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Data Management Issues associated with the August 14, 2003 Blackout Investigation

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3rd Workshop on Next-Generation Analytics for the Future Power Grid
Data Panel Discussion
Richland, WA

Outline

August 14, 2003: The largest blackout in the history of the North American electric power grid

- Investigation process
- Challenges with the sequence of events
- Data request letters and follow-up
- Creating a data warehouse
- Recommendations

In the Immediate Aftermath…

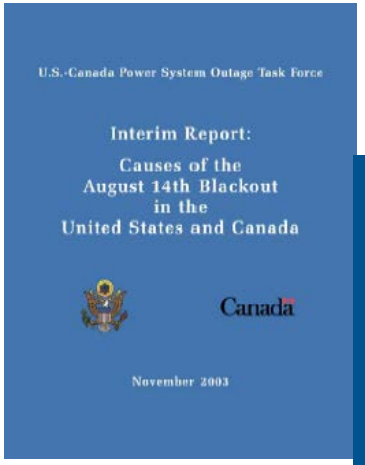
- Early media reports speculated about lightning in the Niagara Mohawk area to problems originating in Canada
  - These were quickly dismissed
- NERC posted a preliminary sequence of events from the Midwest ISO 26 hours after the blackout
  - This very clearly pointed to problems originating in Northern Ohio – a progression of 345 kV lines that tripped during the hour before the blackout
- Key questions early in the investigation process:
  - Why did these lines trip?
  - How did the cascading failure get started?
  - What are the lessons learned?
  - Were the reliability standards inadequate, or were they not being followed?

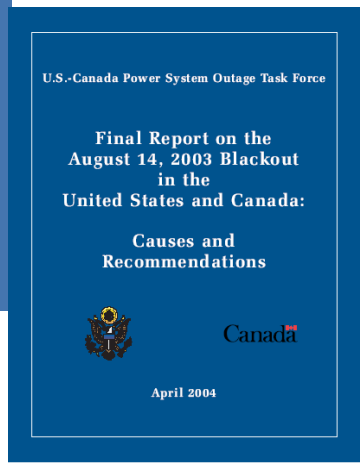
Investigation Process

Joint U.S. - Canada Power System Outage Task Force

Electric System Working Group	Nuclear Working Group	Security Working Group
Investigate the cascading electrical failure.	Review performance of plants and assess possibility of damage.	Determine if failures were caused with malicious intent.

- Phase I
  - Investigate the outage to determine its causes and why it was not contained
  - Interim report released November 19, 2003
- Phase II
  - Develop recommendations to reduce the possibility of future outages and minimize the scope of any that occur
  - Final report released April 5, 2004





Electric System Working Group
North American Electric Reliability Council

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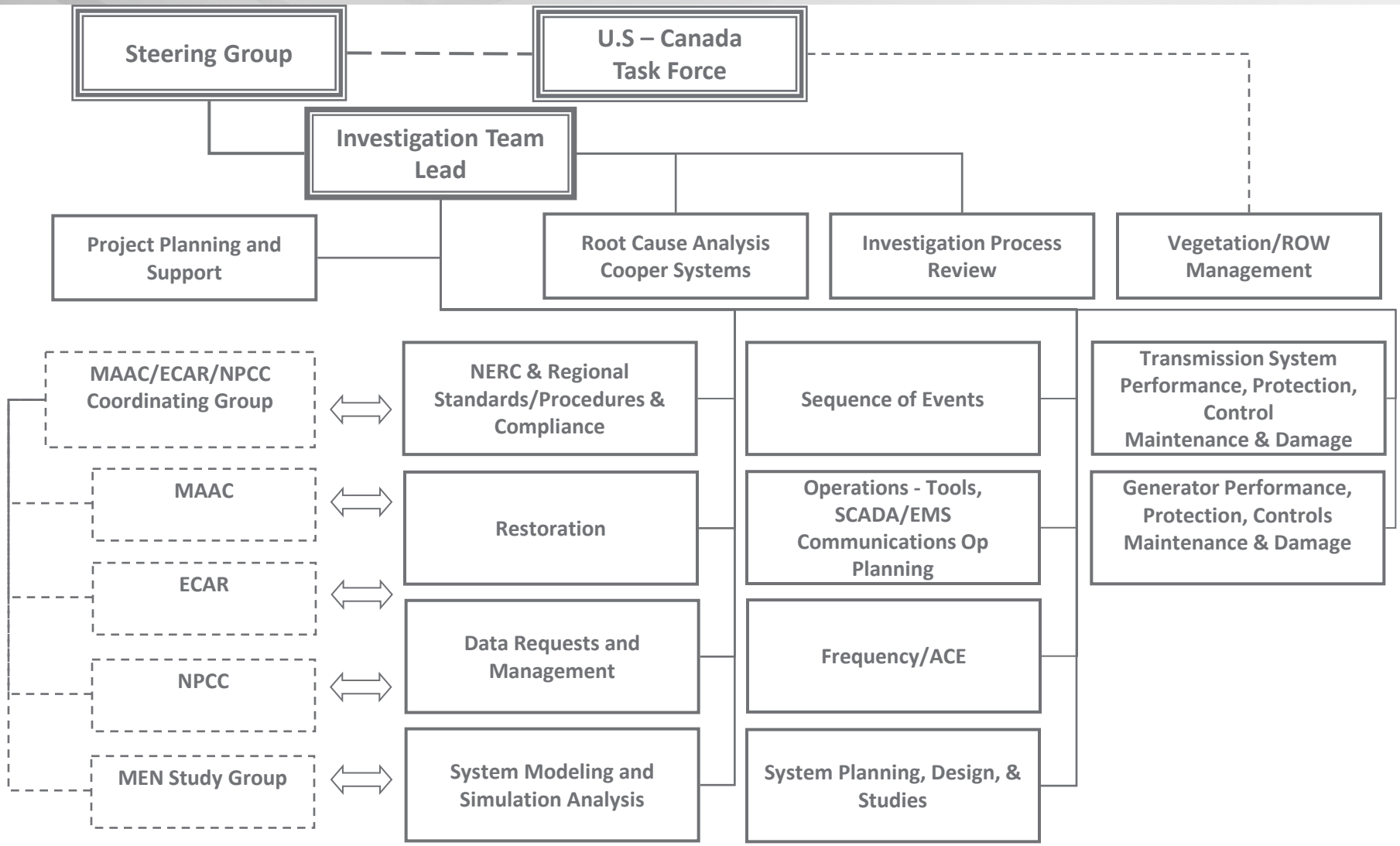

Building the Sequence of Events

- SCADA/EMS alarm logs
  - Inaccurate timing due to communication latency, time skew, buffering issues
- Substation instrumentation
  - Digital fault recorders, digital protective relays, synchronized phasor measurement units
  - Some instrument clocks were not synchronized to an established time standard
  - Data format issues

Initial Data Request Letters

- Issued the week after the blackout
- Disseminated broadly to the reliability coordinators in the affected area
- Information requested included:
  - SCADA alarm logs, and SCADA data at the highest available sample rate
  - Data from DFRs, PMUs, etc.
  - Circuit breaker settings and targets (lines and generating plants)
  - State estimator snapshots and saved contingency cases
  - Operator logs and transcripts
  - Load shedding (automatic or manual)
  - Voltage control equipment, special protection schemes, HVDC, …

Follow-up Data Request Letters

- Targeted to specific organizations
- Topics driven by the investigation team requirements
  - System studies (voltage support, transfer capabilities)
  - Standards and compliance team
  - System planning, design, and studies team
  - Root cause team
  - Generation performance team
  - Other specific questions directed to utilities based upon the investigation team requirements

Formal Data Request Letters

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	Aug 22 suppl. Aug 26	Sep 15	Oct 1	Oct 29	Oct 30	Nov 6
PJM	■		■		■	■
NYISO	■					
TransEnergie	■					
ISO-NE	■					
TVA	■					
VP	■					
MAIN	■					
IMO	■				■	
MISO	■		■	■	■	■
FE		■	■	■	■	
AEP			■	■	■	■
DECO			■			
ECAR			■			■
MECS			■	■	■	
Cinergy				■		■
DPL				■		
MAAC						■
NPCC						■

Creating a Data Warehouse

- Established at NERC
  - Dedicated server on a segmented network
  - Accessible by all members of the blackout investigation team
  - VPN access enabled for off-site members of the investigation team
- Stored data received from the utilities
  - Read-only access to the investigation team
  - Over 20 GB of information, 10,000+ files
  - Wide variety (documents, spreadsheets, special data formats, audio, …)
  - Received via email, FTP, mail (CDs and hardcopy reports)
- Working data, draft report materials, etc.
  - Read access to investigation team, write-access specified by team leaders
- Data entry and tracking procedures
- SQL-server data base developed to provide inventory and querying capabilities
  - Challenge: Database developed in parallel with the investigation process

Recommendation 11: Establish requirements for collection and reporting of data needed for post-blackout analysis

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- FERC and appropriate authorities in Canada should require generators, transmission owners, and other relevant entities to **collect and report data that may be needed for analysis of blackouts** and other grid-related disturbances.
- Some of the data needed to analyze the blackout was not collected or saved, and thus was not available to the blackout investigation team.
- Need to identify information gaps, adopt common definitions, and establish reporting requirements.

Recommendation 14: Establish a standing framework for the conduct of future blackout and disturbance investigations

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- Establish criteria for determining when an investigation should be initiated.
- Establish the composition of a task force to provide overall guidance for the inquiry. The task force should be international if the triggering event had international consequences.
- Provides for coordination with state and provincial governments, NERC and other appropriate entities.
- Designates agencies responsible for issuing directives concerning **preservation of records, provision of data within specified periods to a data warehouse facility**, conduct of onsite interviews with control room personnel, etc.
- Provides guidance on **confidentiality of data**.
- Identifies types of expertise likely to be needed on the investigation team.

Recommendation 24: Improve quality of system modeling data and data exchange practices

- Establish and implement criteria and procedures for validating data used in power flow models and dynamic simulations by benchmarking model data with actual system performance.
- Validated model data shall be exchanged on an interregional basis as needed for system planning and operation.
- All generators, regardless of ownership, should collect and submit generator data to NERC.
- Post-event analysis indicated that load models were overly optimistic – they were absorbing more reactive power than pre-August 14 models indicated.

Recommendation 28: Require use of time-synchronized data recorders

- Require the use of data recorders synchronized by signals from the Global Positioning System (GPS) on all categories of facilities whose **data may be needed to investigate future system disturbances, outages, or blackouts**.
- Determine where high speed power system disturbance recorders are needed on the system, and ensure they are installed by December 31, 2004.
- NERC should establish data recording protocols.
- Investments in these devices should be recoverable through transmission rates.
- Retention of data for subsequent analysis needs to be considered.

Time Stamping of Operational Data Logs

- Draft NERC guideline
- Applicable to SCADA/EMS, IEDs, PLCs, etc.
- Coordinated time synchronization traceable to international time standard
- Stipulates acceptable time errors, e.g.:

  "All applicable IRIG-B connected devices should maintain an internal clock with a maximum error of 50 ms. All NTP/SNTP connected devices should maintain an internal clock with a maximum error of 100 ms."
- Source of time uncertainty should be known and reported

My Lessons Learned and Recommendations

- Better calibration of recording instruments
  - Especially establishing time synchronization
- Pre-defining data reporting requirements
  - Standardized data formats
  - Organizations can immediately begin assembling and forwarding the information vs. waiting for a data request
- Pre-work logistical details (e.g., confidentiality agreements)
- Infrastructure to support a centralized blackout investigation
  - A data warehouse with servers and databases to store and process the incoming data, support the investigation team, manage data inventory, etc.
  - Defined data categories (to readily track and follow-up on data gaps)
- Automated disturbance reporting
  - Routinely collect transmission and generation events
  - Mechanics of data formats, exchange protocols, confidentiality issues, etc., can be worked out and tested on an on-going basis
  - Blackout data can be collected in a matter of hours rather than a matter of weeks (or months)