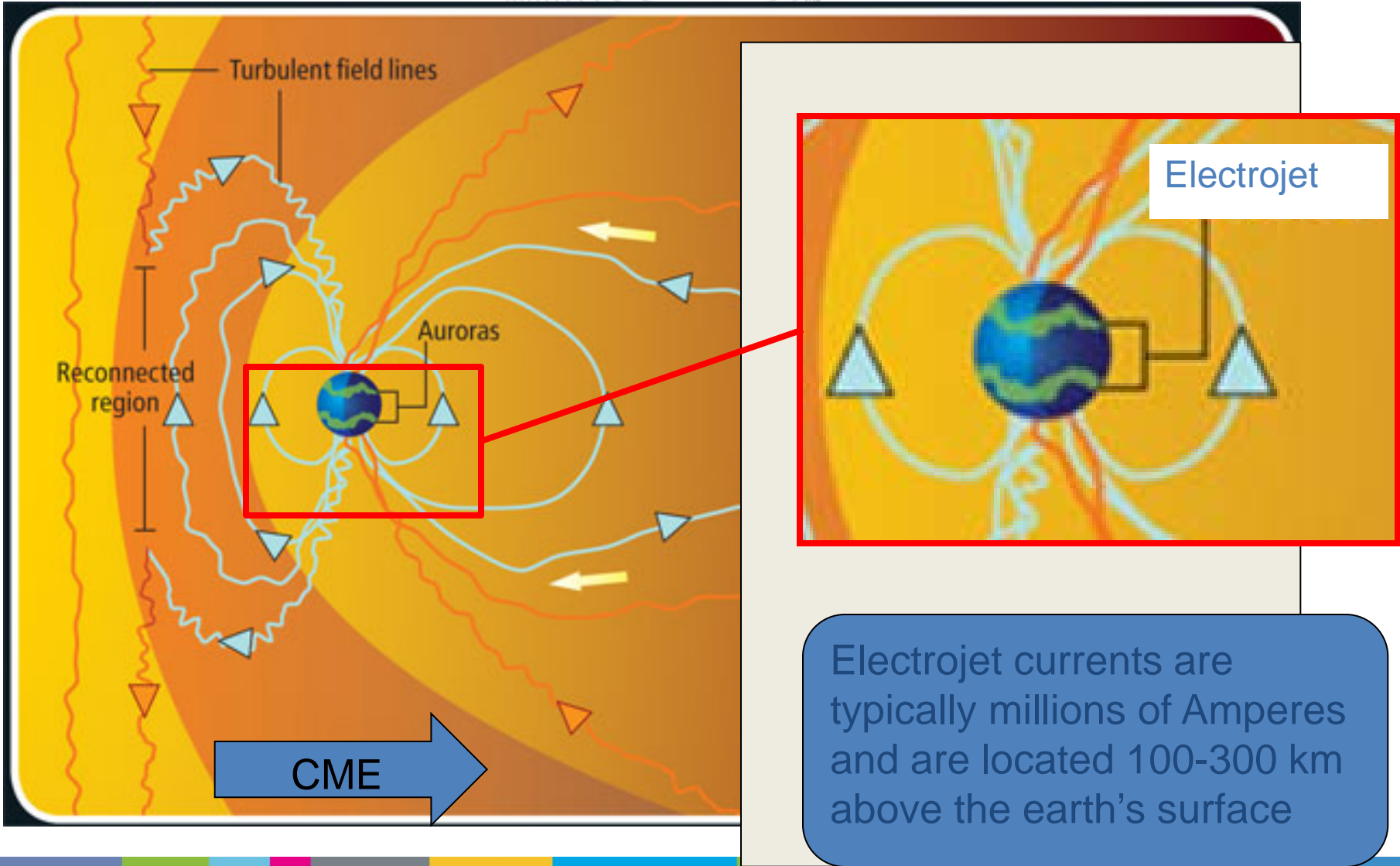
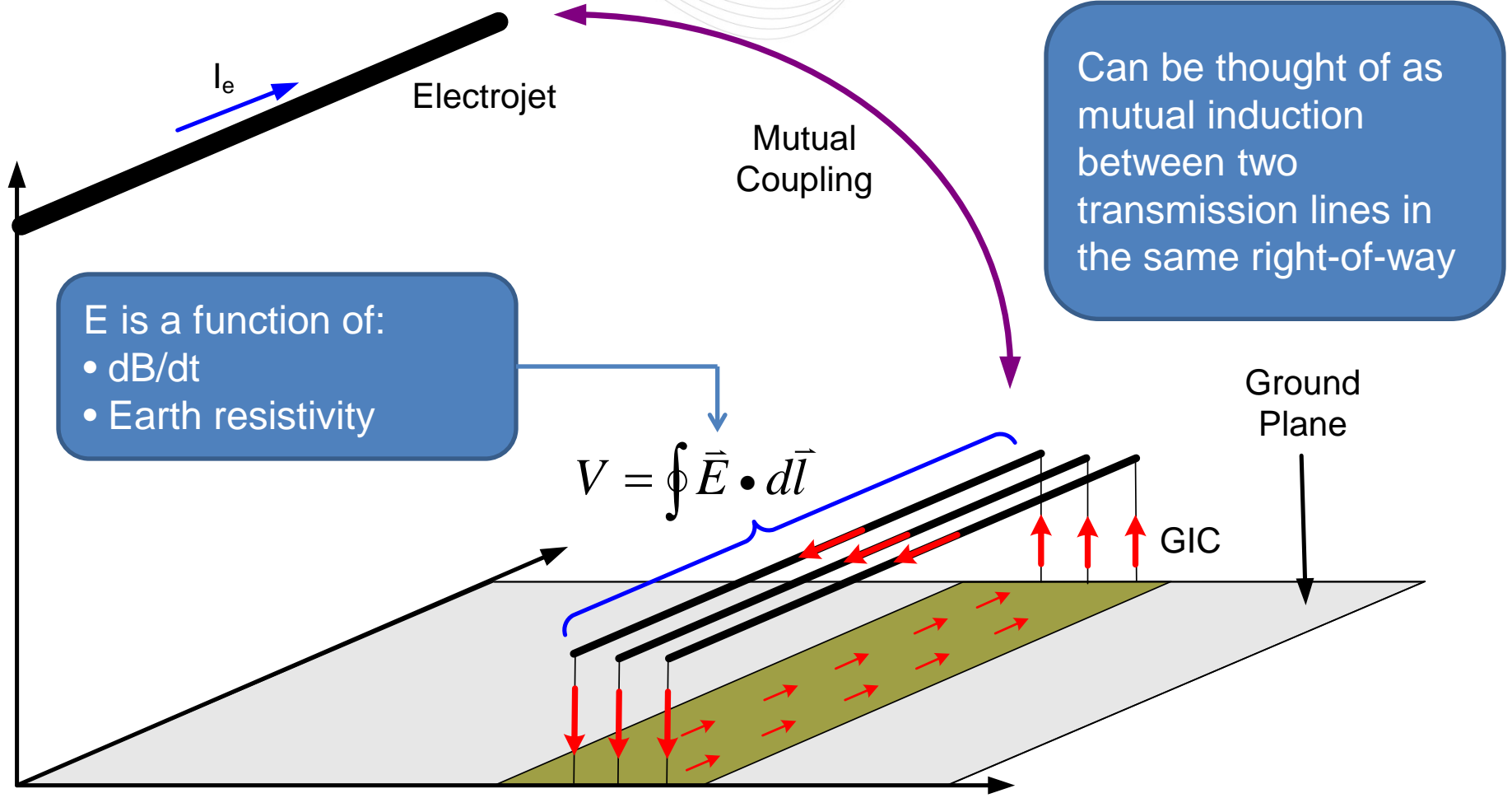


Space Weather Power System Impacts and PJM Response

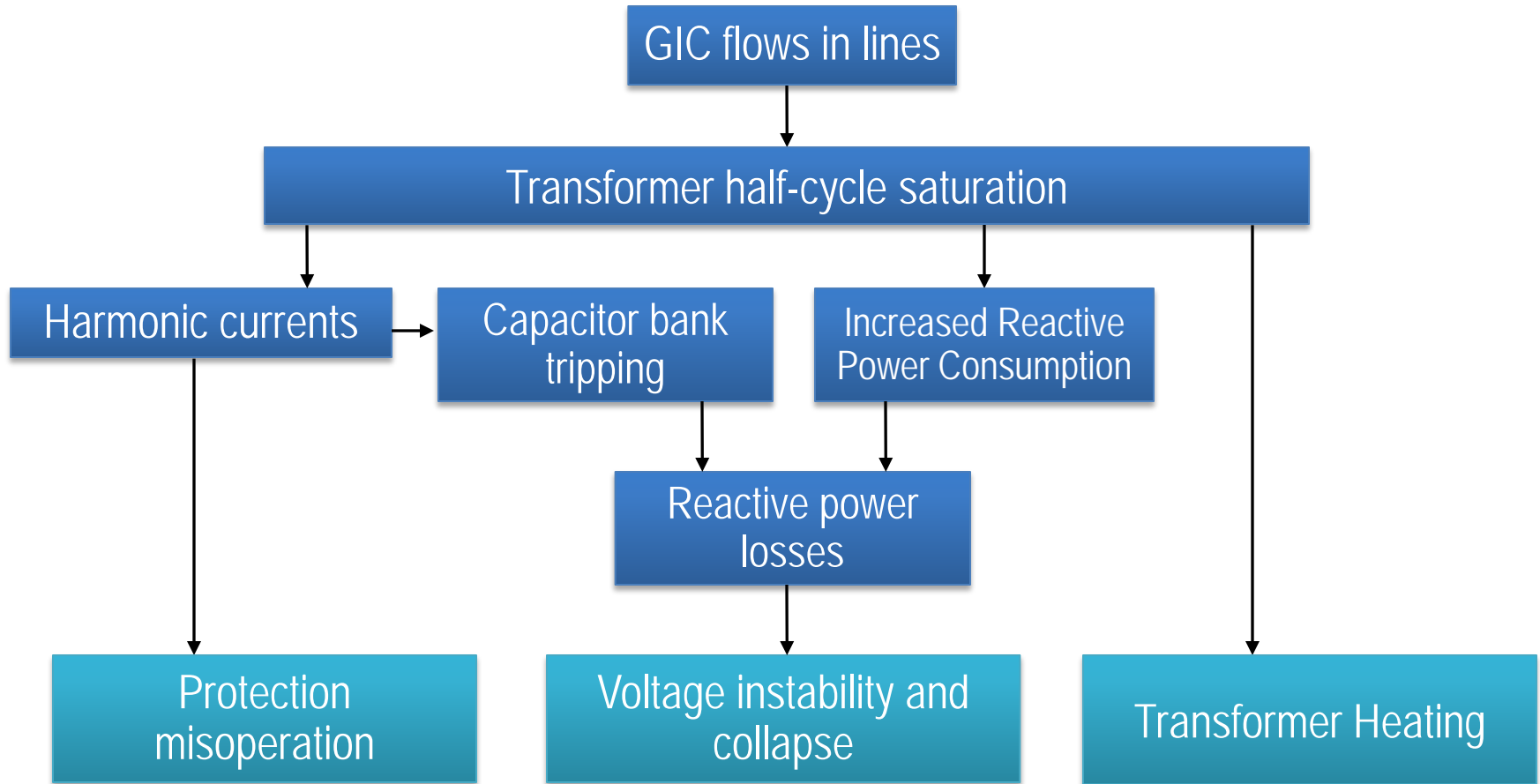
AMS 2016 Washington Forum
April 12, 2016

Frank J. Koza
Executive Director, Infrastructure Planning
PJM Interconnection





Induced Currents are “Quasi-dc” (mHz)

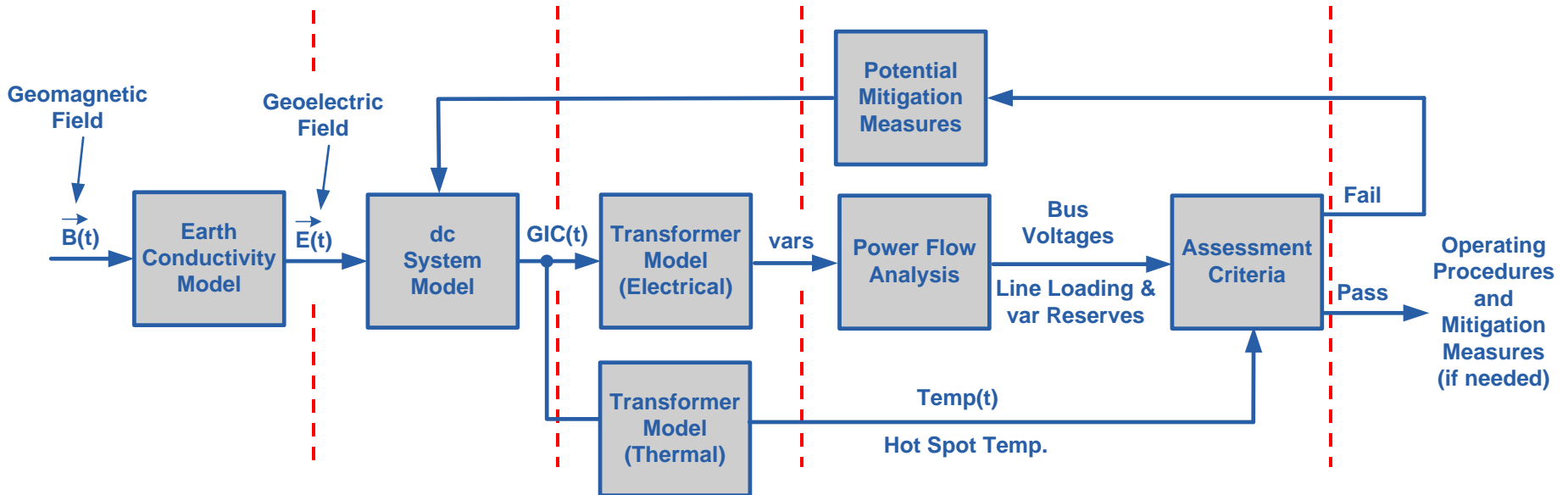


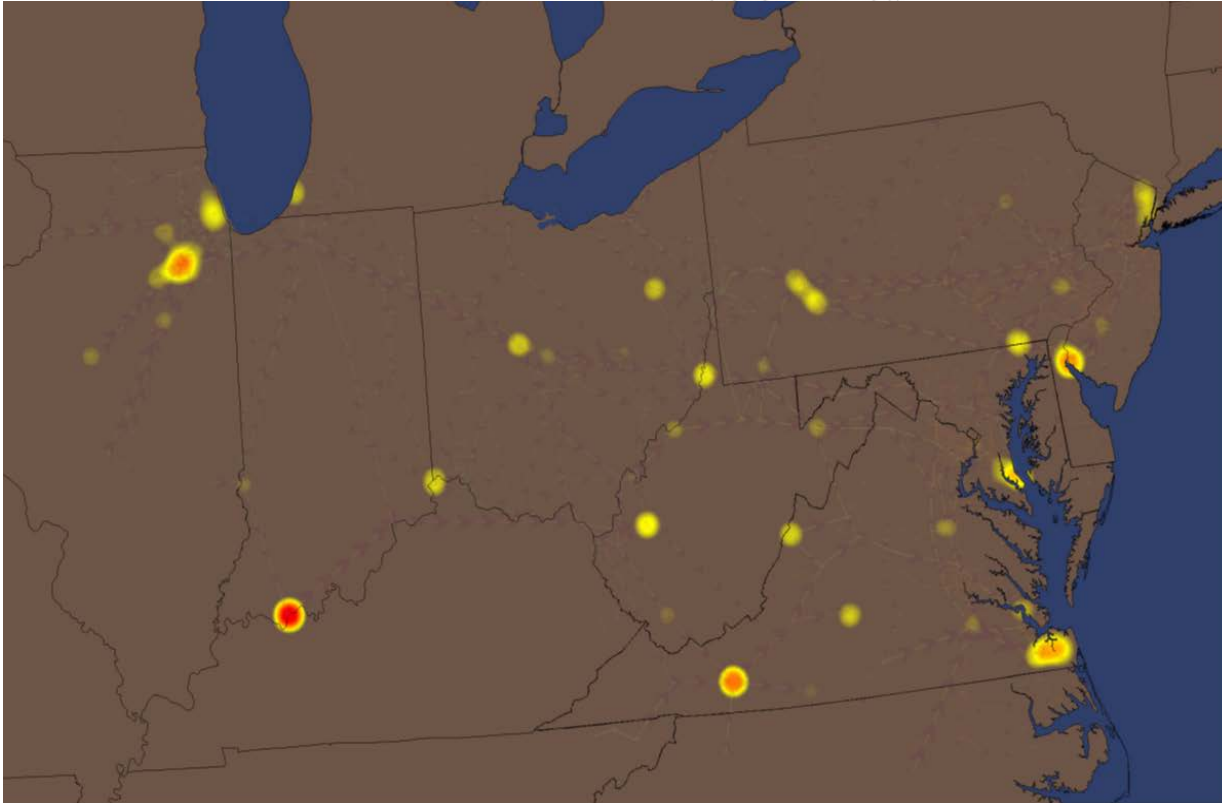
- Prepare (before the event)
 - Alerts/Warnings issues by SWPC 1-3 days in advance and monitored by PJM.
 - Include Intensity (K-scale) and latitudes impacted
 - Notify members and neighbors as needed.
 - Perform sensitivity studies ensure adequate system resiliency for future operating periods
 - Screen 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.
 - 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