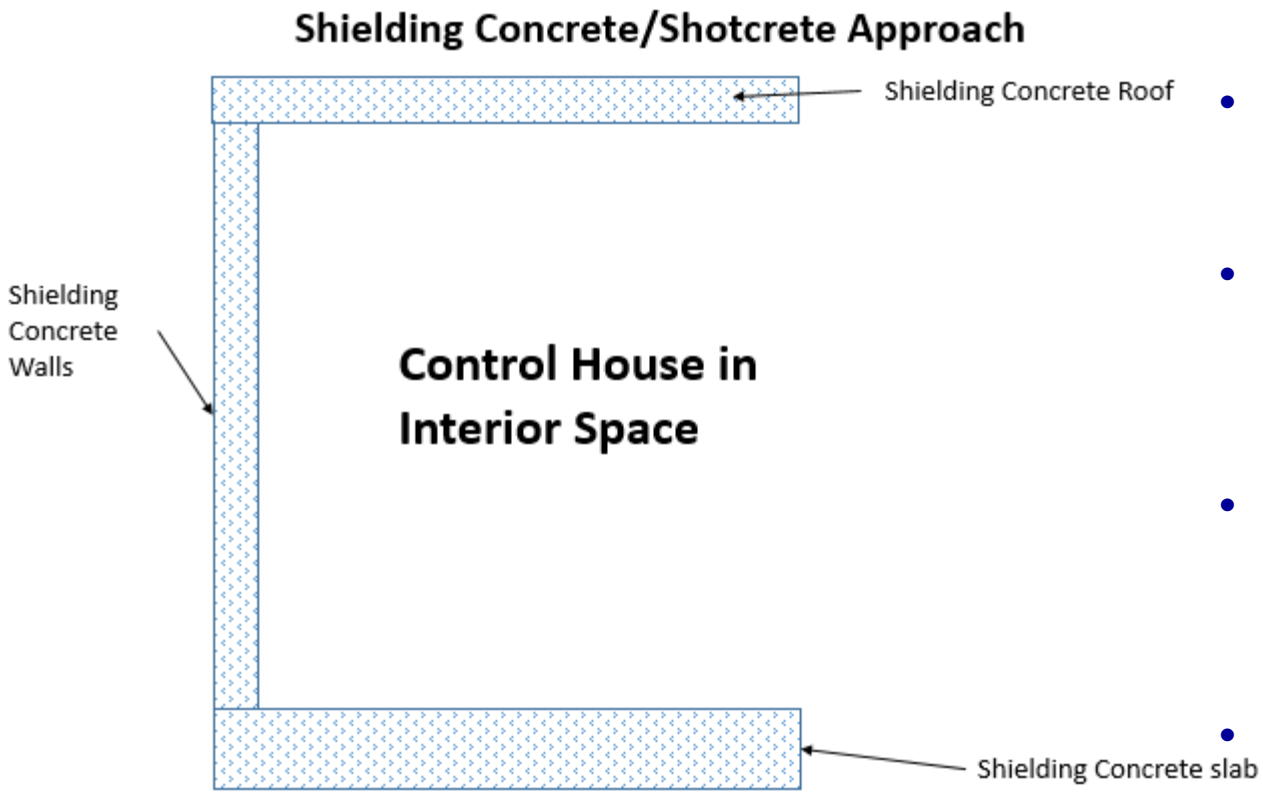
Often Posted around sensitive IT and Control Equipment
Cell Phone Environment which produces
1 to 3 V/m at Single Frequency

EMP E1 Environment footprint over large geographic laydown can have
50,000 V/m over Broad Spectrum



Inside a Substation Control House, EMS Center or Generator Distributed Controls Input Signals to Relays and SCADA Devices that can exceed 100,000 Volts with Multiple Widespread Permanent Damage

EMP E1 – Threat Perspectives
Rethinking Substation Control House using Shielding Concrete



- **Shielded Concrete is an RF-Absorptive medium**
- **Easiest Means to Create 6-Sided Protected Control House Building** with 60-80 dB Attenuation
- **Shielding Concrete/Shotcrete can offer substantial cost savings for EMP shielding** (~40% saving as compared with envelope + metal shielding cost)
- **Tortuous Path/Labyrinth Entryway (Personnel/Vents)** (because RF-Absorptive much simpler and less expensive than RF doors and vents)
- **Multi-Threat (blast/ballistic/EMP/IEMI/tornado) in a single envelope**

Threat Perspectives and Priorities to Harden Grid

- **Given Sufficient Time the Reoccurrence of Large Storm Event is a Certainty – Only with Much more Serious Consequences**
- **EMP Vulnerabilities tend to Invite and Reward Attack**
- **Many Options exist to Harden with various Costs & Efficiencies**
- **Public Lifeline Considerations should be initial focus – Restore Functional Water/Sewage, Food, Transportation, Communication at minimal levels Post-Event**
- **Partial Restoration of Regional Power Grids is necessary to Support Lifeline Services for Public (10-30% restoration as a starting point)**