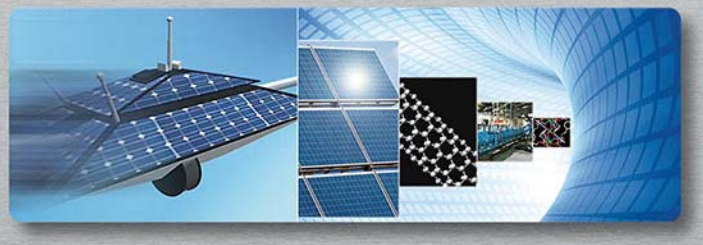

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Large Scale Analysis of GMD Impacts on the Electric Grid: Need for Improved Models and Analysis Techniques

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Space Weather Risks and Society Workshop

NASA Ames Research Center

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Agenda

- System Modeling and Analysis Approach
- Response of Transformers to GIC - Importance of Transformer Models in GMD Impact Analysis
- Large Scale Analysis of GMD Impacts on the Grid
- Conclusions

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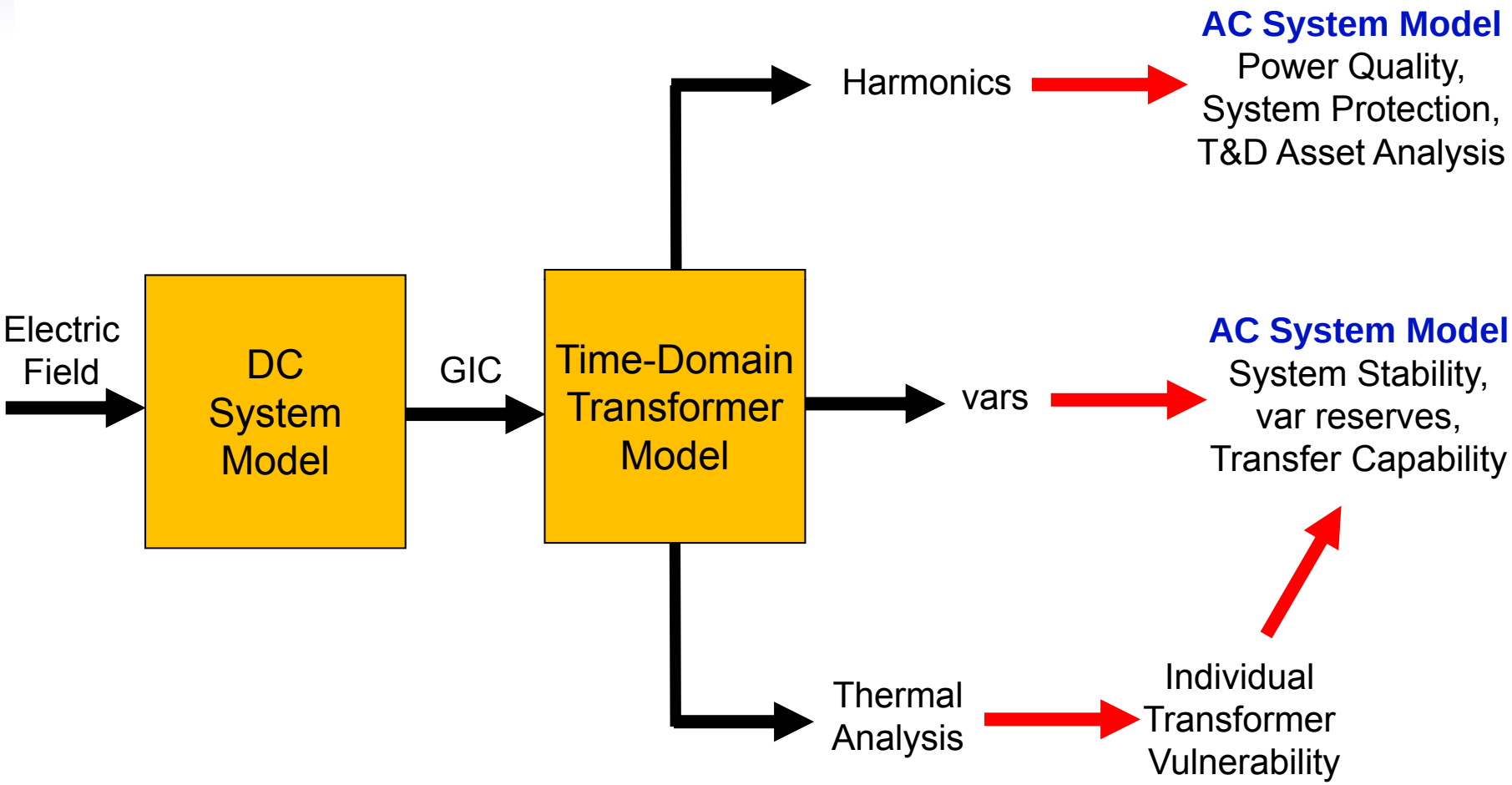
System Modeling and Analysis Approach



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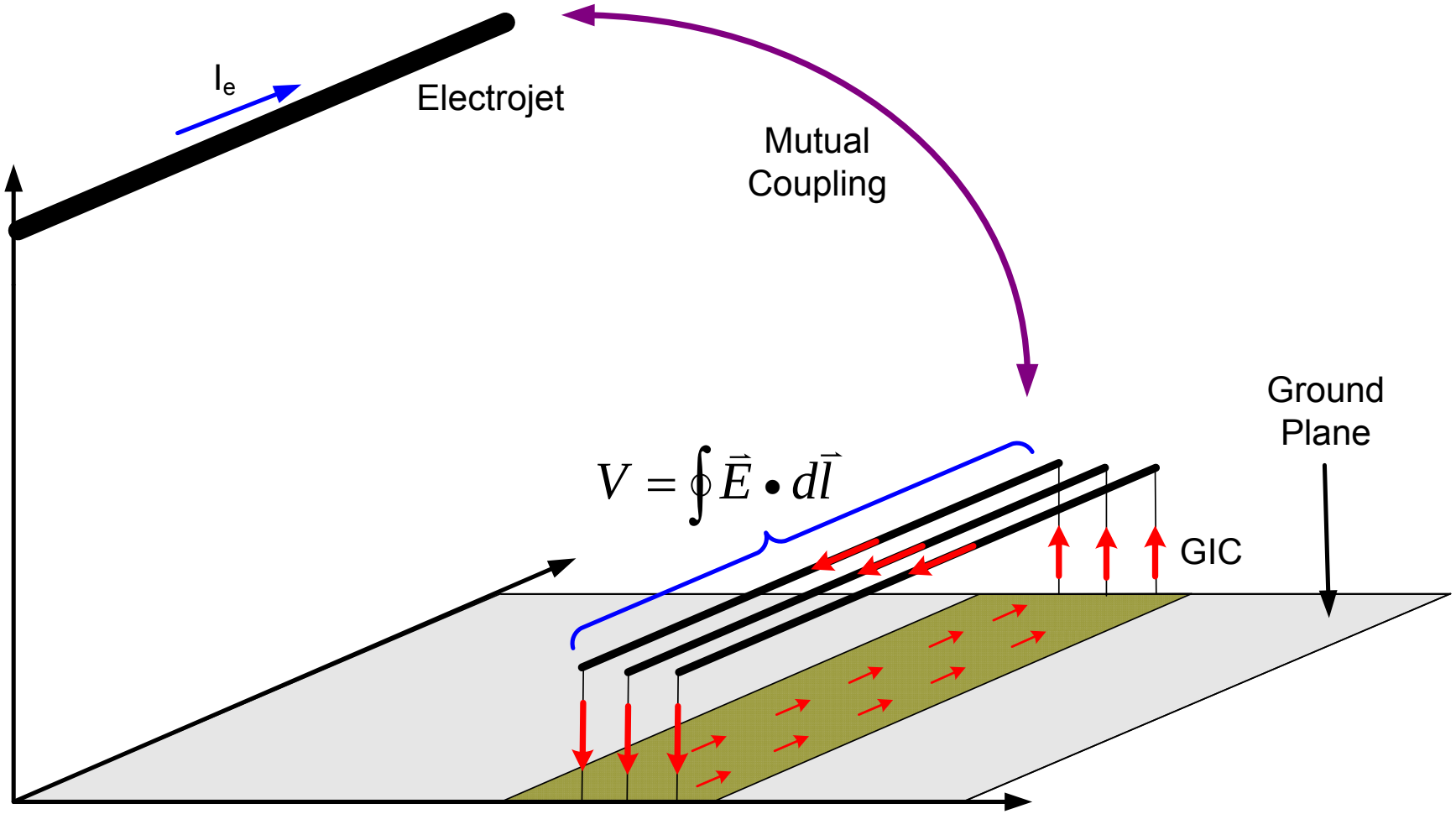
Geomagnetically Induced Current (GIC)



Induced Currents are "Quazi-DC"

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Response of Power Transformers to GIC

- The flow of quazi-dc current in power transformers causes semi-saturation of the core.
  - Commonly referred to as “half-cycle saturation”
- Semi-saturation of the core causes:
  - Increased var demand
  - Harmonics
  - Heating
- When performing studies to determine impact of GMD events on the grid, the transformer is arguably one of the most important and difficult element to model.

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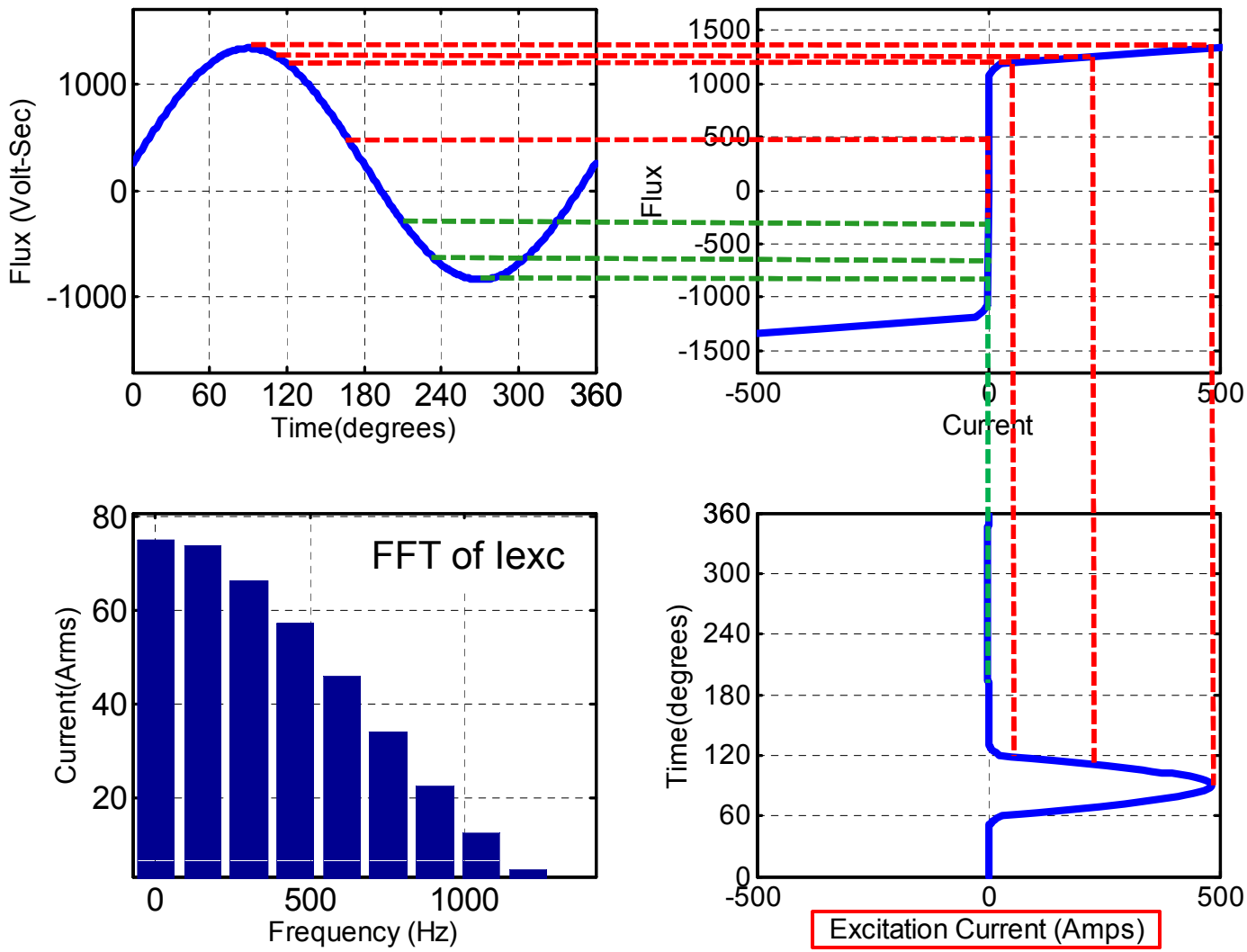
Transformer Response (Semi-Saturation)



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Transformer Response (Heating)

Thermal Model Of Transformer

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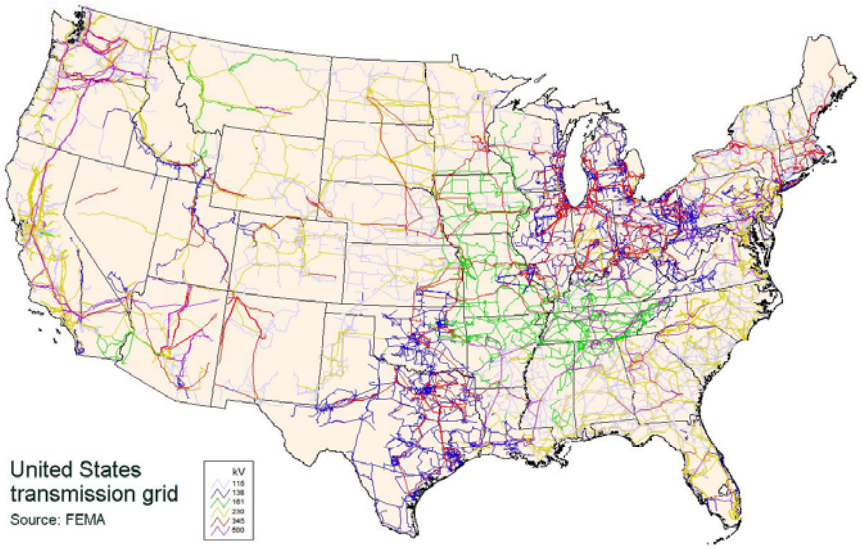
Large Scale System Modeling and Analysis

- What is it?
  - System analysis that is performed over a large geographical area, e.g. North America.
  - Utilizes a single model for the entire grid for each particular type of analysis
- Could prove to be important due to the large footprint of GMD events.
- Analysis could include:
  - Transient Stability Analysis
  - AC Load Flow Analysis
  - Harmonics Analysis
  - System Protection Analysis
  - Transformer Thermal Analysis



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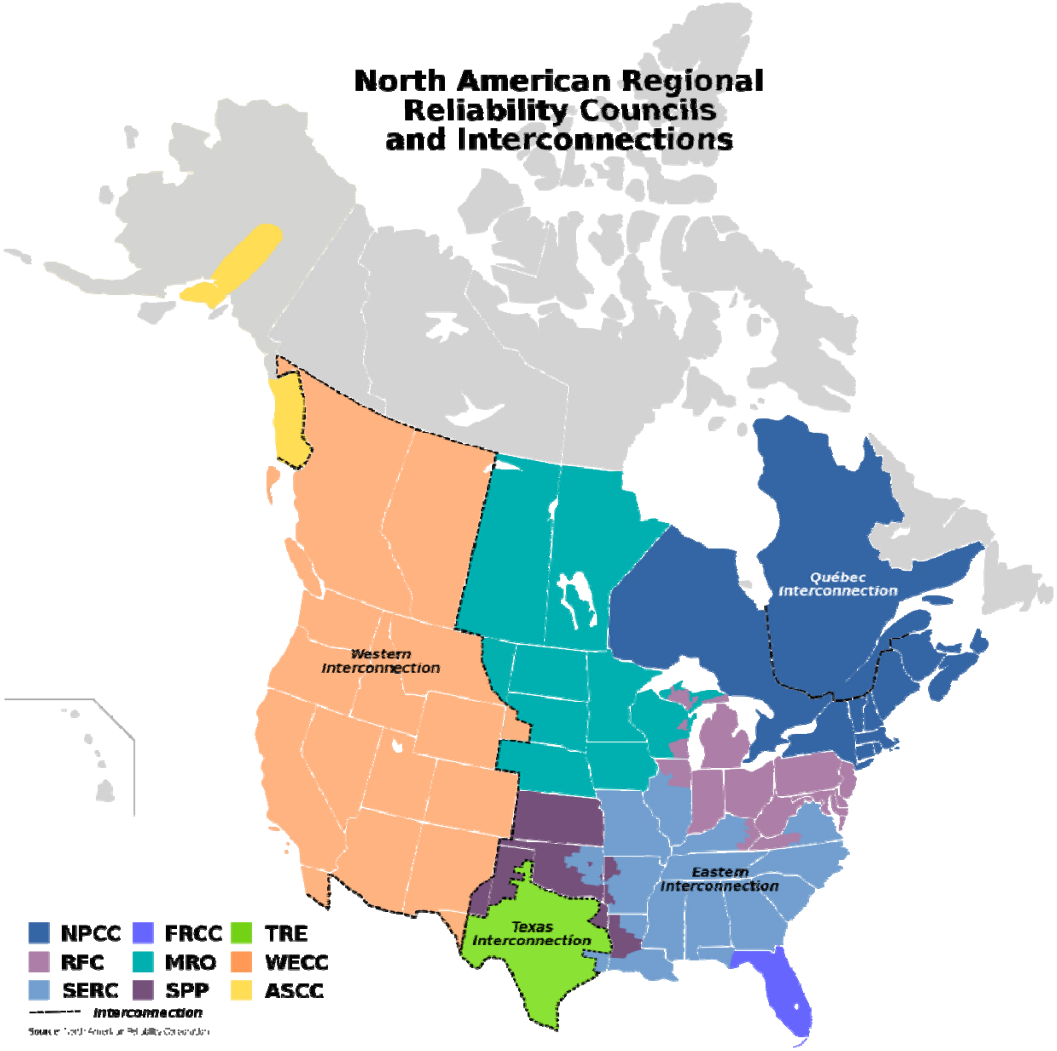
Large Scale System Modeling and Analysis

- To date, AC system analysis has been limited to the utility or regional level.
- Presently, performing AC system analysis on a continental (or national) level is a formidable task.
  - Security issues associated with input data.
  - Modeling uncertainties (AC and GIC)
  - Level of modeling accuracy and detail (time-domain vs. frequency domain)



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Conclusions

- Numerous uncertainties make determining GIC values over a large region difficult (E field variations, earth conductivity).
- Power transformer models have a critical role in the assessment of GMD impacts on the grid (proprietary → public domain).
- To date, AC analysis performed to determine impacts of GMD events has been limited to the utility or regional level.
- Research is currently being performed to determine whether or not large scale analysis is necessary.
- If large scale analysis becomes necessary to assess the impact of wide area GMD events, there will be numerous issues to overcome.

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