12. Appendix

12.1 Network Reliability Council Issue Statement

Problem Statement/Issues to be Addressed

The fundamental issue is the provision of reliable and enduring power for telecommunications network operations. The implicit issues include, but are not limited to: the adequacy of the current telecommunication industry power architecture, installation and maintenance practices, including adequate alarming and alarm response; testing procedures for electrical power systems including back-up systems; the priority restoration of power by electric utility companies to telecommunications facilities; and the resupply of fuel to telecommunications facilities operating on generators for extended periods. Inherent in these issues is the need to educate users, and in particular, energy providers, that telecommunications is a critical lifeline that must not be overlooked in restoration plans.

Areas of Concern And Problem Quantification

Because utility (commercial) power systems periodically fail, telecommunications companies must provide backup power sources at switching, transmission, and control facilities. These backup systems consist mainly of batteries and generators. Power system network disruptions have varying effects on telecommunications network operations. There are five types of power disruptions that can affect telecommunications network operations:

- Power curtailment of "load shedding"
- Short-duration power disruptions
- Local, long-duration power disruptions
- Widespread, long-duration power disruptions
- Telephone power system malfunctions (e.g., rectifiers, fuses).

Commercial power curtailment, or load shedding, at the request of the electric utility companies occurs when power demand exceeds power generating capacity.

Short-duration power disruptions last 12 hours or less, with the majority of short duration power disruptions lasting less than half an hour.*

Local power disruptions of long duration, lasting more than 12 hours are confined to the service area of one electric utility company. Telecommunications facilities in these areas would rely on backup generators and may need to be refueled if the disruption lasts longer that the typical 72 hour on-hand fuel supply.** The majority of these occur as a result of natural disasters such as hurricanes, earthquakes, ice storms, and windstorms.

Widespread long-duration power disruptions lasting more than 24 hours usually encompass geographic areas serviced by more than one electric utility company. These are low-probability, high-consequence events that test the emergency preparedness of both electric utilities and telecommunications service providers.***

Description of Proposed Work

The team working this issue should consider the following total quality process to quantify power systems vulnerability, identify major reliability issues, and propose problem solutions.

1. Collect appropriate data from all available industry sources to determine and/or confirm areas of greatest criticality and risk, and with the greatest potential for power systems reliability improvement. This could be done by conducting a survey to identify and quantify the causes of telecommunications network outages that result from power disruptions, and/or equipment failures, malfunctions or, operator error.

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* For example, in a 1 year period from August 1990 to July 1991, one Interexchange Carrier (IEC) experienced 44,453 such commercial power outages with an average duration of 21 minutes.

** There were more than 50 local, long-duration power outages reported to the Department of Energy (DOE) between 1986 and 1989 with an average duration of 21.3 hours.

*** In the aftermath of the Loma Prieta earthquake, 160 Pacific Bell sites went on emergency power. Power outages there lasted up to 40 hours in metropolitan areas and up to 2 weeks in rural areas. Hurricane Hugo also caused a widespread 11 day power outage involving several electric utility companies in the Carolinas.

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2. Perform sufficient analysis of the data to determine the root cause(s) of the problem(s), including the following aspects:
   - Design shortcomings
   - Alarms
   - Alarm response
   - Procedures
   - Training
   - Documentation
   - Testing
   - Customer education (public service agencies, users, etc.).
3. From the root cause analysis determine an appropriate action plan to reduce/eliminate the possibility or severity of failures in high-risk areas. Also consider ways that recovery procedures may be implemented more quickly or efficiently.
4. Determine industry best practices for dealing with the root cause analysis findings and share this information with industry participants as soon as possible. Also consider cost/benefit tradeoffs of these best practices.
5. Develop a time line and metrics to measure the effectiveness of the team's recommendations.
6. Consider the following tactics/ideas offered by the Steering Team as potential means to address the findings of the root cause analysis. These represent ideas from the Steering Team that we want to share. They may be accepted or rejected by the power systems focus team. The team should consider identifying initiatives that could ensure the provision of enduring, reliable power or telecommunications. Possible initiatives include:
   - Reviewing industry electrical system (utility) installation and maintenance practices
   - Refining telecommunications industry standard operating procedures for managing the effects of power disruptions and load shedding
   - Establishing mutual aid pacts to share power generators
   - Evaluating alternative transportation of emergency fuel and generators
   - Developing priority fuel resupply arrangements
   - Recommending dual private feed arrangements from utility providers for critical CO sites as required.

Existing Work Efforts

Both industry and Government have been working to reduce the vulnerabilities of telecommunications network operations to power disruption.

In the telecommunications industry, Bellcore, the Regional Bell Operating Companies (RBOC), and the interexchange carriers (IEC) have focused on the impact on telecommunications of power curtailment and short-duration power disruption. Each of the RBOCs and the IECs has developed programs to reduce its energy vulnerabilities and continue to refine standard operating procedures as a result of lessons learned from exercises and from actual power disruptions. These programs encompass provisions for preventive maintenance of generators, fuel vendor resupply arrangements, and review of requirements for minimum battery reserves in attended and unattended offices. Also, the President's National Security Telecommunications Advisory Committee (NSTAC) has developed recommendations to mitigate the effects of telecommunications power vulnerabilities. The NSTAC is now developing criteria and procedures to identify critical telecommunications facilities (serving National Security/Emergency Preparedness users) and include them in the local electric utility companies' power restoration priority plans.

Within the Government, the National Communications Systems (NCS) has focused on the effect of widespread long-duration power disruption. The NCS has analyzed a number of electric power networks and developed power profiles to determine the vulnerability of specific telecommunications network elements to disruption of electric power. Work with the Department of Energy (DOE) has led to development of a concept for nationwide electric power restoration called the Electric Service Priority (ESP) program. This new concept would be implemented voluntarily by State and local governments in cooperation with local utilities. Utility managers in New Hampshire and Maryland were recently briefed on the relationship of the ESP concept to the functioning of telecommunications facilities and they appeared to

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be very receptive. However, it is important to note that not all electric utility companies' restoration priorities reflect a recognition of the criticality of telecommunications.

12.2 Questionnaire

Request for Data on AC/DC Power Systems Related Outages

Please provide information on AC/DC systems related telecommunications service interruptions and "near misses" experienced within the past two years (June 1990-present). It is anticipated that the incidents will involve one or more of the following: commercial AC power anomalies, AC transfer switchgear, engine alternators, battery power plants, bulk converter plants, power distribution systems and/or associated alarms.

Information on outages due to failures of DC/DC converters embedded in switches and transmission equipment is not solicited unless the problem was caused by the power plant.

Please complete one **Power Outage Questionnaire** (attached, reproduce locally as needed) per event.

Also, please provide a brief description of any program(s) your company has undertaken within the past two-three years to improve power systems reliability.

Power Outage Questionnaire
(complete one form per event)

1. Time of failure & restoral:

   Failed: Time ____ ; Date ________ ; Day of week ____
   (hr:mn) (mo/day/yr)

   Restored: Time _______ ; Date __________

2. Description of service affected (check all that apply):
   a. Total central office (CO)/switch outage: ____
   b. Partial CO/switch outage: ____
   c. CO isolation: ____
   d. Transmission systems (describe): __________
   e. Other, describe: ____________________
3. What "failed?" Check all that apply:
   a. Commercial power problem: ____
   b. Standby generator: ____
   c. AC transfer switchgear: ____
   d. AC fuses/circuit breakers: ____
   e. Rectifiers/chargers: ____
   f. Battery power plant (batteries discharged): ____
   g. DC/DC converter plant: ____
   h. DC fuses: ____
   i. DC circuit breakers: ____
   j. Alarm systems: ____
   k. Other: ____________________
4. Briefly, describe the sequence of events leading to the outage (who, what, when, etc.) and restoration activities. Use a separate sheet if needed.
5. What was the direct cause(s) of the outage? Some possibilities are listed below, please check all that apply. Write in other direct causes as necessary.
   a. Telco worker error: ____
   b. Installation vendor error: ____
   c. Procedures missing/inadequate: ____
   d. Lack of routine maintenance: ____
   e. No alarms/inadequate alarm system: ____
   f. Failure to respond to alarms: ____
   g. Lightning related: ____
   h. Overloaded/undersized power equipment, fuses, etc (explain): ____
   i. Equipment malfunction (list type & vintage): ____
   j. Design deficiency (explain): ____
   k. "Other," list: ____
6. What was the "root" cause(s) of the outage if different from the direct cause above?
7. What recommendations were made to prevent future outages of this type?

12.3 Preparation of Site Specific Procedures

A. Index/Table of Contents (with page numbers)

B. Escalation Procedures/Contact Lists

   This should normally be covered on one page which would be the same throughout the district.

C. Power Systems Overview. Provide sketches showing locations if necessary.
   - AC Service,
   - Engine(s),
   - DC power plants.
   - Inverters/UPS's

   List the associated documentation: Schematic diagrams, practices, Wiring List and Block Schematics, AC Single Line Diagrams, AC Control Schematics, manufacturer's manuals, etc.

   Note : In many companies the equipment engineering database will contain most of the above information with power plant loads and

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calculated battery reserve times.

D. Normal Commercial Power Failure Procedures
   - Normal automatic operations (sequence of operation for engine timers, etc.)
   - Manual operations normally required for nonautomatic systems.
   - Logging/reporting requirements.

E. Refrigeration/chiller procedures.

F. Engine Failure Contingency Plans:
   - Manual procedures when automatic control fails:
     - — Reset of circuit breakers, air damper shutdowns, etc.
     - — Procedures for bypass of auto control (place selector switch in manual, operate manual bypass for microprocessor controllers, etc.).
   - Basic troubleshooting:
     - — Fuel system (pumps, filters, etc.)
     - — Start system (battery, etc.)
     - — Ventilation system (louvers, etc.)
     - — Cooling system (remote radiators & associated pumps).

G. AC Switchgear Failure Contingency Plan
   - "Manual" operation using push buttons.
   - Manual operation using levers, cranking tools, etc.
   - Disengagement of mechanical interlocks (rack breaker to remain open out of cell, etc.).
   - Manual operation of transfer switches. Safety Note: De-energize both sources to automatic transfer switch if it is necessary to work inside the cabinet to operate a transfer switch manually; see manufacturer's instructions.
   - Basic procedures for troubleshooting switchgear control circuit problems (check fuses, control power relays, etc.).

H. Portable Engine Hook-up (Provide AC tap box outside building when necessary; ensure safety of this operation.)

I. Load Shedding Plan (AC and DC)
   - Identify lower priority AC loads to be turned off if standby engine(s) cannot support all connected loads.
   - Identify DC loads to be turned off to extend battery life: Redundant controllers and converters, and any non critical DC loads.

J. DC Power Plant Contingency Plan
   - Rectifiers inoperative with AC available: check for controller shutdown.
   - Bypass procedures for microprocessor problems.
   - Battery plant restart after deep discharge.

K. Electronic Systems Power Up/Power Down Procedures (for each system). **Note: Extensive damage and prolonged outages can occur with some electronic systems if the prescribed power up procedures are not followed.**

L. Reference Sketches/Diagrams
   - AC feeds/breakers for essential equipment:
     - — DC power plants
     - — Engine support systems: fans, pumps, etc.
     - — Chillers, air handling for switch.
   - Complex engine fuel systems (day tanks, valves, pumps, etc.).

M. Fire Emergency Power Disconnect Procedures (for use by fire department; keep simple; consult with local fire department to determine how their needs may best be met).

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12.4 Network Reliability Industry Initiatives

Topic	Industry Group	Doc. No Issue No Standards No	Version No and Date	Title	Brief Description
Network Reliability Performance Objectives	Bellcore	TR-NWT-000063	I4, 7/91	Network Equipment Building Systems (NEBS) Generic Requirements	
	Bellcore	TR-EOP-000146	I1, 9/85	Engine-Alternator Standby AC Systems	
	Bellcore	TR-NWT-000154	I2, 1/92	Generic Requirements for 24-, ... Volt Central Office Power Plant Control and Distribution Equipment	
	Bellcore	TR-EOP-000232	I1, 6/85	Generic Requirements For Lead-Acid Storage Batteries	
	Bellcore	TR-NWT-000332	I4, 9/92	Reliability Prediction Procedures for Electronic Equipment	Contains the recommended parts count, laboratory and field tracking methods for predicting and measuring hardware reliability
	Bellcore	TR-TSY-000406	I1, 5/88	DC Bulk Power Systems For Confined Locations	
	Bellcore	TR-TSY-000513	I2, 12/87	Power - Section 13 of the LATA Switching Systems Generic Requirements	
	Bellcore	TR-TSY-000757	I1, 7/89	Generic Requirements For Uninterruptible Power Systems (UPS)	
	Bellcore	TR-NWT-000766	I1, 10/91	Generic Requirements for Valve Regulated Lead Acid Cells	
	Bellcore	TR-NWT-001011	I1, 2/92	Generic Requirements for Surge Protective Devices (SPDs) on AC Power Circuits	
	Bellcore	TR-NWT-001197	I1, 7/92	Generic Requirements for Locally Powering ONUs For FITL Systems	
	Bellcore	TR-NWT-001200	I1, 1/92	Generic Requirements for Accelerated Life Testing of Valve Regulated Lead Acid Batteries at High Temperatures	
	Bellcore	SR-NWT-001701	I2, 9/92	Standby Engine-Alternators for Remote Sites	
	ANSI	T1A1.2/93-015	2/93	Draft Proposed Technical Report on Network Survivability Performance, Project T1Q1/90-004R2	
	Comm T1	T1.313	91	Electrical Protection for Telecommunications Central Offices and Similar Type Facilities	

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Topic	Industry Group	Doc. No Issue No Standards No	Version No. and Date	Title	Brief Description
Network Architecture And Design	BellSouth	TR-73503	1B. 7/87	Installation Standards Central Office Equipment	
	Southwestern Bell	TP76300	R2. 5/90	Installation Guide	
	US WEST	TP77350	6/90	Central Office Telecommunications Equipment Installation and Removal Guidelines	
	Comm T1	T1.311	12. 91	DC Power Systems	Telecomm. Environment Protection
	Comm T1	T1.313	91	Electrical Protection for Telecommunications Central Offices and Similar Type Facilities	
	ANSI	NFPA	70	National Electrical Code	
	ANSI	C2	93	National Electrical Safety Code	
	ANSI	T1A1.2/93-015	2/93	Draft Proposed Technical Report on Network Survivability Performance. Project T1Q1/90-004R2	
	CCITT	Study II and XVIII			Survivable architectures
	IEEE	Trans on Reliability	Vol 40. 10/91	Design of Survivable Communications Networks Under Performance Constraints	
Network Interconnection and Interoperability	Bellcore	TR-NWT-001089	I1. 10/91	Electromagnetic Compatibility and Electrical Safety Generic Criteria for Network Telecommunications Equipment	
	Comm T1	T1.315	Draft	DC Voltage Level	Standard voltage operating range for all equipment
Restoration and Recovery	Comm T1	T1.308	90	Central Office Equipment	Electrostatic Discharge Requirements
	CCITT	Study Group IV			Restoration studies

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Topic	Industry Group	Doc. No. Issue No. Standards No.	Version No. and Date	Title	Brief Description
Human Factors Design					
	Bellcore	TR-NWT-000293	11. 11/87	Isolated Ground Planes - Definition and Application to Telephone Central Offices	
	Bellcore	TR-NWT-001089	11. 10/91	Electromagnetic Compatibility and Electrical Safety Generic Criteria for Network Telecommunications Equipment	
	Comm T1	T1.316	92	Electrical Protection	Electrical Protection of Telecom Outside Plant
	ANSI	T1E1.7 & 8			Develops electrical and physical protection standards for exchange and interexchange carrier networks
	ANSI	C62	Surge Prot. Devices		Develops standards for telephone protectors & ac surge protective devices
	National Fire Fire Protection Association (NFPA)	National Fire Codes and Standards	Vols 1-11. 1988	NFPA 110 - Standard for Emergency and Standby Power Systems	
	NFPA	Standard 37		Installation and Use of Stationary Combustion Engines and Gas Turbines	
	Underwriter Lab Industry Advisory Committees	UL1008-89	4th Ed. 9/90	Standard for Safety Automatic Transfer Switches	
	Underwriter Lab Industry Advisory Committees	UL1459,UL1863 & UL1950		Safety standards advise for telephone and information technology equipment	
	Protection Engineers Group	PEG			Develops seed documents for protector, NID standards, resolves network electrical protection issues

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Topic	Industry Group	Doc. No Issue No Standards No	Version No. and Date	Title	Brief Description
Survivability Analysis Models and Tools	IEEE	Journal on Selected Areas	Vol. SAC-4 10/86	Approximate Markov Modeling of High-Reliability Telecommunications Systems	
	IEEE	Trans. on Communications	pp 69-72. 1989	Modeling and Analysis of Systems with Multimode Components and Dependent Failures	
	IEEE	Trans. on Communications	pp 495-503. 1990	A path-based approach for analyzing reliability of networks with dependent failures and multimode components	
	IEEE	Computer	pp 49-57. 4/91	Reliability Modeling: An Overview for System Designers	
	IEEE	INFOCOM '92	Paper 7B.1	Token Ring Reliability Models	Models the reliability of IEEE 802.5 token LAN rings
	Globecom	92 Proceedings	12/92	Survivability Risk Analysis and Cost Comparison of SONET Architectures	
	Globecom	92 Proceedings	12/92	Risk Analysis for Improving CCS#7 Survivability	
	RAM	Annual 1991 Proceedings	pp. 129-136. 1991	Reliability and Availability Modeling of Coupled Communications Networks	
Regulations	Congress	H.R. 4789	4/92	Telephone Network Reliability Improvement Act of 1992	This bill would have required the FCC to establish and enforce network reliability standards (failed to pass in 92)
	Congress	S.237	1/93	National Network Security Board Act of 1993	Bill to create NS board to investigate and make recommendations regarding network security and reliability
	Congress	S.238	1/93	Telecommunications Network Security and Reporting Act of 1993	Bill to require FCC to report to Congress network security and reliability matters

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REFERENCES

1. TR-NWT-000063, *Network Equipment-Building System (NEBS) Generic Equipment Requirements*, Issue 4 (Bellcore, July 1991).
2. ANSI T1.311-1991 *DC Power Systems - Telecommunications Environmental Protection*, American National Standard For Telecommunications (ANSI), May 1991.
3. TR-TSY-000513 *Power LATA Switching Systems Generic Requirements (LSSGR): Section 13*, Issue 2 (Bellcore, June 1988).
4. TR-NWT-000295 *Isolated Ground Planes - Definition and Application to Telephone Central Office*, Issue 1 (Bellcore, November 1987).
5. TR-NWT-001089 *Electromagnetic Compatibility & Electrical Safety Generic Criteria for Network Telecommunications Equipment*, Issue 1 (Bellcore, October 1991).
6. *National Power Laboratory Power Quality Study Results Based on 600 Site-Months*, Douglas Dorr, National Power Laboratory (a division of Best Power Technology, Inc.).
7. *National Electrical Code, 1993 Edition*, Quincy, MA, National Fire Protection Association.
8. NFPA 110 *Standard for Emergency and Standby Power Systems*, 1988, National Fire Codes and Standards, Volumes 1 through 11.
9. NFPA 37 *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines* 1990, National Fire Codes and Standards, Volumes 1 through 11.
10. TR-EOP-000146 *Engine-Alternator Standby AC Systems provide requirements for standby generators*, Issue 1 (Bellcore, May 1985).
11. *Wind Storms In Britain - Impact on the British Telecommunications Network*, John Coppinger, Intelec '90, Paper 1-2.
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17. Technical Publication TP76300 *Installation Guide*, Revision 2 (Southwestern Bell Telephone Company, May 1990).
18. U S West Technical Publication 77350 *Central Office Telecommunications Equipment Installation and Removal Guidelines* (U S WEST, June 1990).
19. TA-NWT-001275 *Central Office Environment Installation/Removal Generic Requirements*[20] Issue 1 (Bellcore, July 1992).
21. SR-NWT-001701, *Standby Engine-Alternators for Remote Sites*, Issue 2, (Bellcore, September 1992).
22. TA-NWT-001293, *Generic Requirements for Permanent Engine-Generators For Remote Electronic Sites*, Issue 1, (Bellcore, January 1993).

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