Transmission Line Availability Data Guidelines and Definitions

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Presentation Objectives

- **About SGS**
- **Post-August 14 2003 observations**
- **Transmission Line Availability Data (detail)**
  - –Existing Standards and Practices
  - –*Transmission Line Availability Data Guidelines and Definitions*
- **Stations & Terminals (brief)**
- **Conclusion**

SGS Experience

- Statisticians, established in 1989, certifications by the American Society for Quality and SAS Institute.
- 1993, exclusive focus on T&D reliability analysis.
- 1995 began transmission reliability benchmarking.
- In 2005, SGS Transmission Reliability Benchmarking Study marks its **eleventh** year of operation:
  - 32 participating transmission owners, +50% of US grid.
  - 97% Renewal from ‘04 to ‘05
- 2001-2003: Development of *Transmission Line Availability Data Guidelines and Definitions*

2005 SGS Study Participants

Allegheny Power System
American Transmission Co.
Arizona Public Service
BC Transmission Corp.
CLECO Energy
Dominion Virginia Power
Duke Electric Transmission
Duquesne Light Co.
Entergy Transmission
Exelon Corporation
First Energy
Georgia Power
Georgia Transmission Corp.
Long Island Power Authority
Lower Colorado River Authority
Michigan Electric Transmission Co.
Municipal Elec. Auth of Georgia
National Grid USA
NorthWestern Energy
Northeast Utilities
Pacific Gas & Electric
PacifiCorp
Progress Energy
Public Service Electric & Gas
Public Service of New Mexico
Salt River Project
San Diego Gas & Electric
South Carolina Electric & Gas
Tennessee Valley Authority
Tucson Electric Power
TXU Electric Delivery
Xcel Energy

2005 participation ~ 50% of US grid based on NERC Bulk Power Circuit-Miles. Approximately 400,000 MW of System Peak Load.

Transmission Line and Station Events Precipitate Major Problems

System Disturbances/Blackouts:

- **July 2, 1996:** "…a flashover occurred between a 345,000-volt transmission line and a tree…"
- **August 10, 1996:** "…a combination of random transmission line outages…"
- **August 14, 2003:** "Transmission lines disconnect between eastern Ohio and Northern Ohio"

Nuclear Plant Outages:

- **June 14, 2004:** Palo Verde...
- **May 15, 2003:** Commanche Peak...

In the Wake of August 14, 2003

"NERC Actions to Prevent and Mitigate the Impacts of Future Cascading Blackouts" had few elements directly related to availability data.

- Identified ROW and Vegetation as part of the "direct causes", yet Vegetation accounts for only ~3% of bulk power outages.
- Does not contain specific directives for outage data or performance measures.

SGS feels the transmission industry's traditional focus on security and adequacy may not sufficiently address:

- Transmission Line and Station Outage and Availability Data
- Root Cause Analysis
- Transmission Line, Station and System performance measures

Statement of Needs for Transmission Availability Data Guidelines

- Reconstructing Major Events based on commonly available outage data, not EMS logs.
- Probabilistic Planning with “real” data.
- Consistency for Benchmarking Performance:
  - Repair vs. Restoration
  - What is Forced? Scheduled? Transient? Temporary? Permanent?
- INPO - NRC consideration of reliability of off-site transmission, terminals and sources.
- What is the impact of generation on grid reliability?
- Non-Reliability Uses
  - Asset Management / Decision Support
  - Performance Based Rates (PBR)

Many Existing Standards…

- CIGRE WG 03/SC 38, 1987, “Power System Analysis”
- IEEE 859, 1987, Reaffirmed 1993
- CEA: Committee on Outage Statistics, ERIS
- MAPP/MAIN: Guide for Reporting Transmission Unit Characteristics and Outage Data (230kV+)
- ECAR Transmission Line Outage Reporting Instructions (230 kV+)
- California ISO: Transmission Control Agreement, Appendix C (50 - 500 kV)
- Individual systems’ practices and procedures

…So Why Establish Guidelines?

- IEEE, CIGRE and CEA documents date from 1980s to mid-90s. *The US transmission climate has changed.*
- Some Reliability Councils have some bases covered for bulk power, but not for load serving transmission.
- California-ISO guide supports specific performance metrics and is insufficient for modeling.
- Many stones are left unturned with current standards:
  - Scheduled Outages
  - Multiple Contingencies
  - Non-outage Unavailability
  - Terminals, Stations and Transfer Points.

Transmission Line Availability Data Guidelines Development

- Fall Technical Meeting on Outage Data Definitions and Management October 30-31, 2001 (24 systems)
  - SGS Organized, National Grid Hosted
- First Draft written in Spring 2002 (w/Blue Arc as contractor)
- Review May 13, 2002 at SGS Conference in Tucson (26 systems)
- Second Draft written in Summer 2002
- Review of Second Draft September 23, 2002 hosted by ATC in Milwaukee (21 systems)
- Final Draft posted January 13, 2003, minimal review changes.
- Finished document **Transmission Line Availability Data Guidelines and Definitions** posted February 22, 2003
- **Download at: http://www.sgsstat.com**

What the Development process was NOT

- Develop a *"Guideline"*, **not** a *"Standard"*
  - Leaves "standards" implementation up to Transmission Owners, RTO's, Reliability Councils, Regulators, CIGRE or IEEE.
- Membership and financial contributions were **not** required:
  - Strictly a volunteer effort from all parties involved
- It was **not** dominated or directed by any transmission owner or other entity, professional organization or EPRI.
- The process did **not** propose or endorse any specific reliability or availability metrics or benchmarks...

...but the Guideline assures that whatever metrics are employed by a transmission entity, there are adequate definitions and data to support them!

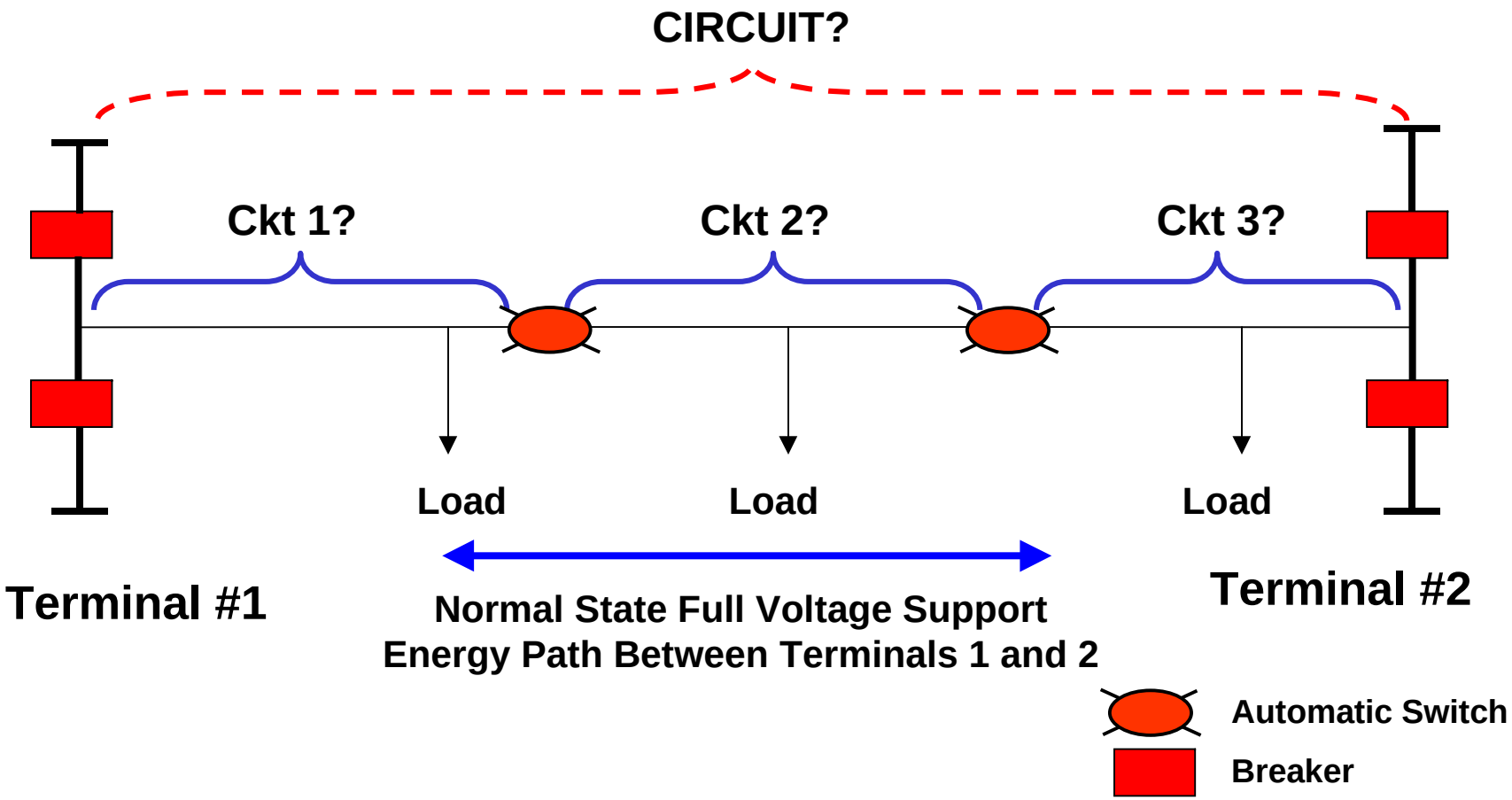
Structure of TL Guideline

Section	Heading	Contents and Purpose
1.	Systems and Units	Defines circuits and sub-units for outage reporting
2.	Defects, Failures, and Faults	Conditions for outages
3.	Dependency and Commonality	Tying dependent events to initiating outage and defining common-mode failures
4.	Transmission Unit Availability States	Forced and Scheduled outages and non-availability conditions
5.	Restoration to Available State	Defines ending intervals for repairs, deferred repairs, load and flow restoration, etc.
6.	Customer Impact	How and when to record customer impacts
7.	Non-Availability Root Cause Description	Root cause categorization and identifying failures and non-fault conditions (e.g., scheduled outages)
8.	Data Management and Reporting Guidelines	General guidelines of how to collect the various data elements under headings 1-7.

1. SYSTEMS AND UNITS

- Hierarchical approach
- Systems definitions primarily for context
- Unit focus and detail
- Protected zone basis for unit boundaries
- Functionality and design basis within boundaries

One Circuit or 3 Circuits?



1.2.3 Transfer Points

…where customer reliability is measured

1.2.3 Transfer Points: A transfer point is where energy is received, distributed or transferred to/from the transmission system by a transmission circuit. There are four types of transfer points:

1.2.3.1. Production Transfer Point

1.2.3.2. Distribution Transfer Point

1.2.3.3. Internal Transfer Point

1.2.3.4. Interconnection Transfer Point

1.4 Transmission Units and Sub-Units: The basis for outage reporting

1.4.1. Transmission Units – key properties:

- Boundaries defined by protected zone
- Can completely isolate the entity from system for fault conditions within the unit
- Has a designed capability within boundaries.
- Has specific functionality to operators and/or users.

1.4.2. Transmission Sub Unit

- Can NOT completely isolate the entity from system.
- Line sections, segments, taps, etc.

1.4.3. Transmission Circuit (or Line) Units

- Usually a “breaker-to-breaker” transmission line.

2. DEFECTS, FAILURES AND FAULTS

Condition definitions; differentiation of severity

- 2.1. Defect
- 2.2. Failure
- 2.3. Latent Failure
- 2.4. Fault
- 2.4.1. Short Circuit Fault

3. DEPENDENCY AND COMMONALITY

- Accurate characterization of ***Dependency*** and ***Commonality***
- Necessary to assess the occurrence or probabilities of multiple contingency events.

  3.1. Independent Mode

  3.2. Dependent Mode

  3.3. Common Mode

4. TRANSMISSION UNIT AVAILABILITY STATES

4.1. Available State

Completely In-service, no limitations

4.2. Non-available States

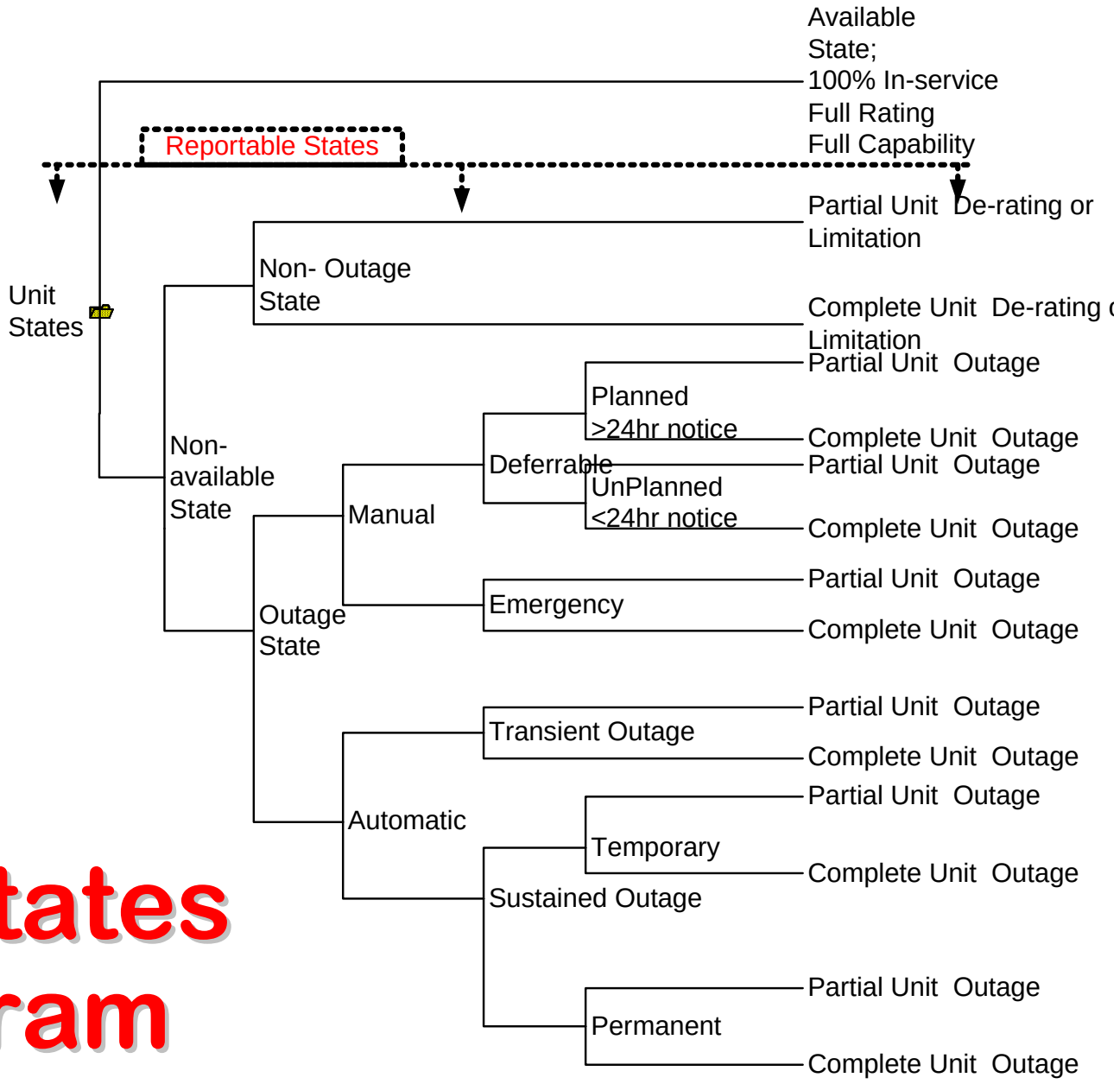
4.2.1. Non-Outage States

In-service with limitations

4.2.2. Outage States

Out of service or de-energized condition

Unit States Diagram



5. RESTORATION TO AVAILABLE STATE

5.1. Outage Restoration

5.2. Repair Time

5.3. Load Restoration

5.4. Customer Restoration

5.5. Flow Restoration

5.6. Deferred Restoration

5.7. Permanent Restoration (As-designed)

6. CUSTOMER IMPACT

6.1. Exposed Load

6.2. Exposed Customers

6.3. Actual Load Interrupted

6.4. Actual Customers Interrupted

7. NON-AVAILABILITY ROOT CAUSE DESCRIPTION

Broad categories for root cause of non-availability...

7.1. Failure Cause Classification:

Terminal Equipment, System Protection, Lines, Weather, Lightning, Vegetation, External, Other, Unknown

7.2. Non-Failure Causes:

Operational Outage, Maintenance and Construction,Third Party Request

7.3. Characterization of Failure Causes

7.4. Major Event Classification

8. DATA MANAGEMENT AND REPORTING GUIDELINES

Two Levels of Reporting...

[**B**] for **Basic** Reporting

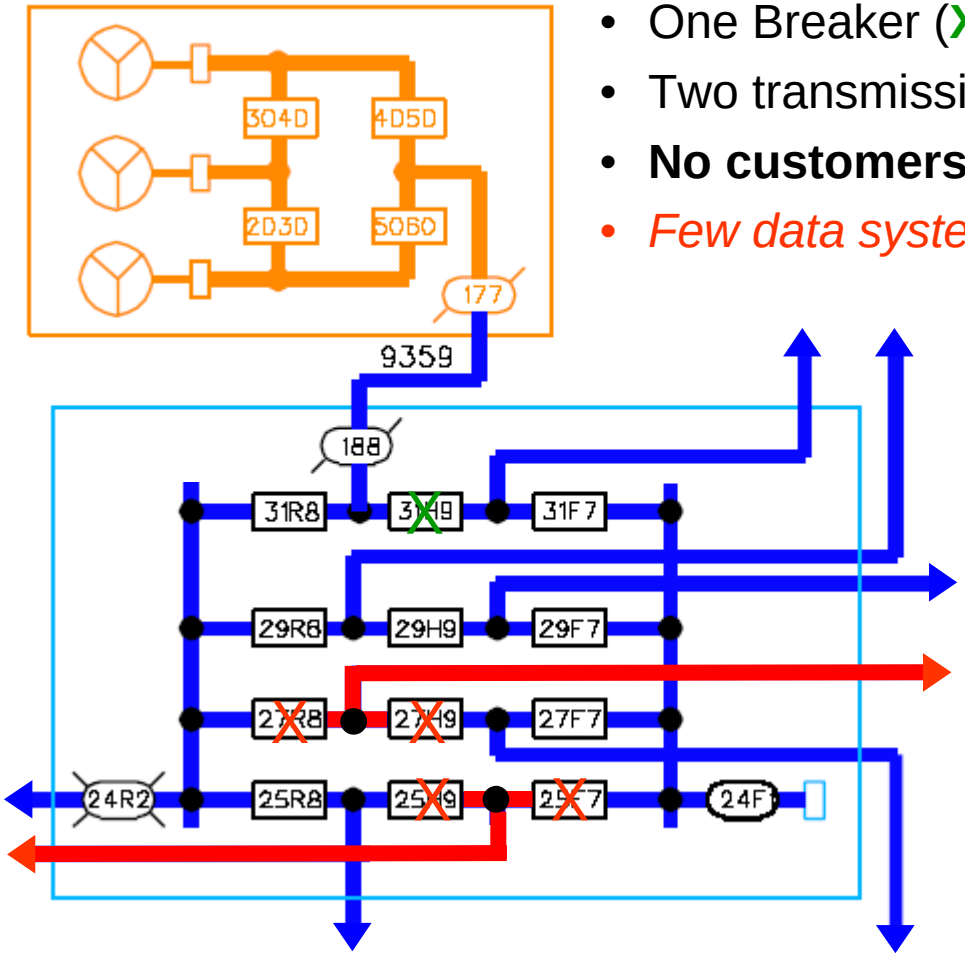
[**A**] for **Advanced** Reporting

Recognizes that some systems have considerable work to implement even basic reporting practices.

Station and Terminal Data

- In the United States...
  - To my knowledge, there are **no** reporting comprehensive standards from ISOs or regional councils.
  - Individual systems often record their own data, but consistency and completeness is highly variable.
- Canada: CEA Equipment Reliability Information System
  - Comprehensive outage history for all major categories of transmission equipment .
  - Data is collected on a *component* level and is aggregated into similar categories.
  - I do not believe the CEA data model supports the electrical model in place at the time the data was recorded.

Terminals and Stations Pose Significant Data Management Challenges



- One Breaker (**X**) is out for scheduled maintenance.
- Two transmission lines have independent faults (**X**).
- **No customers are impacted.**
- *Few data systems have easy access to:*

- Double Contingency line outages, Independent-mode.
- Scheduled breaker outage.
- Loss of flow-through on 3 of 4 busses.
- Other terminal equipment affected in the outage (e.g., transformers, capacitors, busses).
- Other coincident control area conditions compromising security.

Terminal and Station Data Benefits

- Many major events have been initiated by terminal-related failures.
  - Historical terminal failure data is generally available only for catastrophes and does not exist for “near misses”.
  - We ***really*** don’t know how reliable are stations and terminal equipment and have no basis for benchmarking.
  - How many terminal failures are attributable to undiscovered “latent failures” (fixable by maintenance)?
- Terminal failures are large proportion of EHV Outages
  - 9.5% of line outages and 20.4% of line duration
  - Rates are much higher for high-density networks.
- Terminal outage and failure data must include not only faults, but also *latent failures* and *scheduled* outages.

There is a Penalty of Inaction

- Consider Distribution Reliability...
  - Every state regulator is **different**, some are **very** tough
  - "Worst Feeder" Measure drive bad decision making
  - No regulatory body fully recognizes IEEE Std 1366, which came ***after*** many state distribution reliability requirements.
- The "next bad thing" *can* happen
  - Will the industry continue business as usual?
  - The cost of bad data is recognized in nuclear, aerospace, medicine and insurance, *but not in transmission*.
- There is no shortage of **bad** "improvement" ideas ready for imposition... if the industry is not proactive.

There are Very Tangible Benefits

- Better benchmarks
- Provide a model to replace legacy systems
- Eventually, a common transmission availability standard
  - Use the *Transmission Line Availability Data Guidelines and Definitions* as a starting point.
  - Add terminal equipment; leverage off of CEA to provide guidance for US industry efforts.
  - Respect each system's current practices and data systems; transition to improved data model over time.
- Avoid Potential Regulatory Nightmares
- Feed Probabilistic Planning with **Real and Complete** Data
  - What *really* is the probability of N-2?
- Improved Reliability Decision Support
  - Improvements guided by historical risk assessment in addition to traditional deterministic planning.

What Can Interested Parties Do?

How can Interested Parties help?

- **Awareness**:
  - Outage Data is more complicated than it looks. It need standardized handling for maximum benefit.
  - Download a free copy for review and use:

http//www.sgsstat.com/Transmission_Line_Availability_Data_Guidelines_and_Definitions.pdf

- **Advocacy**:
  - Within your organization, NERC, regional councils and with regulators and stakeholders.
- **Implementation**:
  - Pick the portions of Guideline which are relevant to your interests and stakeholders. ***Cherry pick!***

More Information

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References:

– Selected references @ web (“Detailed Study Info” document)

– Other references available