Space Weather and its Associated Impacts to the Electric Power System

Space Weather Enterprise Forum

June 26, 2019

Frank Koza

EIS Council

Frank.koza@eiscouncil.org

About EIS Council

Mission

- EIS Council hosts national and international collaboration on resilience and whole community restoration and response planning, addressing severe, national and global scale hazards to lifeline infrastructures

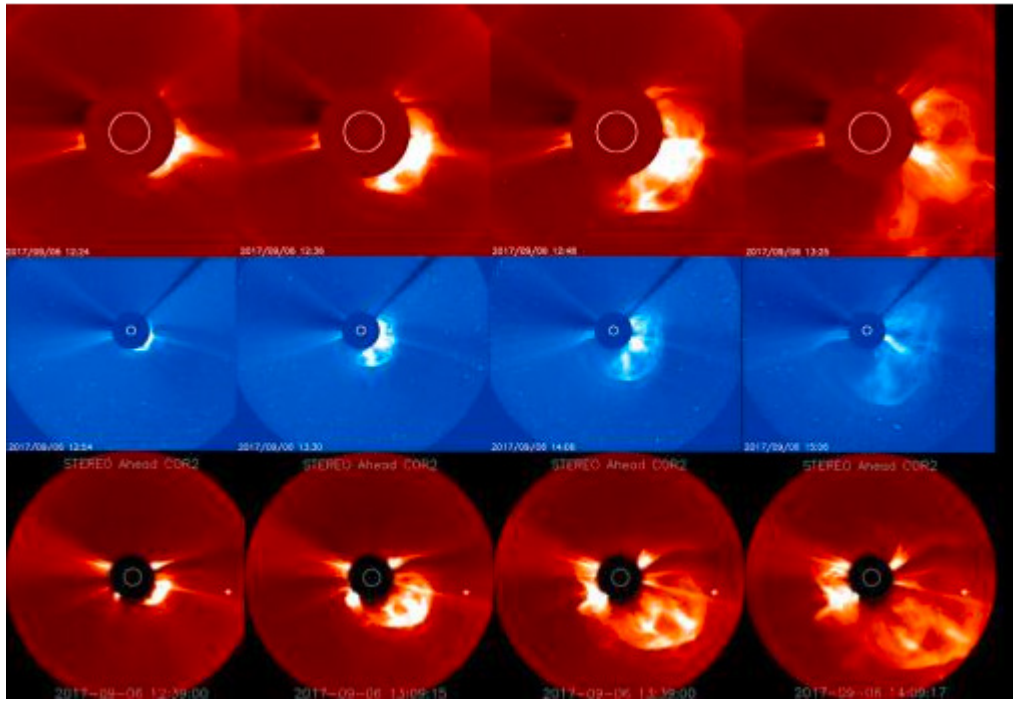
Summary of Resources

- Annual EIS Summit (Washington, DC, June 24-25, 2019)
- EarthEX (Aug 21, 2019, registration open now!)
- ePRO Handbooks
- Black Sky Exercise Facilitation and Support

www.EIScouncil.org

EIS COUNCIL

Coronal Mass Ejection (CME) Background

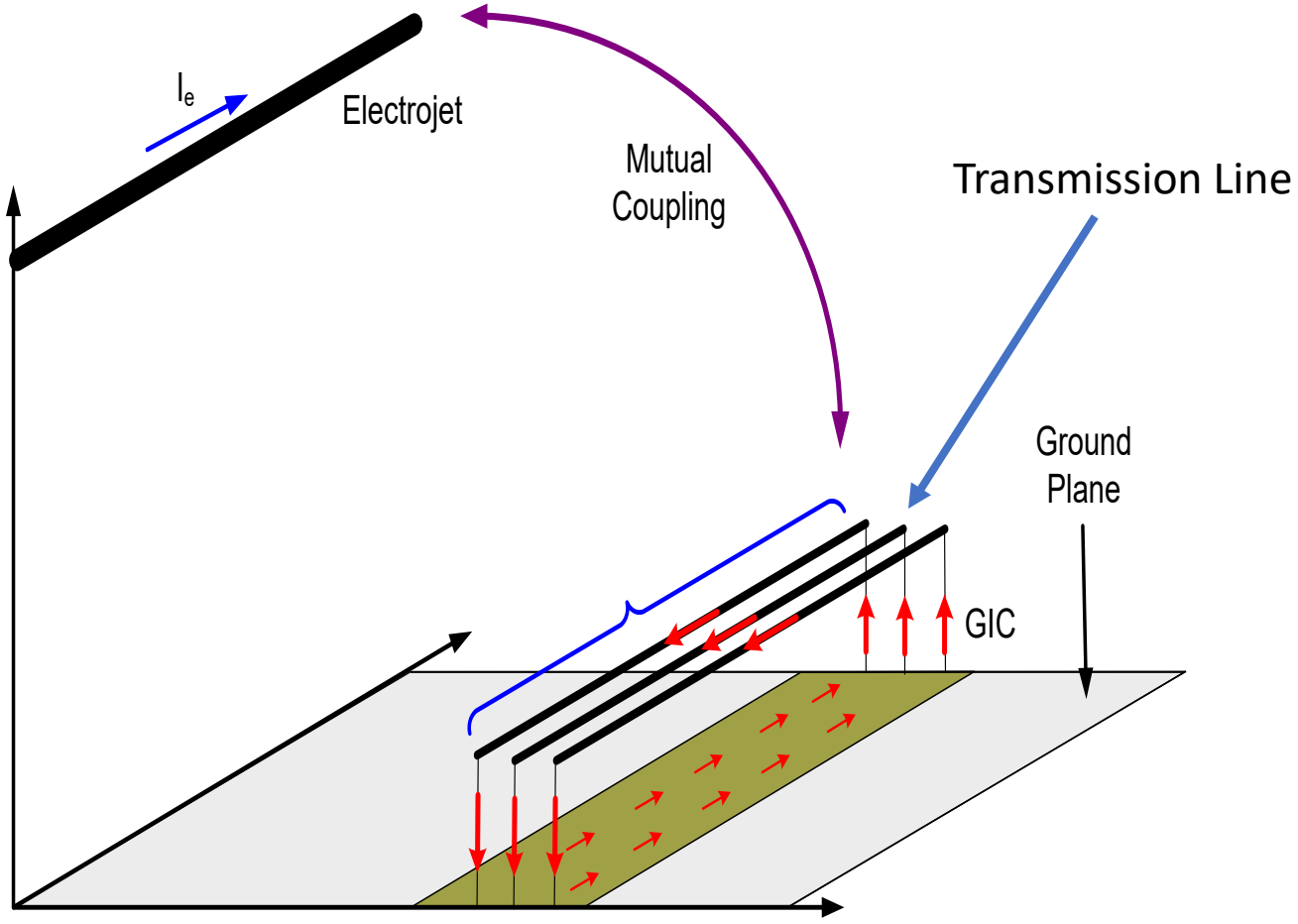


Source: Space Weather Prediction Center Website

- CMEs are large clouds of plasma, ejected from the Sun into space (can be billions of tons!)
- Fast CMEs can travel at up to 5-6 million mph! (Good news: we get at least a 15-18 hour warning!)
- NOAA Space Weather Prediction Center, NRCan Space Weather Canada, and a number of satellites are always watching (https://www.swpc.noaa.gov/) (http://www.spaceweather.gc.ca/)

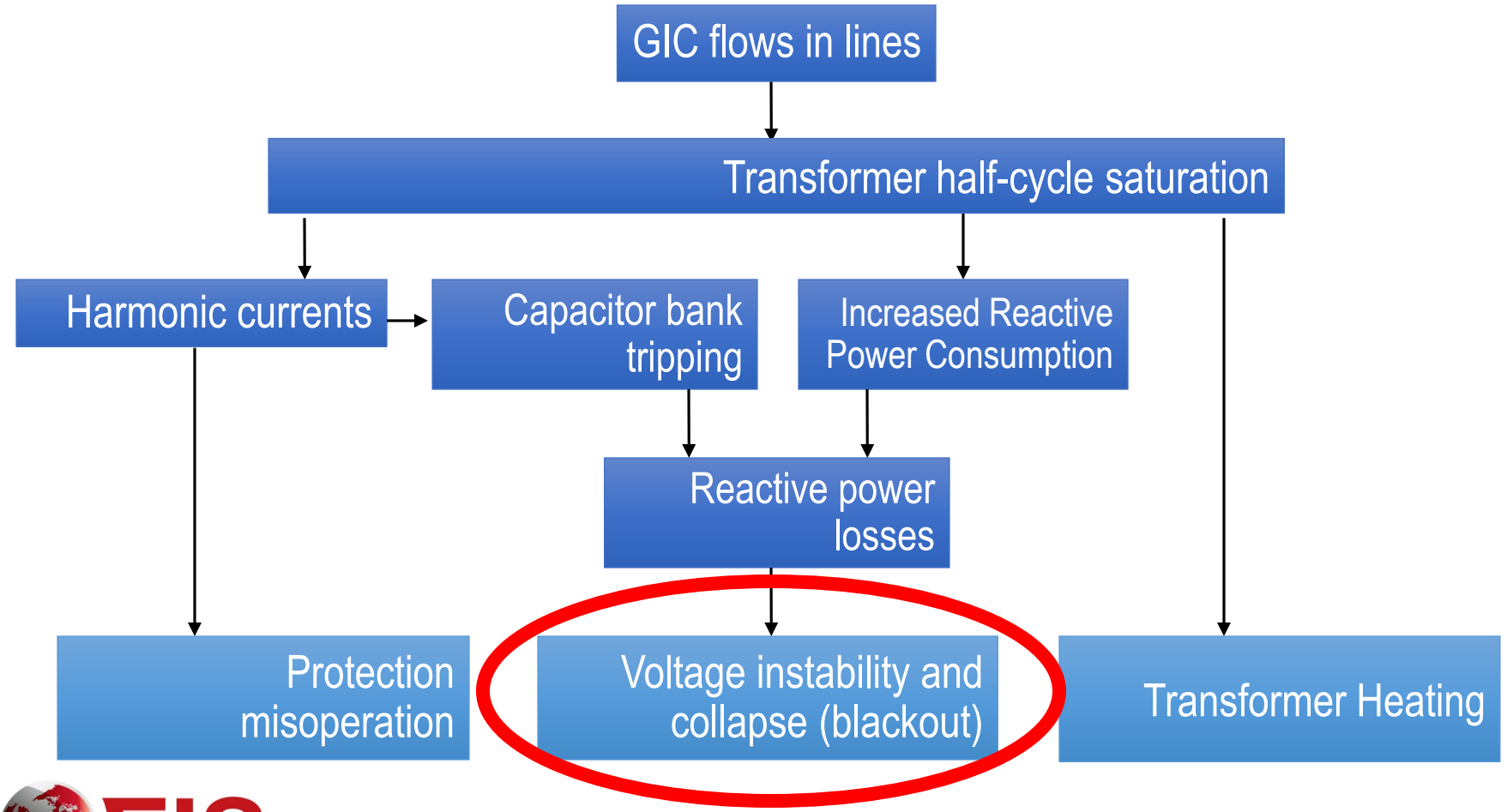
EIS COUNCIL

Interaction with the Transmission System



- CMEs induce electrical currents in the transmission lines and the ground
- The magnitude of the Ground Induced Current (GIC) depends mainly on:
  - Transmission impedance (higher voltage lines are most susceptible—230kV and higher)
  - Ground conductivity
  - Geomagnetic latitude
  - Transmission line topology (East-west lines are most vulnerable)

Potential Impacts to Power System Operation



- Voltage collapse and blackout
  - August 2003 Northeast Blackout
  - Jul, Aug 1996 Western blackouts
- Transformer Hot Spot Heating and failure
  - Some transformers are likely to fail in an extreme event, but not large numbers (10s, not 100s)

EIS COUNCIL

System Operations Response

Can we react in real time to mitigate the impacts?

- Prepare (before the event)
  - Monitor alerts/warnings issued by Space Weather Prediction Center or Space Weather Canada 1-3 days in advance (based on satellite and USGS and NRCan magnetometer ground station information)
  - Perform sensitivity studies to ensure adequate system resiliency for future operating periods (reduce transfers/bring more local generation on/stop transmission maintenance)
- Monitor (during the event)
  - GIC Detectors are in place at numerous locations to watch for GMD impacts in real time (installed on transformer neutrals)
  - Adjust/operate more conservatively based on system conditions (boost voltage wherever possible)

But What If the Blackout Happens?

- If no system damage, expect a “replay” of August 2003
  - Systematic restoration and recovery that would likely take 8-24 hours to accomplish in most areas
  - Some significant impacts to other infrastructures—water, oil and gas, communications, transportation, etc.
  - No need for evacuations
- With system damage, restoration and recovery becomes more problematic (think: Hurricane Sandy)
  - Could cause long term outages (days or weeks) in some localized areas
  - With long term power outages comes long term outages of other infrastructures
  - Local evacuations may become necessary, or at least local sheltering

System Planning Response

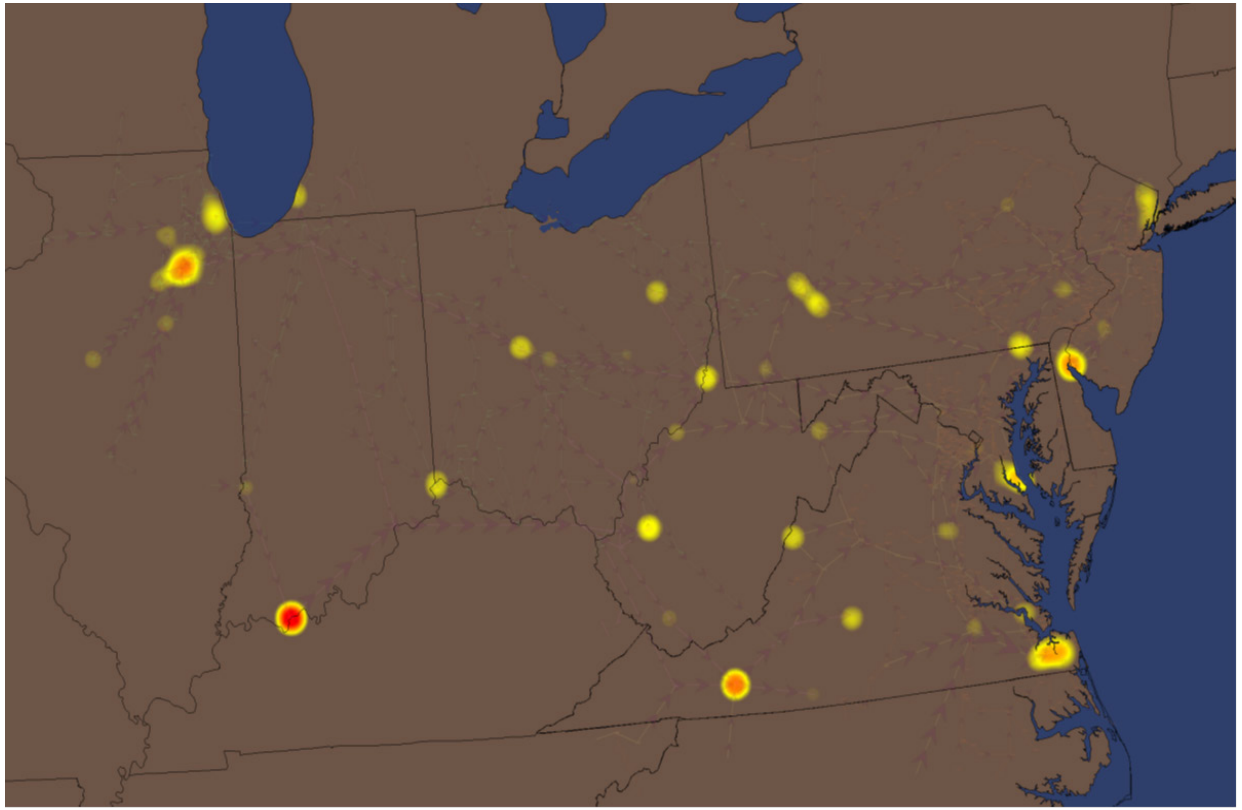
Can the risk be “engineered out” of the system?

NERC Standard TPL-007 (applies to North American transmission planning entities and asset owners)

- Requires a **GMD Vulnerability Assessment** of the system for its ability to withstand the Benchmark and Supplemental GMD Events without causing a wide area blackout, voltage collapse (due 1/1/2023)
- Requires a **Transformer thermal impact assessment** to ensure that all high-side, wye grounded transformers connected at 200kV or higher will not overheat based on the Benchmark and Supplemental GMD Events (due 1/1/2022)

EIS COUNCIL

Sample GIC Calculation Results—PJM Example



- GICs are generally high at terminal points of extra high voltage EHV(345kV and up) transmission lines
- Proximity to the ocean is another predictor of higher GICs

EIS COUNCIL

Where is the Industry on Protection from CMEs?

- NERC Standard TPL-007 is requiring analysis and mitigation to be undertaken
- American Transmission Company (Wisconsin) has successfully installed a GIC reduction device
- Research by NERC, EPRI, and others continues to better understand the phenomena
  - Improved earth conductivity models
  - Improved harmonics analysis tools
  - Transformer thermal impacts
  - Spatial averaging

Courtesy: EMPRIMUS

Sobering Closing Points

- The Sun is in a quiet period right now…but the most severe disturbances can and have occurred during relatively quiet periods – continuing vigilance is required.
- We have not experienced an event like the benchmark 1859 Carrington event in the era of high voltage power grid (although we had a near miss in July 2012)
- CMEs have been compared to EMP E3 which is the slower, longer lasting portion of the EMP pulse, which also induces GICs in electrical equipment. EMP E3 has higher amplitudes than GMD, although it doesn't last as long.

EIS Council Activities

- Facilitate and support Black Sky exercises – generally, not space weather, but the learnings are applicable (Iowa, CUSEC, UK, and others)
- Encourage cross sector discussion and planning (March 2019 electric subsector meeting: various utility sectors, government agencies)
- Create resources to facilitate plan development (Working group, working on resilience guidelines for the electric industry)
- Run EARTH EX (August 21, 2019)—also not a space weather scenario, but comprehensive exercise with 32 specific participation lanes this year!

EIS COUNCIL