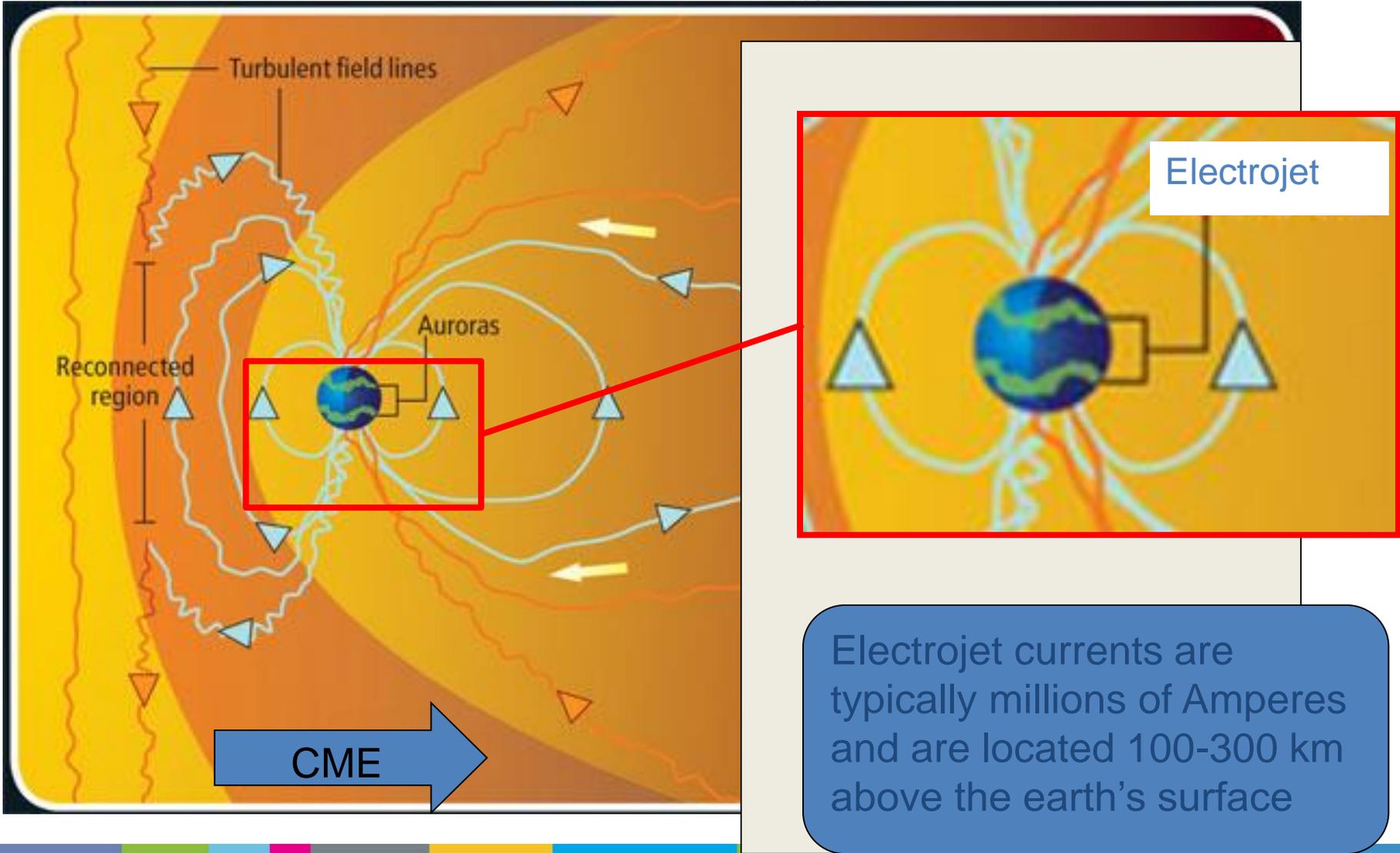


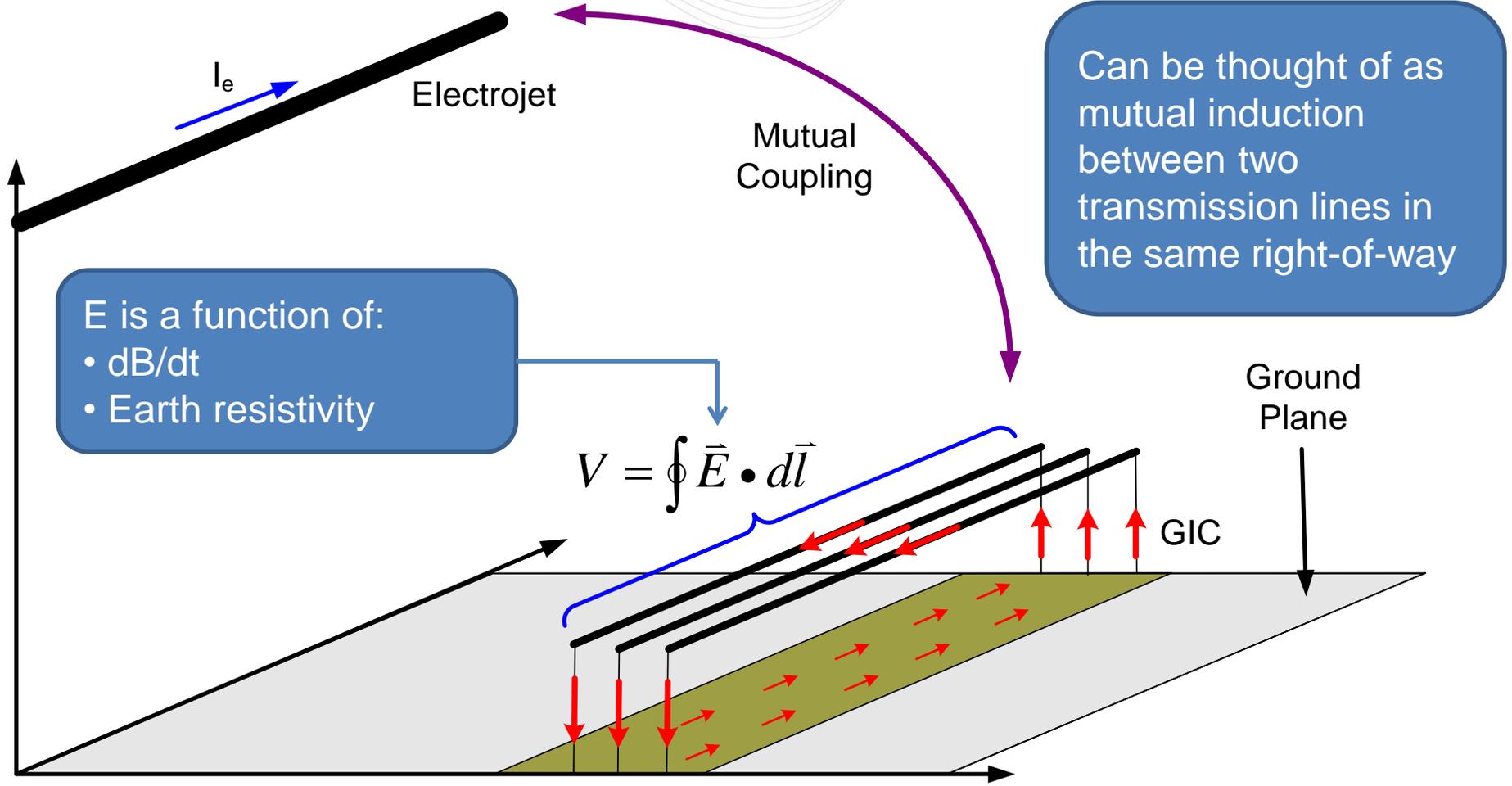
# Space Weather Power System Impacts and PJM Response

NOAA/NWS/SWPC Space Weather  
Workshop  
April 27, 2016

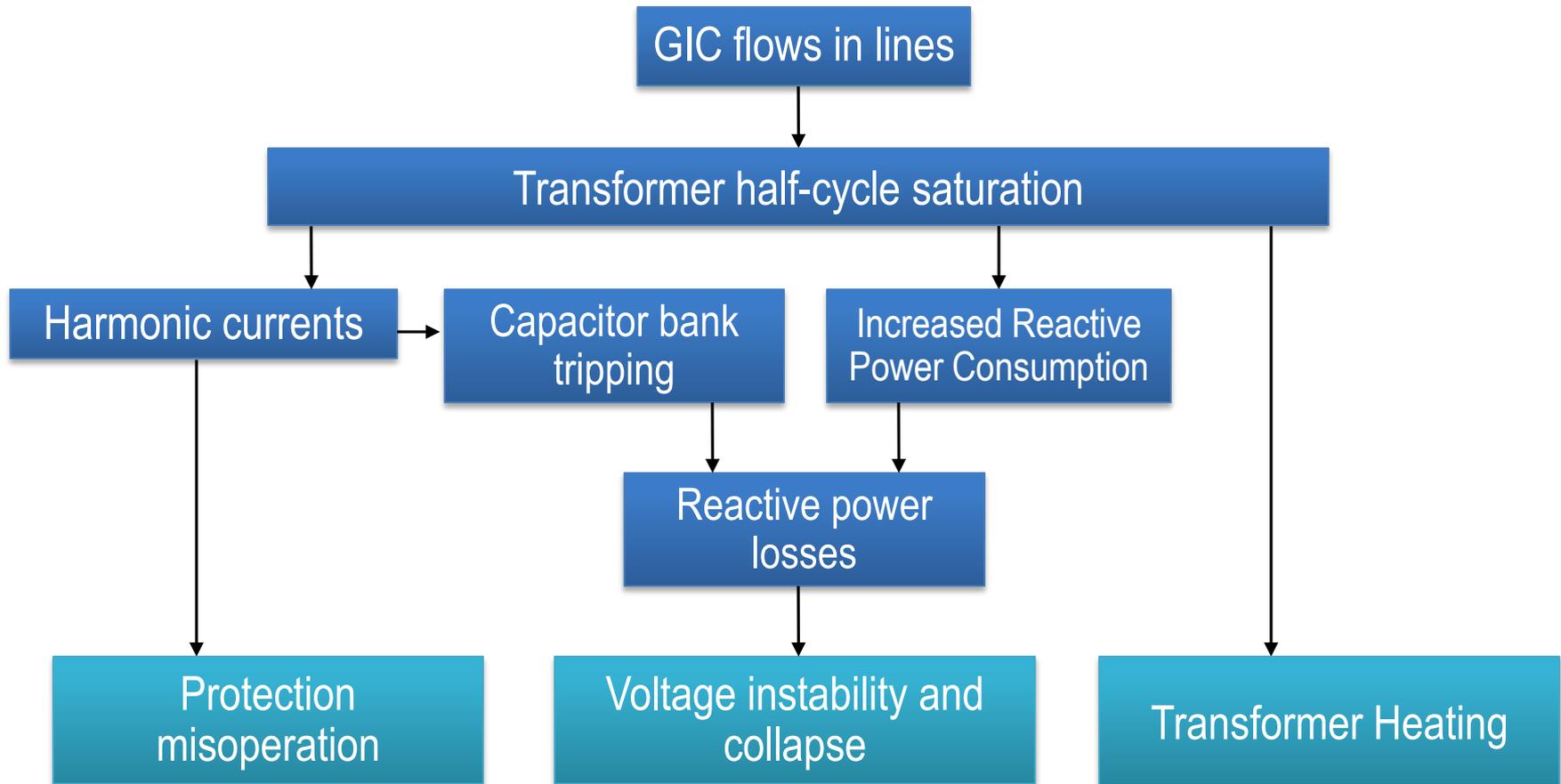
Frank J. Koza  
Executive Director, Infrastructure Planning  
PJM Interconnection



Electrojet currents are typically millions of Amperes and are located 100-300 km above the earth's surface



**Induced Currents are “Quasi-dc” (mHz)**

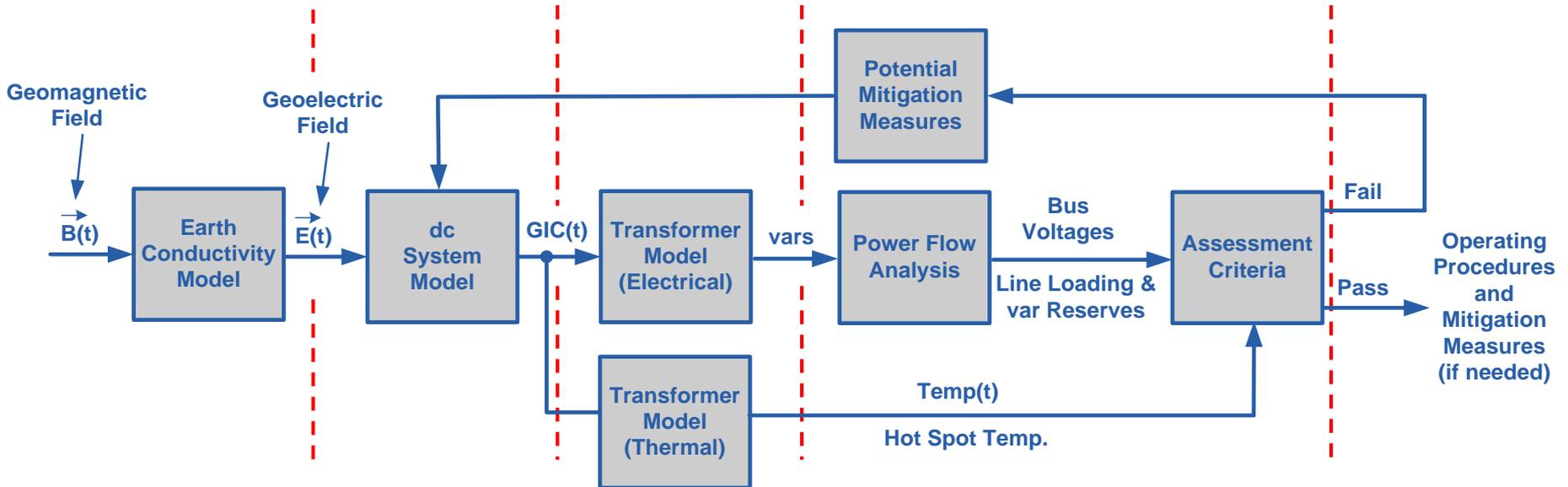


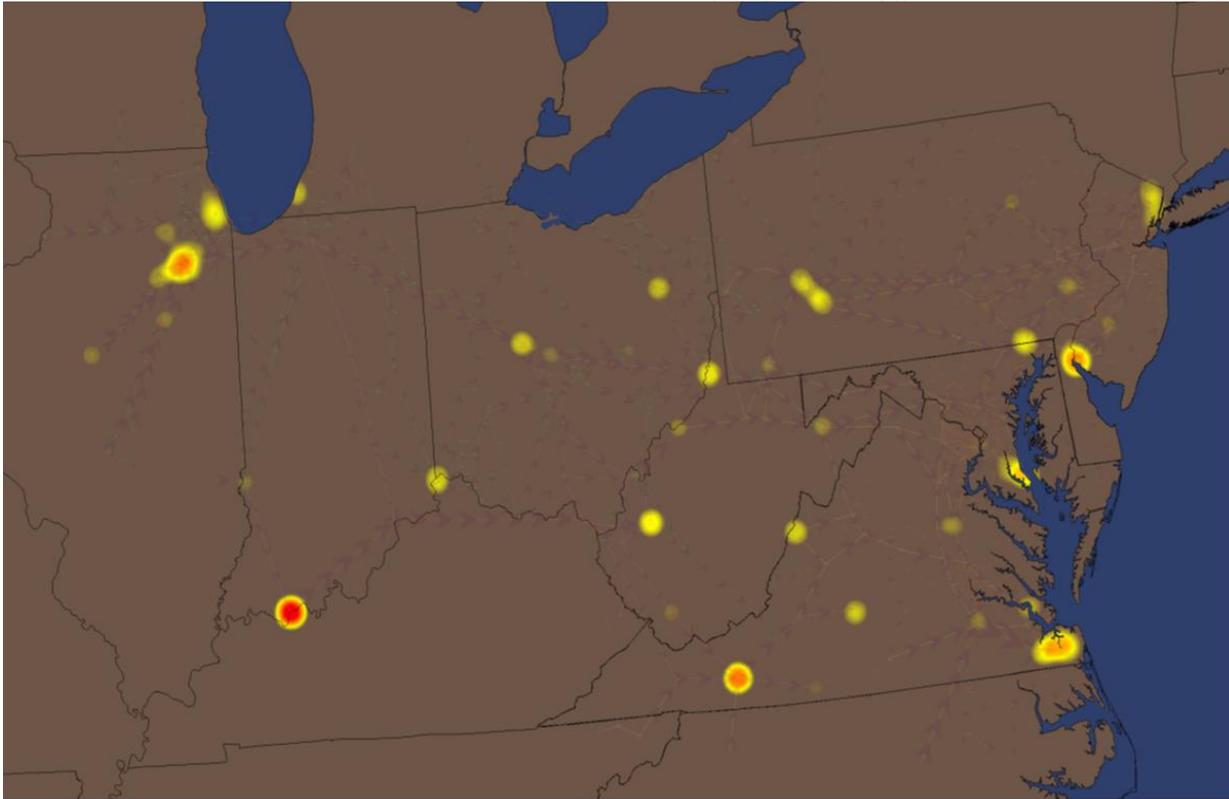
- Prepare (before the event)
  - Alerts/Warnings issues by SWPC 1-3 days in advance and monitored by PJM.
    - Include Intensity (K-scale) and latitudes impacted
  - Notify members and neighbors as needed.
  - Perform sensitivity studies ensure adequate system resiliency for future operating periods
    - Screen for loss of EHV capacitors, loss of major generating sites such as Artificial Island, loss of EHV transformers, etc.
  - Schedule additional generation if needed.
  - Potentially delay/defer/restore transmission and generation outages

- Monitor (during the event)
  - GIC Detectors are in place at ~50 locations to watch for GMD impacts in real time.
  - Adjust/operate more conservatively based on system conditions.
    - Boost system voltage, where possible
    - Bring additional generation on line, if possible
    - Reduce energy transfers
    - Remove vulnerable transformers from service
  - Coordinate with members, neighbors, etc. as the situation dictates.

## GMD Standard TPL-007

GMD Benchmark Storm	GIC Application Guide	Transformer Modeling Guide	GMD Planning Guide	GIC Mitigation Guide
				Operating Procedure Template





GIC intensity is a function of many variables, including:

- System topology
- Magnetic field strength and orientation
- Ground conductivity
- Proximity to water (read: ocean)

- PJM
  - Operational procedures in place since after the 1989 Hydro Quebec blackout (and compliant with NERC Standard EOP-010)
  - PJM members have installed ~50 GIC detectors around the system and the data is telemetered into PJM
  - AEP is installing a number of magnetometers with which to validate models. Dominion has implemented design changes to enhance GMD protection on capacitors and transformers
  - PJM and our members collaborated to do a GIC calculation study of the PJM system
  - PJM, Dominion, AEP to participate with NASA on a research program to use ground measurement devices to validate electric field models
- Industry
  - Awareness is increasing and a number of systems are installing detectors. GIC calculation is now included in power analysis software
  - American Transmission (Wisconsin) has installed a GIC blocking device
  - NERC planning standard (NERC Standard TPL-007) will require network analysis and transformer thermal assessment