Performance Metrics Team

Final Report

Eva Low
Executive Director - Switching Engineering
Pacific Bell
2600 Camino Ramon, Room 3S952
San Ramon, CA 94583
Tel. (510) 823-2910
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1. EXECUTIVE SUMMARY

The Network Reliability Council (NRC), a Federal Advisory Committee originally established by the Federal Communications Commission (FCC) in January 1992, had its charter amended in April 1994. Under the revised charter, the new NRC (referred to hereinafter as NRC II) was asked, among other requests, "to evaluate the reliability of network services in the United States on a local and regional basis . . . and to collect data on whether network outages have disproportionate impact on certain geographic areas or certain demographic groups[1]."

A cross-industry Performance Metrics Team (PMT) was formed to examine the issues identified in the revised charter. The PMT collected and analyzed aggregated industry data along seven national population categories and four U.S. Bureau of the Census geographic categories. An Industry Data Request Questionnaire seeking information on outage frequency, duration, impact (as measured by the T1A1 outage index), and cause was sent to existing and emerging telecommunications industry segments--namely, local exchange carriers (LEC); interexchange carriers (IC); and cellular, Cable TV (CATV), and satelllite service providers.

Industry response to the Industry Data Request Questionnaire from the LEC and IC segments was excellent. The conclusion based on analysis of the data for these segments is that there is little or no demographic or geographic difference in network reliability.

However, for the remaining industry segments, the responses were sporadic and less complete. Only the cellular industry provided sufficient data for quantitative analysis. The conclusion from this limited data set is that although the cellular results do not indicate a major problem, it is recommended that the cellular industry continue to focus on performing root cause analysis and to place increased attention on software reliability.

Data from the CATV and satellite industry segments were either unavailable or incomplete; thus, no analysis could be performed. The PMT encourages providers in these and future industry segments seeking to provide telecommunications services to review and implement (where applicable) the recommendations of the Outage Reporting and Customer Notification Team.

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[1] "New Members Appointed to the Network Reliability Council," *FCC Public Notice*, May 12, 1994.

2. BACKGROUND

The NRC is a Federal Advisory Committee that was originally established by the FCC in January 1992 to provide recommendations both to the FCC and to the telecommunications industry that, when implemented, will ensure the reliability of the public telecommunications network. The original NRC examined key focus areas of network reliability concern based on historical data, and published its findings in the report entitled "Network Reliability: A Report to the Nation."

In April 1994, the FCC continued the existence of the NRC under a revised charter. The modified charter called on the new NRC II "to evaluate the reliability of network services in the United States on a local and regional basis; to evaluate potential new risks from new interconnection arrangements and changing technologies; to evaluate access to emergency services during network outages; and to collect data on whether network outages have a disproportionate impact on certain geographic areas or certain demographic groups[2]."

As with the original NRC, the NRC II established focus groups under the direction of a Network Reliability Steering Team (referred to hereinafter as NOREST II) to examine the aforementioned areas and other issues assigned by the NRC II. For each focus group, NOREST II assigned one of its members as the focus group "champion," and documented the purpose and scope of the team's work in the form of an Issue Statement. The following five focus groups were created:

- Focus Group I: Network Reliability Performance
- Focus Group II: Increased Interconnection
- Focus Group III: Reliability Concerns Arising From Changing Technologies
- Focus Group IV: Essential Services in Emergencies
- Focus Group V: Telecommuting in Emergencies.

Focus Group I was assigned to examine three distinct areas related to Network Reliability Performance, and separate teams were formed to examine each area as described below. (See also the Issue Statement in Appendix 1.)

- Performance Metrics Team
  - Collect and analyze network outage data for local and regional differences
  - Collect and analyze network outage data for demographic and geographic differences
- Best Practices Team
  - Report on best practices implementation
  - Evaluate the effectiveness of best practices
- Outage Reporting and Customer Notification Team
  - Evaluate if other service providers should report outage data
  - Determine whether and how customers should be notified of outages.

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[2] "New Members Appointed to the Network Reliability Council," *FCC Public Notice*, May 12, 1994.

The overall coordination and management of these teams' activities was provided by the Network Reliability Performance Committee (NRPC) chaired by Ray Albers of Bell Atlantic. Frank Ianna of AT&T served as the Focus Group I champion.

This report addresses the PMT's findings and recommendations.

3. FOCUS TEAM STRUCTURE

3.1 Focus Team Membership

The cross-industry PMT was composed of representatives from the LEC, IC, cellular, CATV, and satellite industries as listed below.

Name	Industry	Company
Eva Low (Chair)	RBOC	Pacific Bell, Chair
Frank Ianna	IC	AT&T, NOREST II Champion
Wayne Chiles	RBOC	Bell Atlantic
Tim Mack	RBOC	Ameritech
Penny Christensen	RBOC	U S WEST
Norb Lucash	LEC	USTA
P. J. Aduskevicz	IC	AT&T
Ron Pixler	IC	MCI
Michael Angi	Cable	Colony Communications
Stan Edinger	Satellite	AT&T
Chuck Adams	Cellular	McCaw
Harold Daugherty	NRSC	Bell Atlantic
Bill Klein	NRSC	ATIS
Jay Bennett	Data Aggregator	Bellcore
John Healy	Data Aggregator	Bellcore
Ari Jain	Data Aggregator	Bellcore
Spilio Makris	Data Aggregator	Bellcore

3.2 Focus Team Work Plan and Process

As set forth in the NOREST II Issue Statement, the PMT's task was to collect and analyze network outage data to determine not only the reliability of network services on a local and regional basis, but also whether and to what extent network outages have disproportionate demographic and geographic impacts. The PMT expanded upon the general study outline contained in the Issue Statement by developing a detailed Work Plan to organize and guide its work. (See Appendix 2 for a copy of the PMT Work Plan.)

Specifically, the Work Plan defined the study approach, data collection and analysis methodology, deliverables, and timetable for accomplishing the PMT's task. Key elements of the Work Plan are summarized below.

1. *Study Approach*

The study would be based on aggregated data collected from the "total industry," including both traditional and emerging telecommunications industry segments:

- LECs
- ICs
- Cellular service providers
- CATV service providers
- Satellite service providers

The aggregated data for the "total industry" would then be analyzed from different outage perspectives (frequency, duration, impact, and cause) and along predefined demographic, geographic, and local versus regional classifications. Unfortunately, because of difficulties in obtaining data from all of the industry segments, the original intent of conducting the analysis on a "total industry" basis was not possible. Instead, an alternative approach was adopted. This approach consisted of conducting two, separate, stand-alone analyses: one for the wireline local and interexchange carriers, and the other for the wireless cellular providers.

2. *Classification Definitions*

To facilitate the analysis, definitions were developed for the following demographic, geographic, and local versus regional classifications:

- "Demographic" was defined as the statistical characteristics of human population. Two specific demographic characteristics were chosen for the study work:
  - Population Size
  - Population Density per square mile.
- "Geographic" was defined as the physical characteristics of an area. The U.S. Bureau of the Census' hierarchy of territorial units[3] served as the source document for the two territorial units selected for this study work:
  - County
  - Region (Northeast, Midwest, South, and West).

[3] In ascending order, the US Bueau of the Census hierarchy of territorial units is as follows:

- County
- Metropolitan Statistical Area (MSA)
- State
- Divisions (9)
- Regions (4)

The county, which is the smallest geographic unit, is the basis for the geographic rollups to the nine census divisions and the four census regions, as illustrated in Appendix 3.

- "Local" was synonymous with “County” as defined by the U.S. Bureau of the Census.
- "Regional" was synonymous with “Region” as defined by the U.S. Bureau of the Census.

3. *Outage Analysis Dimensions*

The PMT selected the following four outage characteristics to assess the geographic and demographic impact of outages:

- Outage Frequency
- Outage Duration
- Outage Impact (using T1A1 Index)
- Outage Cause

4. *Industry Data Request Questionnaire*

Because of differences in technology and data collection practices in the various industry segments, separate Industry Data Request Questionnaires were developed for each industry segment. The Work Plan outlines the relevant data sources and data elements that would be used for each industry segment’s Data Request.

5. *Data Processing and Analysis*

The Work Plan specified that only aggregated data would be used. It also contained high level descriptions as to how the demographic, geographic, and outage profiles would be developed.

6. *Administrative Matters*

The Work Plan documented the PMT’s organizational structure, major tasks, deliverables timetable, and meeting schedule.

4. DATA COLLECTION AND ANALYSIS METHODOLOGY

The PMT determined that to fulfill its task, it required information on equipment locations and outages from five existing and emerging industry segments: LECs, ICs, cellular, CATV, and satellite service providers. Accordingly, the PMT developed three data requests for LEC and IC industry segments, and two data requests for the other three industry segments.

4.1 Questionnaire Description

For each industry segment, the first Industry Data Request Questionnaire asked for information on equipment locations as of December 31, 1994. The remaining data requests asked for information on outages that occurred between January 1, 1993 and December 31, 1994. The outage data requests asked for information on date, time, duration, cause, and location (including county) for each outage. These data requests were accompanied by instructions for completing them. Appendix 4 contains Industry Data Request Questionnaires for the five segments, which are described below.

- *LEC Segment.* Appendix 4-1 gives the spreadsheets for the three data requests for the LEC segment. Data Request #1 contains the spreadsheet for recording information on the end office switches of the LEC service provider. Data Request #2 contains the spreadsheet for recording all major outages affecting at least 30,000 customers (or causing 90,000 blocked calls) and lasting 30 minutes or longer (consistent with FCC reporting requirements in FCC Docket 91-273). Data Request #3 contains the spreadsheet for recording all unplanned total end office switch outages (FCC Report 43-05 Table IV-A) lasting 5 minutes or longer (excluding unplanned total outages that were reported as major outages in Data Request #2).

- *IC Segment.* Appendix 4-2 includes the spreadsheets for the three data requests for the IC segment. Data Request #1 contains the spreadsheet for recording information on the tandem switches of the IC service provider. Data Request #2 contains the spreadsheet for recording all major outages affecting at least 30,000 customers (or causing 90,000 blocked calls) and lasting 30 minutes or longer (consistent with FCC reporting requirements in CC Docket 91-273). Data Request #3 contains the spreadsheet for recording all unplanned total tandem switch outages lasting 5 minutes or longer (excluding unplanned outages that were reported as major outages in Data Request #2). Data Requests #2 and #3 were combined in one spreadsheet.

- *Cellular Segment.* Appendix 4-3 gives the spreadsheets for the two data requests for the cellular segment. Data Request #1 contains the spreadsheet for recording information on the mobile switching centers of the cellular service provider. Data Request #2 contains the spreadsheet for recording all unplanned total mobile switching center outages lasting 5 minutes or longer.

- *CATV Segment.* Appendix 4-4 provides the spreadsheets for the two data requests for the CATV segment. Data Request #1 contains the spreadsheet for recording information on the head ends of the CATV service provider. Data Request #2 contains the spreadsheet for recording all unplanned total head end outages lasting 5 minutes or longer.

- *Satellite Segment.* Appendix 4-5 gives the spreadsheets for the two data requests for the satellite segment. Data Request #1 contains the spreadsheet for recording information on the earth stations and satellite transponders of the satellite service provider. Data Request #2 contains the spreadsheet for recording all unplanned total outages lasting 5 minutes or longer in earth stations and satellite transponders.

4.2 Data Collection Process and Responses

The NRC designated Bellcore as the central point for requesting, collecting, compiling, and aggregating data for all focus groups. All data provided to Bellcore were protected under a non-disclosure agreement. These data were treated as proprietary information, and specific references to individual respondents were removed during the aggregation process.

The NRC was directed to obtain a view of all segments of the industry. Accordingly, the NRC asked all of the largest companies in each industry segment to participate. These companies represent more than 90 percent of the subscribers in that respective industry segment.

Each prospective respondent company was asked to identify a Single Point of Contact (SPOC). In total, 6 ICs, 12 LECs, 18 cellular companies (including the 10 largest), 9 CATV companies, and 9 satellite (or Mobile Satellite) companies identified SPOCs. Only 3 companies that were asked to provide a SPOC did not participate. Bellcore sent all data requests to the SPOC in each company.

The data requests from the PMT were sent to the SPOCs for the LECs, ICs, cellular, CATV, and satellite service providers on April 12, 1995. The companies that were late in identifying their SPOCs received their questionnaires immediately after they identified their SPOCs. The original cutoff date for responses was April 30, 1995. However, this date was extended to August 31, 1995, in order to include as many responses as possible

The response rates to the data requests for the LEC and IC segments, most of whom had participated in the original NRC (NRC I) were 100 percent and 83 percent, respectively. The responses from these segments were received by early July 1995. These responses were aggregated and a detailed analysis was conducted on the LEC and IC data.

Only eight of the ten largest cellular companies responded. The responses were slow and incomplete and spanned an extended time period with the last response received on September 27, 1995. Despite these problems, a stand-alone analysis of the cellular data was completed by aggregating all the responses from the cellular data providers.

The CATV-designated companies did not provide individual company equipment and outage data to Bellcore. Only a summary of the CATV outages was provided to Bellcore by the National Cable Television Association.

Several designated satellite companies did provide equipment and outage data to Bellcore. However, the satellite data were generally not usable for this study, because the data were incomplete, especially in regard to the extent of the outages.

The original intent of the study was to aggregate data from all industry segments, and on that basis, assess the demographic and geographic impacts of outages. However, given the late responses and the incomplete data from some of the newer industry segments that did not participate in NRC I, quantitative analysis is available only for the LEC/IC and cellular industry segments. This report does not include any analysis of the outages for the CATV and the satellite segments because the data were not available or incomplete.

4.3 Data Analysis Methodology

To organize and analyze the data, the PMT established computation methodologies for the following analysis elements:

- Equivalent Access Lines
- National County Population Categories
- Geographic and Regional Categories
- Outage Index

4.3.1 Equivalent Access Lines

An original objective of the PMT was to combine data from the various telecommunication industry segments to obtain combined measures of outages and their relationships to population and equipment. To facilitate this combination of disparate data, the PMT developed equivalencies between the LEC's access lines and other industry segments' equipment. These equivalencies were also needed to compute the outage indices that reflect the relative impact to the end users.

In particular, the following equivalence relationships for the IC service providers' tandem trunks and cellular service providers' voice paths were obtained:

- One tandem trunk = 10 LEC access lines
- One radio voice path = 29 LEC access lines.

Similar equivalencies were also developed for the CATV and satellite segments; however, these equivalencies could not be used because of the insufficient data situation noted previously. Appendix 5.1 gives the details on how the equivalent access lines were derived for the different industry segments.

4.3.2 National County Population Categories

One of the objectives of the PMT was to conduct an analysis of the outages from a demographic perspective. The PMT could have divided the country into two groups: urban and rural. Instead, it defined the demographic breakdown in terms of both population size and population density of the counties. It classified all the counties in the 50 states of the U.S. into seven population categories based on the county population and the county population density (i.e., the number of persons per square mile of the county area).

The PMT developed the seven population categories in three steps. First, the county population and population density were obtained from the U.S. Bureau of the Census. Second, the counties were classified into four population groups: (i) Mega (at least 500,000 persons), (ii) Large (50,000 - 499,999 persons), (iii) Medium (15,000 - 49,999 persons), and (iv) Small (below 15,000 persons). Third, the Large, Medium, and Small population categories were further classified into Higher and Lower county population density.

If we define urban as counties with populations equal to or greater than 50,000 persons, and rural as counties with population less than 50,000 persons, then urban would be equivalent to an aggregation of the Mega and Large population categories. Similarly, rural would be an aggregation of the Medium and Small population categories. However, because the objective of the PMT study was to provide a more granular demographic breakdown, the PMT opted to conduct its analysis for the seven population categories.

In the Large population group, Higher and Lower population densities were defined to be at least 160 people per square mile, and below 160 people per square mile, respectively. A population density threshold of 160 was selected so that the number of counties in the two population density categories is about the same. Similarly, in the Medium and Small population groups, the Higher and Lower population densities were defined to be at least 26 and below 26, respectively, so that the common threshold of the population density of 26 divides the combination of Medium and Small counties into roughly equal halves.

The above breakdown of all U.S. counties into seven population categories was supported by the PMT's investigation of the relationship between county population and county population density. By plotting the county population density against the county population, the PMT found that there was a strong positive correlation between the two, as shown in Figure 1. The Mega population category counties had high population densities; therefore, it was left as one category. The remaining county population categories were split into Higher and Lower county population density to obtain further differentiation attributed to county population density.

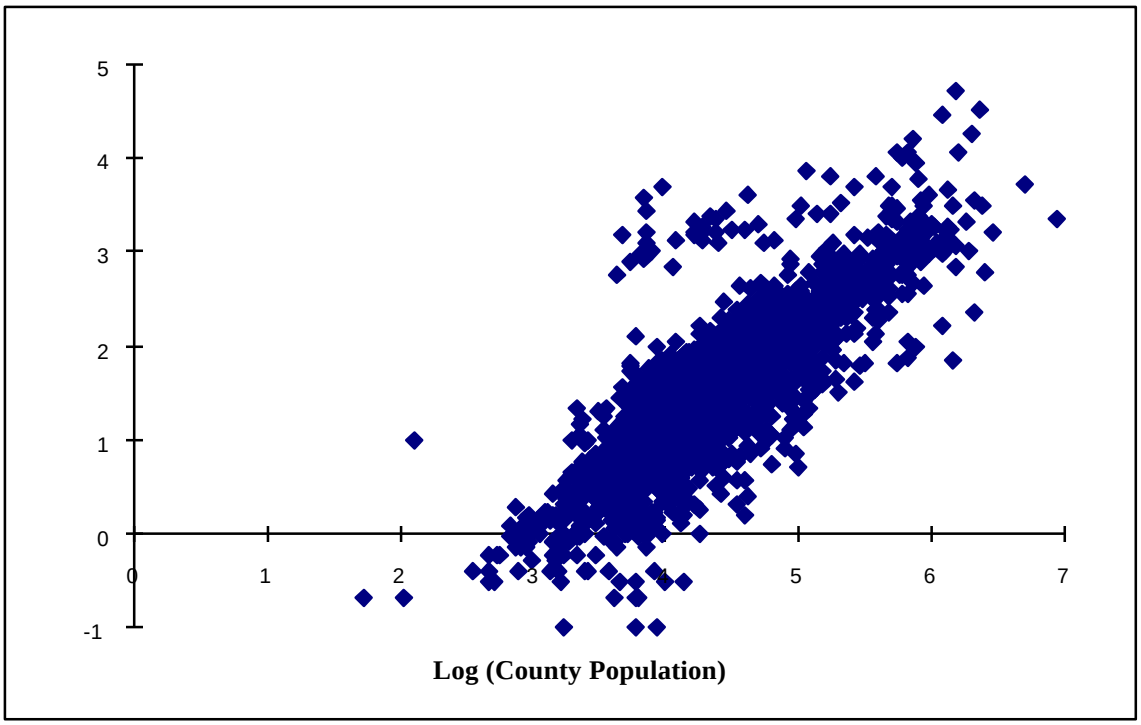

Figure 1
County Population Density Versus County Population

The PMT also investigated the relationship between county population and county area as well as equivalent access lines per person in the county. The PMT did not find any relationship.

Table 1 lists the number of counties, average population, and average population density for each of the seven population categories. There are 3,138 counties (and independent cities in a few states) in the United States; the average county population is 79,257; and the average county population density is 70 people per square mile. As expected, both population and population density decrease significantly from Population Category 1 to Population Category 7.

Table 1
Breakdown of All Counties by Population and Population Density

Population Category	*County Population*	*Population Density*	*No. of Counties*	*Average Population*	*Average Population Density*
1	At least 500,000	Any	97	1,086,601	791
2	50,000 - 499,999	At least 160	366	191,191	352
3	50,000 - 499,999	Less than 160	379	84,930	60
4	15,000 - 49,999	At least 26	924	29,118	52
5	15,000 - 49,999	Less than 26	218	22,902	10
6	Less than 15,000	At least 26	238	10,854	38
7	Less than 15,000	Less than 26	916	7,275	4
Total			3,138	79,257	70

4.3.3 Geographic and Regional Categories

Another objective of the PMT was to conduct an analysis of the outages from a geographic and regional perspective. For this geographic and regional analysis, the PMT adopted the U.S. Bureau of the Census definition of the four geographic regions. Table 2 gives the number of counties, average county population, and average county population density for each of the four census regions.Appendix 3 includes a map that shows the four census regions.

Table 2
Breakdown of Counties by Region

Region	*No. of Counties*	*Average County Population*	*Average Population Density*
Midwest	1054	56,612	79
Northeast	217	234,144	313
South	1423	60,046	98
West	444	118,888	30
All	3138	79,257	70

4.3.4 Outage Index

To assess the outage impact of the outages, the PMT used the outage index developed by Committee T1, and documented in Technical Report No. 42 (August 1995). The index, which was designed for the LECs and ICs, has been adapted to the cellular, CATV, and satellite segments. Based on input from subject matter experts, interim indicies were developed for these industry segments and documented in Appendix 5.2. It is recommended that Committee T1 enhance the outage index to include services provided by these industry segments.

4.4 Scope of LEC/IC Analysis

As indicated earlier, all the designated LEC service providers and five out of the six designated IC service providers turned in their equipment and outage data to Bellcore. These companies constitute a very large majority of the LEC/IC service within the United States. Table 3 shows the average population and population density by population category for those counties in which the participating LEC/IC service providers have equipment. By comparing Table 3 with Table 1 for all U.S. counties, it can be seen that all 97 Mega population counties are served by the participating LECs/ICs, and that a large majority of the other six population categories have participating LECs/ICs' equipment. The total number of counties served by participating LECs/ICs is 2,717. The remaining 421 counties are served by LECs/ICs that either were not requested or did not provide data. Because all 97 Mega population counties and 86 percent of the remaining counties are served by the participating LECs/ICs, it is clear that the participating LECs/ICs are dominant in the market.

To make meaningful comparisons of outage rates across the seven population categories and to avoid weighting the results to account for the different coverage rates by the LEC/IC data providers in the seven population categories, the PMT decided to conduct the analysis of the equipment and outage data by using the number of counties shown in Table 3. Thus, the LEC/IC data analysis results discussed in Section 5 are based on the data for the 2,717 counties in which the participating LECs/ICs have equipment.

Table 3
Breakdown of Counties That Have Participating LEC/IC Equipment by Population and Population Density

Population Category	*County Population*	*Population Density*	*No. of Counties*	*Average Population*	*Average Population Density*	*Equivalent Access Lines/Person*
1	At least 500,000	Any	97	1,086,601	791	1.48
2	50,000 - 499,999	At least 160	359	192,952	353	1.08
3	50,000 - 499,999	Less than 160	363	85,367	60	0.59
4	15,000 - 49,999	At least 26	856	29,321	52	0.55
5	15,000 - 49,999	Less than 26	203	22,931	11	0.47
6	Less than 15,000	At least 26	168	11,186	37	0.85
7	Less than 15,000	Less than 26	671	7,937	5	0.43
Total			2,717	89,296	84	1.11

4.5 Scope of Cellular Analysis

Table 4 gives the total population, total area, total number of switches, and total number of outages for each population category for those counties in which the cellular respondents to the study have equipment. This table demonstrates that cellular respondents do not represent as high a share of the total market as the participating LECs/ICs. None of the cellular companies that provided data have equipment in Population Categories 6 and 7 (i.e., county population below 15,000 persons). Population Category 1 has more than half of all the outages identified for this study and the number of switches in Population Categories 3 to 5 is very small (42 out of 234). Therefore, it was decided to combine Population Categories 2 to 5 into one category and leave Population Category 1 by itself. Thus, the cellular data analysis results discussed in Section 6 are based on two groupings of counties that have cellular data providers' equipment: Population Categories 1 and 2 to 5.

Table 4
Breakdown of Counties That Have Participating Cellular Equipment by Population Category

Population Category	*No. of Counties*	*Total Population*	*Total Area (Sq. miles)*	*Total No. of Switches*	*Total No. of Outages*
1	53	66,339,116	82,597	102	73
2	67	16,814,271	43,831	90	39
3	21	2,566,855	41,698	26	12
4	9	343,035	5,554	9	2
5	7	162,456	27,763	7	1
Total	157	86,225,733	201,443	234	127

5. DATA ANALYSIS RESULTS: WIRELINE LEC/IC TELECOMMUNICATIONS INDUSTRY PERSPECTIVE

This section presents an in-depth analysis of the impact that LEC/IC telecommunications outages have on the nation from a demographic perspective. In addition, this section examines outage data from a geographic and regional perspective. As discussed in Section 4, LEC/IC telecommunications service providers, representing more than 90 percent of the industry, provided information on which the PMT could base its results and conclusions. The PMT used this data to investigate and report on the metrics listed below.

- For each of the seven national population categories, an analysis was prepared to investigate the following:
    - Outage frequency per switch
    - Outage frequency per million people
    - Impact of outage index by population category
    - Equivalent access lines in each population category
    - Average outage index per incident
    - Average outage duration
    - Cumulative outage frequency of outage duration
    - Summary of demographic analysis
- For each of the four census regions, an analysis was prepared to investigate the following:
    - Outage frequency per switch
    - Outage frequency per million people
    - Population in each category
    - Total outage index
    - Equivalent access lines
    - Average outage index per incident
    - Average outage duration
    - Cumulative outage frequency by outage duration
    - OutageFrequency
    - Summary of geographic and regional analysis.
- For the outage incidents, an analysis was prepared to investigate the cause of outages in the following manner:
    - Breakdown of switch-related outages
    - Average impact of switch-related outages
    - Average duration of switch-related outages
    - Breakdown of facility-related outages.

5.1 Demographic Analysis of Wireline LEC/IC Telecommunications Industry Outage Frequency, Outage Index, and Duration

The aforementioned metrics--outage frequency, outage index, and duration--were first analyzed from a demographic perspective. The goal of the analysis was to determine if people located in the seven demographic (or population) categories experienced significant differences in network reliability based on the frequency, outage index, or duration of outages derived from the data collected by the PMT.

The analyses in the following subsections use a series of figures and tables to illustrate the findings. These figures and tables are designed to highlight relative similarities and differences among the population categories.

5.1.1 Outage Frequency by Population Category

Table 5 and Figure 2 show the number of outages per 100 switches, total population per switch, and number of outages per million total population (total population is abbreviated as person). The number of outages per 100 switches is about 13.2 for all population categories. The number of outages per switch is also a good representation of the outage frequency experienced by an individual customer.

Table 5
Outage Frequency Per Switch and Per Person by Population Category

Category	*No. of Counties*	*Total Population*	*Total No. of Switches*	*Total No. of Equivalent Access Lines*	*Total No. of Outages*	*Total Population (K)/ Switch*	*No. of Outages/ Switch (100)*	*No. of Outages/ Person (M)*
1	97	105,400,340	3,820	156,361,592	473	27.6	12.4	4.5
2	359	69,269,781	4,214	75,078,124	580	16.4	13.8	8.4
3	363	30,988,273	3,053	18,275,225	427	10.2	14.0	13.8
4	856	25,098,720	4,063	13,731,266	529	6.2	13.0	21.1
5	203	4,655,038	929	2,209,074	120	5.0	12.9	25.8
6	168	1,879,257	520	1,593,985	50	3.6	9.6	26.6
7	671	5,325,410	1,812	2,307,199	257	2.9	14.2	48.3
Total	2,717	242,616,819	18,411	269,556,465	2,436	13.2	13.2	10.0

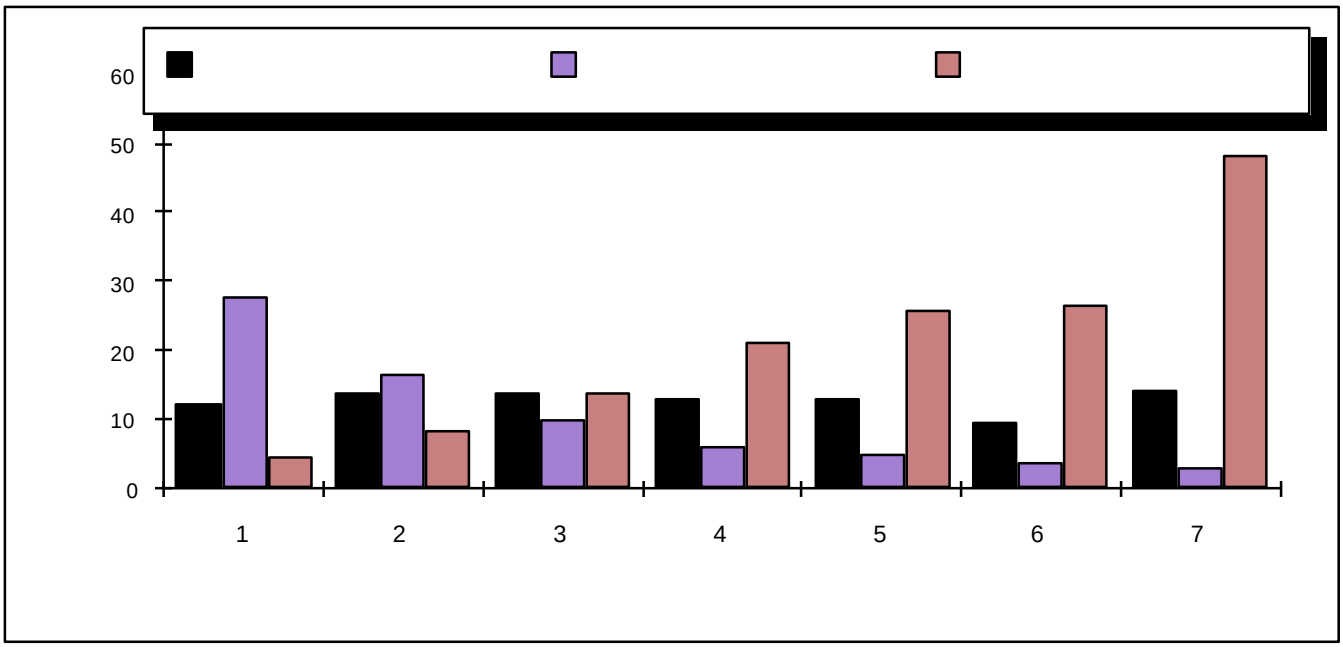

Figure 2
Outage Frequency Per Switch and Per Person (M) for Each Population Category

The number of persons per switch declines as the population size and density decrease, decreasing from 27,592 persons per switch for Population Category 1 to 2,939 persons per switch for Population Category 7. The number of outages per million total population increases from 4.5 for Population Category 1 to 48.3 for Population Category 7. The number of outages per person can be obtained by dividing the number of outages per switch by the number of persons per switch. Because the number of outages per switch is about the same across the seven population categories and the number of persons per switch is decreasing with the county population size and density, the ratio of the two quantities has an increasing pattern.

Thus, the PMT concludes that the outage frequency per switch is about the same for all population categories regardless of the size of the population or population density.

5.1.2 Impact of Outage Index by Population Category

The next area of study reviewed the impact that outages had on different population categories. The PMT calculated the outage index based on the Committee T1 Technical Report No. 42 (August 1995). The index is based on the characteristics of the outage such as customers affected, duration, time of day, day of week, and types of services affected.

Table 6 shows the total outage index computed for the outages in each population category. From this table, it can be seen that there is a consistent and direct relationship between the total index calculated for each population category and the total population and total equivalent access lines in each category.

This direct relationship is also evident when examining the relative percent share of the outage index compared with that of the total population. Table 6 and Figure 3 illustrate that the

percent share of the overall outage index decreases as the county population decreases. From this analysis, the PMT confirmed that the outage index for a typical outage is higher for larger population counties than that for smaller population counties

Table 6
Total Population, Outage Index, and Equivalent Access Lines
by Population Category

Population Category	*No. of Counties*	*Total Population*	*Total Outage Index*	*Total Equivalent Access Lines*	*% Overall* Population*	*% Overall Outage Index***	*% Overall Equivalent Access Lines*
1	97	105,400,340	1,912.90	156,361,592	43.4	56.5	58.0
2	359	69,269,781	921.4	75,078,124	28.6	27.2	27.9
3	363	30,988,273	356.6	18,275,225	12.8	10.5	6.8
4	856	25,098,720	132.6	13,731,266	10.3	3.9	5.1
5	203	4,655,038	10.6	2,209,074	1.9	0.3	0.8
6	168	1,879,257	0.3	1,593,985	0.8	0.0	0.6
7	671	5,325,410	53.8	2,307,199	2.2	1.6	0.9
Total	2,717	242,616,819	3,388.30	269,556,465	100	100	100

* "Overall" is the sum over the seven categories. Therefore, "% Overall Population" in a category is the percentage of the total population contained in that category.

** Outage Index is based on the Committee T1 Technical Report No. 42 (August 1995).

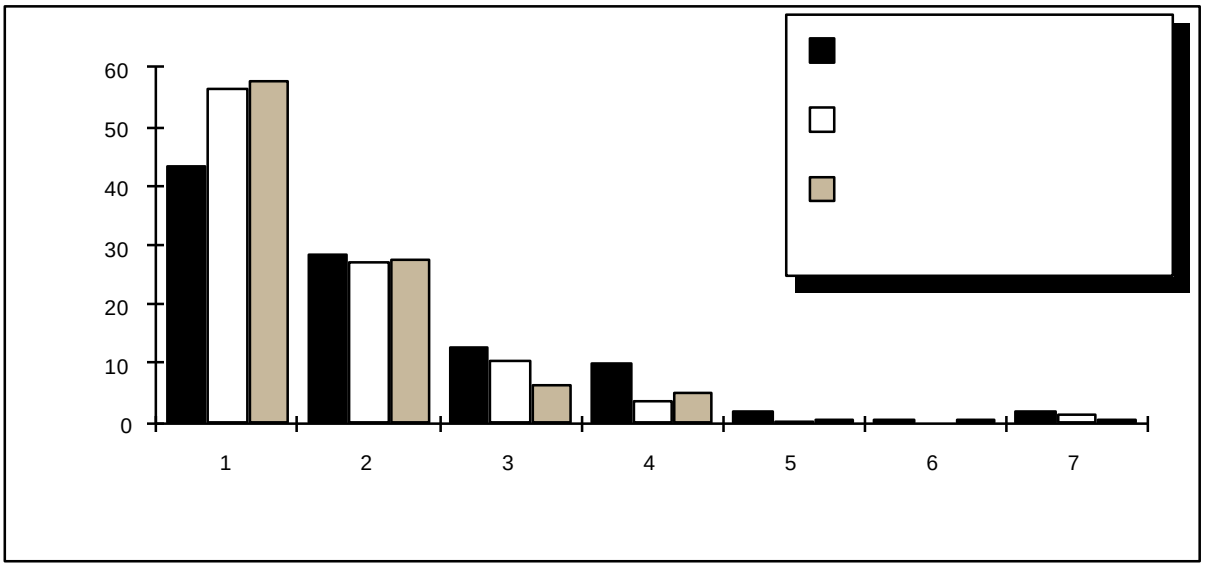

Figure 3
Percentage of Overall Population, Outage Index
and Equivalent Access Lines by Population

The PMT conducted further investigation on the total outage index to determine the average index per outage. The average index provides a more useful and usable figure to compare the impact of outages among the population categories. Table 7 gives the average index per outage for each population category. Figure 4 depicts the average index for each category. This analysis shows that the average index per outage decreases as the county population decreases.

Table 7
Average Index Per Outage for Each Population Category

Population Category	*Total No. of Outages*	*Total Outage Index*	*Average Index Per Outage*
1	473	1,912.90	4.04
2	580	921.4	1.59
3	427	356.6	0.84
4	529	132.6	0.25
5	120	10.6	0.09
6	50	0.3	0.01
7	257	53.8	0.21
Total	2,436	3,388.30	1.39

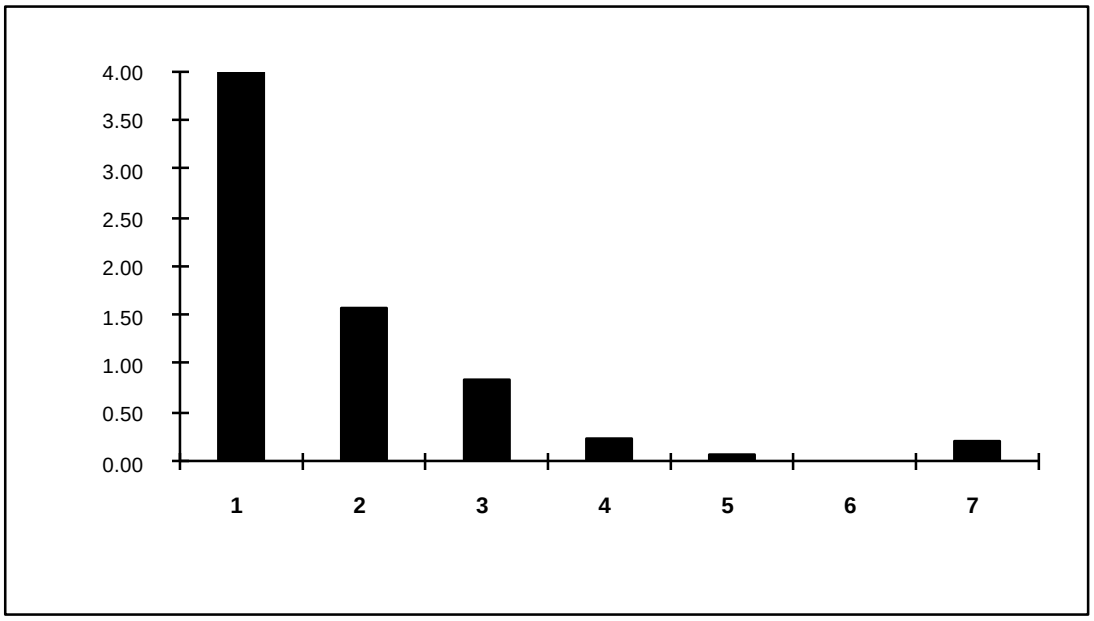

Figure 4
Average Index Per Outage for Each Population Category

5.1.3 Outage Duration by Population Category

The third metric investigated by the PMT involved examining the outage duration experienced in each population category. Table 8 provides the average outage duration. This table indicates that all population categories experience about the same average duration except for Category 1. Therefore, the PMT concluded that the outage duration was similar for Population Categories 2 through 7.

Table 8
Average Outage Duration by Population Category

Population Category	*Total No. of Outages*	*Sum of Outage Duration (Min.)*	*Average Outage Duration (Min.)*
1	473	55,711	117.8
2	580	56,035	96.6
3	427	37,764	88.4
4	529	48,895	92.4
5	120	9,407	78.4
6	50	4,421	88.4
7	257	21,683	84.4
Total	2,436	233,915	96.0

The PMT analyzed Population Category 1 further to understand the reason that the average outage duration was approximately 20 minutes longer than the other categories. Table 9 gives the average duration by population category for outages categorized as being Major (duration greater than 30 minutes and at least 30,000 lines affected) and "Other." The table reveals that when the outages are sorted in this manner, there are no significant differences among population categories within the outage categories (i.e., Major and Other). This table also shows that the majority of Major outages occur in the largest population categories, which is attributed to larger size switches and facilities being deployed in the largest population categories. This is consistent with expectations, given the definition of major outages. The majority of Major outages occur in metropolitan areas.

Table 9
Average Outage Duration by Population Category
for Major, Other and All Outages Combined

Population Category	*% Major Outages*	*Average Duration (Min.)*		
		Major	*Other*	*All*
1	32.8	236.1	60.1	117.8
2	15.0	287.0	63.5	96.6
3	9.6	329.5	62.8	88.4
4	3.6	300.4	84.9	92.4
5	1.6	215	75.4	78.4
6	0	NA	88.4	88.4
7	2.6	256.9	80.2	84.4
Total	12.7	266.9	71.3	96.0

Population Category 1 contains the most "Major" outages (32.8 percent). The average duration is about 4 times the duration of "Other" outages in the study primarily because there are more long duration facility outages in Category 1. Therefore, the PMT concluded that outage duration is similar for all population categories with the exception of Category 1, which has a higher overall average duration because of a large proportion of facility-related "Major" outages.

5.1.4 Other Measures of Outage Duration

Because the average outage duration in the population categories can be affected by a few outliers, the PMT examined two other measures of outage duration. Table 10 gives five percentiles of the outage duration for each population category. The median (i.e., the 50th percentile) and the other percentiles of outage duration exhibit the same pattern as the average duration, confirming that the result described in Section 5.1.3 was not due to a few outliers.

Table 10
Percentiles of Outage Duration for Each Population Category

Population Category	*Percentile of Outage Duration (Minutes)*				
	10th	*25th*	*50th*	*75th*	*90th*
1	7	15	44	120	323
2	6	10	33	85	237
3	6	10	35	94	206
4	6	10	30	86	237
5	5	7	32	83	193
6	6	9	35	95	420
7	6	11	31	110	231

The PMT also examined the percentage of cumulative outage frequencies for different outage durations. Table 11 and Figure 5 show that Population Category 1 starts out with a lower frequency of outages below 15 minutes, as compared with the other population categories, and that pattern continues till 120 minutes. The results shown in Table 11 are consistent with those shown in Tables 8 and 10. Thus, by examining outage duration from these two additional

measures--percentile and cumulative frequency--the PMT was able to confirm the conclusions stated in Section 5.1.3.

Table 11
Cumulative Outage Frequency by Outage Duration for Each Population Category

Population Category	*% Outages Less Than*				
	15 Min.	*30 Min.*	*60 Min.*	*120 Min.*	*120+ Min.*
1	24.3	41.2	57.7	74.6	100
2	34.3	47.8	66.6	81.6	100
3	32.8	45.4	63.7	79.2	100
4	35.3	49.9	66.2	80.2	100
5	39.2	46.7	65.8	80.0	100
6	42.0	48.0	70.0	84.0	100
7	27.6	45.9	65.0	77.0	100
Total	32.0	46.3	64.1	79.0	100

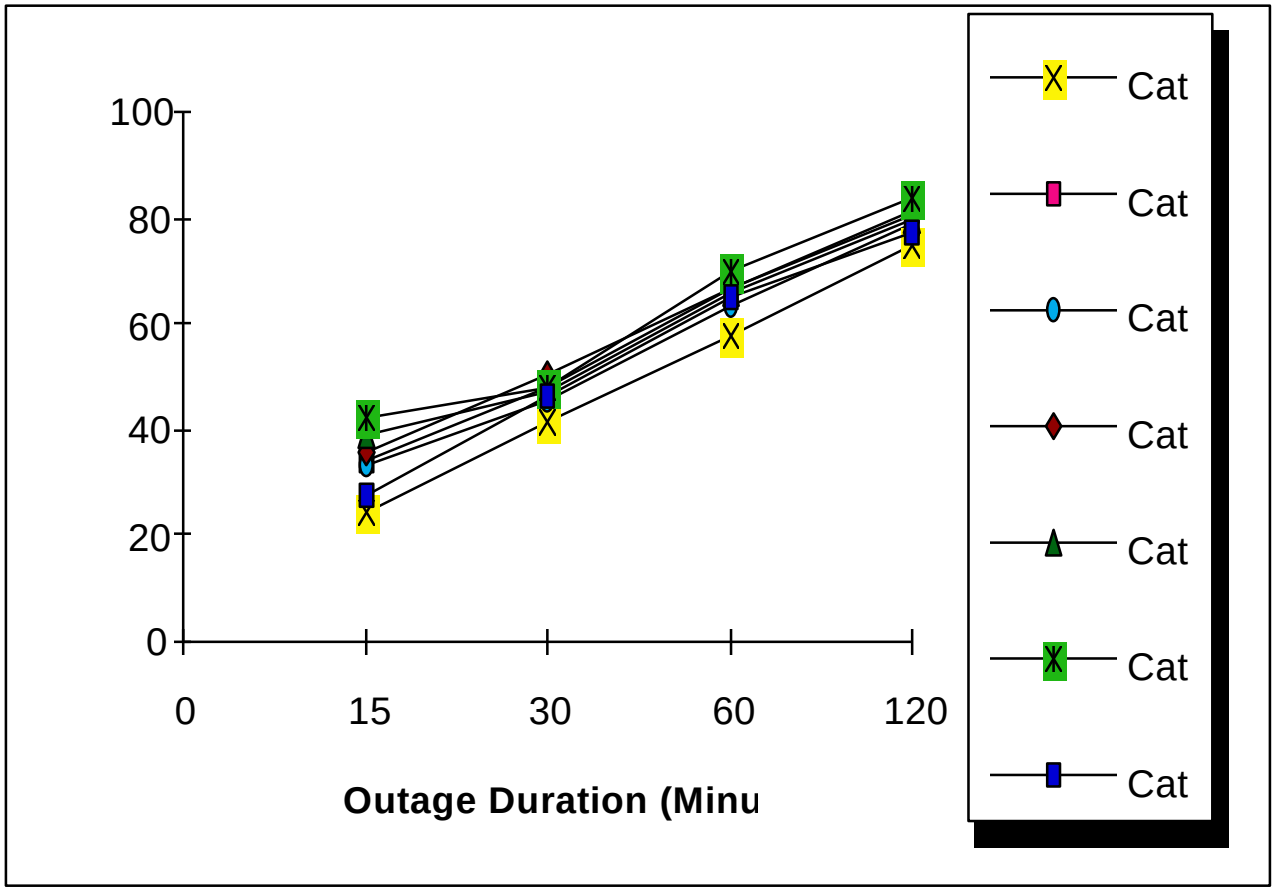

Figure 5
Cumulative Outage Frequency by Outage Duration
for Each Population Category

5.1.5 Demographic Summary for Wireline LEC/IC Telecommunications Industry

Table 12 summarizes the comparisons of outage frequency, outage duration, and outage index for the seven population categories. This Table illustrates that the outage frequency per switch is about the same for all population categories. The average outage duration is about the same for Population Categories 2 through 7. The average outage duration is longer in Population Category 1 than for the other categories primarily because the facility outages are longer in Category 1. Finally, the average index per outage decreases as the population category decreases in size. From these observations, the PMT concluded that network reliability is similar across the different population categories.

Table 12
Outage Frequency, Average Index Per Outage and Average Outage Duration by Population Category

Population Category	*No. Outages/ Switch (100)*	*No. Outages/ Person (M)*	*Avg. Index/Outage*	*Avg. Outage Duration (Min)*
1	12.4	4.5	4.04	117.8
2	13.8	8.4	1.89	96.0
3	14.0	13.8	0.84	88.4
4	13.0	21.1	0.25	92.4
5	12.9	25.8	0.09	78.4
6	9.6	26.6	0.01	88.4
7	14.2	48.3	0.21	84.4
Total	13.2	10.0	1.39	96.0

5.2 Geographic and Regional Analysis of Wireline LEC/IC Telecommunications Industry

To address the geographic and regional perspectives specified in the FCC's charter, the PMT conducted this analysis by sorting the county data into census regions. This allowed information to be analyzed and compared among census regions. A series of tables and figures were assembled, resembling those used for the demographic analysis, to highlight the relative similarities and differences among regional census areas. The goal of this analysis was to determine if the census regions experienced any significant differences in network reliability (frequency, outage index, or duration of outages) based on the data collected by the PMT.

5.2.1 Outage Frequency by Region

An analysis was conducted to compare the frequency of outages experienced in each of the census regions. Table 13 gives the number of outages per switch (100) and person (M). This table shows that outages per person (M) in the Northeast and West were slightly below average, whereas in the Midwest and South they were slightly above the average. However, the number of outages per switch (100) for each region is close to the average for all regions, showing only minimal variation from the average. Thus, the PMT concluded that the outage frequency/switch is about the same for all four Census Regions.

Table 13
Outage Frequency Per Switch and Per Person by Region

Region	*Total Population*	*Total No. of Switches*	*Total Equivalent Access Lines*	*Total No. of Outages*	*No. of Outages/ Switch (100)*	*Total Population (K)/Switch*	*No. of Outages/ Person (M)*
Midwest	58,765,282	5,952	61,516,236	668	11.2	9.9	11.4
Northeast	50,410,614	2,542	57,936,123	327	12.9	19.8	6.5
South	81,601,989	6,797	91,944,384	951	14.0	12.0	11.7
West	51,838,934	3,120	58,159,722	490	15.7	16.6	9.5
All	242,616,819	18,411	269,556,465	2,436	13.2	13.2	10.0

5.2.2 Population, Outage Index and Equivalent Access Lines by Region

The next area of study focused on the population, outage index, and equivalent access lines among the four census regions. Again, the PMT calculated the outage index for each region. Table 14 shows the total outage index and percentage of overall population, outage index, and access lines for each Census Region. The relative share of the outage index compared to that of the total population is higher for the South and West Census Regions.

Table 14
Population, Outage Index, and Equivalent Access Lines by Region

Region	*Total Population*	*Total Outage Index*	*Total Equivalent Access Lines*	*% Overall Population*	*% Overall Outage Index*	*% Overall Equivalent Access Lines*
Midwest	58,765,282	544.0	61,516,236	24.2	16.1	22.8
Northeast	50,410,614	438.7	57,936,123	20.8	12.9	21.5
South	81,601,989	1384.3	91,944,384	33.6	40.9	34.1
West	51,838,934	1021.3	58,159,722	21.4	30.1	21.6
All	242,616,819	3388.3	269,556,465	100.0	100.0	100.0

Further analysis was conducted to examine the average index per outage for each census region. Table 15 shows the results of the analysis. This analysis reveals that the regions are comparable, with the West region results above average, and the Midwest region results slightly below average.

Table 15
Average Index Per Outage by Region

Region	*Total No. of Outages*	*Total Outage Index*	*Average Index per Outage*
Midwest	668	544.0	0.8
Northeast	327	438.7	1.3
South	951	1,384.3	1.5
West	490	1,021.3	2.1
All	2,436	3,388.3	1.4

Based on the outage index results of the comparisons among the four census regions, the PMT concluded that there are no major disparities in network reliability among the regions.

5.2.3 Average Outage Duration by Region

The last geographic and regional metric investigated by the PMT involved looking at outage duration experienced in each of the census regions. Table 16 provides the average outage duration. This table indicates that all four census regions experience roughly the same average duration, which range between 88.9 minutes in the South and 108.2 minutes in the Midwest. The observed differences are not statistically significant. Therefore, the PMT concludes that outage duration is similar for all census regions.

Table 16
Average Outage Duration by Region

Region	*Total No. of Outages*	*Sum of Outage Duration (Min.)*	*Average Outage Duration (Min.)*
Midwest	668	72,306	108.2
Northeast	327	32,900	100.6
South	951	84,562	88.9
West	490	44,147	90.1
All	2,436	233,915	96.0

5.2.4 Cumulative Outage Frequency by Region

Table 17 and Figure 6 show that the Midwest region starts out with a lower frequency of outages below 15 minutes, and the South region starts out with a higher frequency of outages below 15 minutes; that pattern continues till 120 minutes. These patterns are consistent with the results shown in Table 16.

Table 17
Cumulative Outage Frequency by Outage Duration for Each Region

Region	*% Outages Less Than*				
	15 Min.	*30 Min.*	*60 Min.*	*120 Min.*	*120+ Min.*
Midwest	25.6	35.3	56.7	73.8	100
Northeast	31.5	46.2	62.1	79.5	100
South	35.8	52.7	70.2	81.9	100
West	33.9	49.0	63.7	80.0	100
All	32.0	46.3	64.1	79.0	100

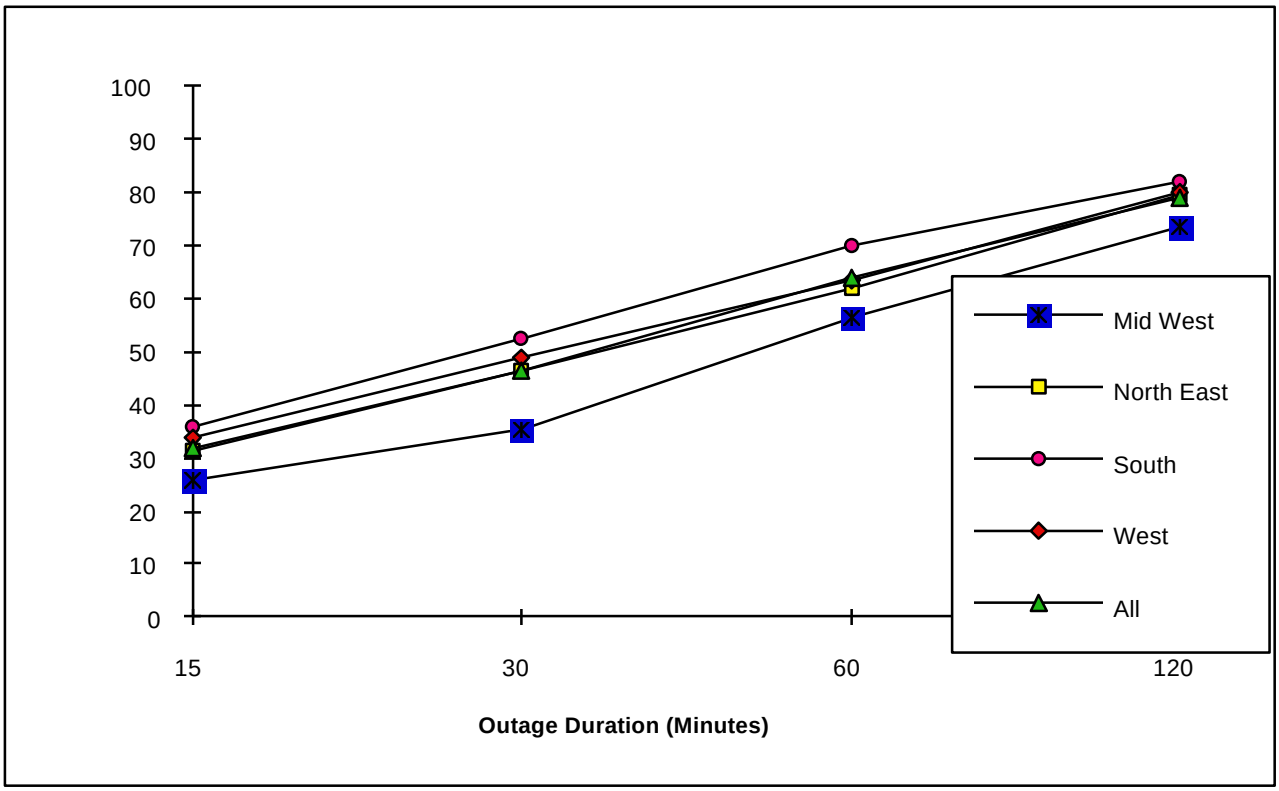

Figure 6
Cumulative Outage Frequency by Outage Duration for Each Region

5.2.5 Geographic and Regional Summary for Wireline LEC/IC Telecommunications Industry

Table 18 and Figure 7 summarize the key components of the census region comparisons. This table reinforces that there are only slight variations among the regions in the metrics investigated and none are considered important. Therefore, this table further illustrates that there is no large difference in network reliability experienced by people living in the four census regions.

Table 18
Outage Frequency, Average Index per Outage and Average Outage Duration for Each Region

Region	*No. of Outages/Switch (100)*	*No. of Outages/Person (M)*	*Average Index per Outage*	*Average Outage Duration (10 Min.)*
Midwest	11.2	11.4	0.8	10.8
Northeast	12.9	6.5	1.3	10.1
South	14.0	11.7	1.5	8.9
West	15.7	9.5	2.1	9.0
All	13.2	10.0	1.4	9.6

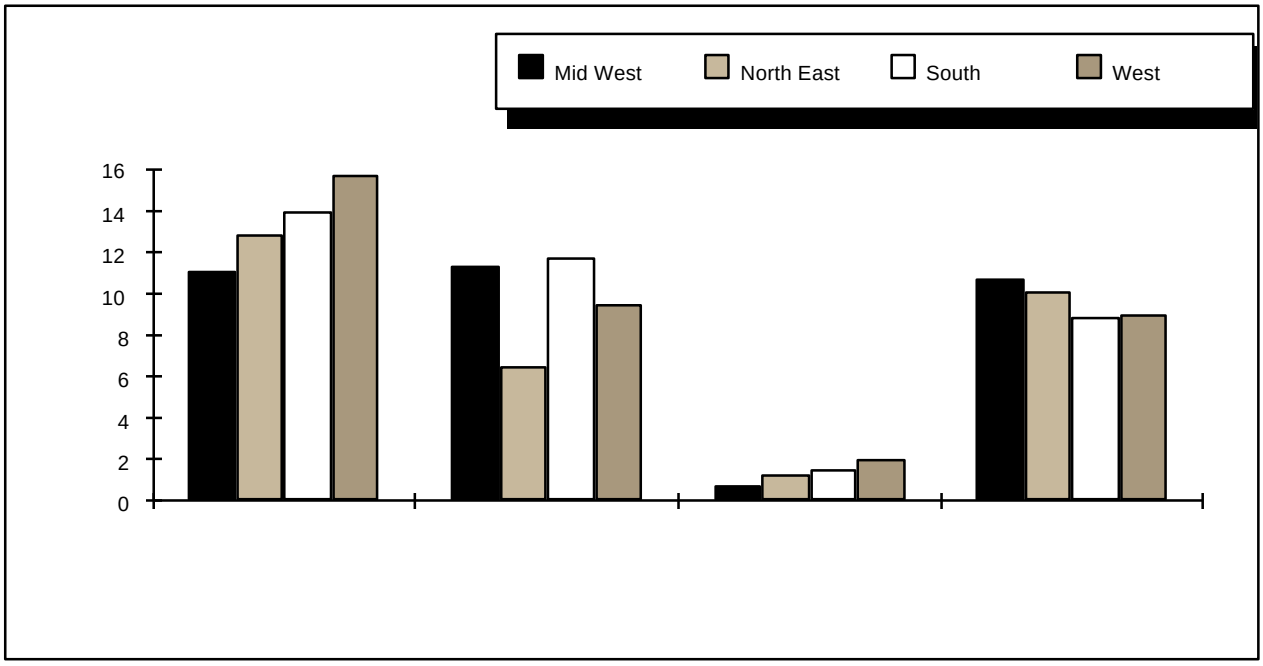

Figure 7
Outage Frequency, Average Index Per Outage, and Average Outage Duration for Each Region

5.3 Demographic Analysis of Wireline LEC/IC Telecommunications Outages by Cause Code

The PMT requested service providers to indicate the cause of each outage for each incident submitted in the data request. For this analysis, the outages were separated into switch-related outages and facility-based outages. Because the outage duration and outage index for facility outages are quite different from those for switch-related outages, the PMT decided to analyze these two types of outages separately. Below is a summary of the findings.

5.3.1 Breakdown of Switch-Related Outages by Cause Code

Table 19 provides a breakdown of switch-related outages by cause code. The data request contained a list of 17 cause codes. (See Data Requests in Appendix 4 for detailed definitions.) This table highlights cause codes that accounted for the majority of outages. The PMT's data indicates that Hardware failures (Code 8) and Software Design failures (Code 6) are major factors in switch-related outages, which is consistent with results that have been published in the Network Reliability Steering Committee (NRSC) Quarterly and Annual Reports. In addition, Procedural Error contributed to nearly 25 percent of the failures.

Table 19
Breakdown of Switch Related Outages by Cause Code

		% Switch Related Outages by Cause						
Population Category	*Total No. of Outages*	*Hardware Failure Code 8*	*Software Design Code 6*	*Proc. Error Inst/Mtce Code 2*	*Proc. Error Not Inst/Mtce Code 3*	*Proc. Error Syst Vendor Code 4*	*Other Codes*	*All Codes*
1	435	29.6	21.6	12.6	7.8	8.5	20.0	100
2	541	27.0	22.2	12.0	9.4	5.5	23.8	100
3	395	30.6	24.3	11.6	5.3	3.8	24.3	100
4	508	30.9	23.8	9.4	7.5	5.7	22.6	100
5	121	24.8	30.6	9.1	5.0	1.7	28.9	100
6	49	22.4	38.8	6.1	6.1	2.0	24.5	100
7	253	20.6	22.5	15.0	5.9	5.9	30.0	100
Total	2,302	28.1	23.6	11.6	7.3	5.6	23.9	100

5.3.2 Average Index Per Outage for Switch-Related Outages by Cause Code

As indicated above, Hardware and Software Design failures were the major contributors to switch-related outages. To further analyze this finding, the average outage index for each cause code was developed for each Population Category.

Table 20 shows that Procedural Errors result in higher average index per outage than Hardware or Software Design failures. From Table 20, it is also evident that causes classified as “Other Codes” include some large outage events that result in a higher average index per outage (1.2) than the overall average index per outage for all switch related outages (0.9).

The PMT conducted a supplemental analysis to identify the biggest contributors to the average index for “Other Codes”. Since Population Categories 1 - 3 are the important categories for the outage index, the cause codes that had an average index per outage above the the overall index for all cause codes were identified. In rank order, those cause codes were: Natural Disaster (Cause Code 9), Traffic Overload (Cause Code 10), and Hardware Design (Cause Code 7).

Table 20
Average Index Per Outage by Cause Code
for Switch-Related Outages by Population Category

Population Category	Average Index per Outage by Cause Code						
	Hardware Failure Code 8	*Software Design Code 6*	*Proc. Error Inst/Mtce Code 2*	*Proc. Error Not Inst/Mtce Code 3*	*Proc. Error Syst Vendor Code 4*	*Other Codes*	*All Codes*
1	0.7	2.4	3.6	5.0	7.8	3.8	3.0
2	0.3	0.7	1.5	0.5	0.4	1.5	0.8
3	0.3	0.4	0.4	0.3	0.0	1.3	0.6
4	0.0	0.0	0.0	0.2	0.0	0.0	0.0
5	0.1	0.0	0.0	0.0	0.4	0.2	0.1
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.3	0.6	1.2	1.2	2.3	1.2	0.9

5.3.3 Average Outage Duration for Switch Related Outages by Cause Code

Table 21 shows the average outage duration for each switch-related outage by cause code. The average outage duration is about the same for all switch-related cause codes that account for at least 5 percent of the outages. Further analysis of the causes classified as "Other Codes" was conducted to identify the major contributors to the large duration of outages in this category. In rank order, they were: Environmental (Cause Code 11), Natural Disaster (Cause Code 9), and Power Failure (Cause Code 12).

Table 21
Average Outage Duration by Cause Code for
Switch Related Outages by Population Category

Population Category	Total No. of Outages	Average Outage Duration (Min.) by Cause						
		Hardware Failure Code 8	*Software Design Code 6*	*Proc. Error Inst/Mtce Code 2*	*Proc. Error Not Inst/Mtce Code 3*	*Proc. Error Syst Vendor Code 4*	*Other Codes*	*All Codes*
1	435	80	91	65	100	125	105	91
2	541	68	60	63	71	45	137	81
3	395	72	47	56	33	48	120	73
4	508	70	52	73	61	42	158	84
5	121	66	42	25	106	23	134	76
6	49	187	43	62	32	7	66	81
7	253	78	35	103	63	43	108	78
Total	2,302	74	57	68	69	67	128	81

5.3.4 Breakdown of Facility Cut Outages by Population Category

Table 22 gives the number of outages, average outage duration, and average index per outage for facility cut outages. The average duration for facility outages is 327 minutes, which is 3 times longer than that for switch-related outages. Similarly, the average index per outage for facility cuts is 9.8, which is much longer than that for switch-related outages.

Table 22
Average Outage Duration and Average Index per Outage
for Facility Cut Outages by Population Category

Population Category	*No. of Outages*	*Avg Outage Duration (Min.)*	*Avg Index Per Outage*
1	32	483	18.9
2	35	293	12.5
3	30	295	3.7
4	23	261	4.8
5	2	137	0.5
6*	1	461	0.0
7	11	231	4.7
Total	134	327	9.8

* Small index (0.001) because it affected only 751 customers.

6. DATA ANALYSIS: WIRELESS CELLULAR PERSPECTIVE

This section presents an analysis of the impact that cellular outages have on the nation from a demographic perspective. In addition, this section examines outage data from a geographic and regional perspective. As discussed in Section 4, cellular service providers, representing approximately 50 percent of the industry, provided information on which the PMT could base its results and conclusions. The goal of the PMT was to investigate and report on the following metrics:

- For each national population category, a study was conducted to investigate, analyze, and compare the following:
    - Outage frequency per switch
    - Outage frequency per million people
    - Total outage index in each population category
    - Average outage index per incident
    - Average outage duration.
- For each of the four census regions, a study was conducted to investigate, analyze and compare the following:
    - Outage frequency per switch
    - Outage frequency per million people
    - Average index per outage
    - Average outage duration.
- For the outage incidents, a study was conducted to investigate the cause of outages in the following manner:
    - Breakdown of switch related outages
    - Average impact of switch related outages
    - Average duration of switch related outages.

6.1 Demographic Analysis of Cellular Outage Frequency, Outage Index, and Duration

The PMT grouped the equipment and outage data provided by the participating cellular carriers into the same seven population categories used to analyze data for the traditional wireline industry. As discussed in Section 4.5, none of the cellular carriers in the study had equipment in counties with populations below 15,000 (i.e., Population Categories 6 and 7). Population Category 1 accounted for about half of the equipment and outages. There were only 16 mobile switching centers and three outages in Population Categories 4 and 5. Therefore, the PMT combined Population Categories 2 through 5 into one group for further analysis. This is an expected result because the major population centers have the greatest demand for cellular services.

6.1.1 Outage Frequency by Population Category

Table 23 gives the cellular outage frequency per switch and per million total people. The number of outages per 10 switches is 7.2 in Category 1 and 4.1 in the remaining population categories. The total population per switch in Category 1 is about 4 times that of the other population categories.

Table 23
Cellular Outage Frequency per Switch and per Person by Population Category

Population Category	*No. of Counties*	*Total Population*	*Total No. of Switches*	*Total No. of Equivalent Access Lines*	*Total No. of Outages*	*No. of Outages/ Switch (10)*	*Total Population (100K)/ Switch*	*No. of Outages/ Person (M)*
1	53	66,339,116	102	6,894,257	73	7.2	6.5	1.1
2-5	104	19,886,617	132	1,983,455	54	4.1	1.5	2.7
Total	157	86,225,733	234	8,877,712	127	5.4	3.7	1.5

6.1.2 Average Index Per Outage by Population Category

Table 24 gives the average index per outage for Population Categories 1 and 2 through 5. The average index per outage for Population Category 1 is about 5 times that for Population Categories 2 through 5.

Table 24
Average Index per Cellular Outage by Population Category

Population Category	*Total No. of Outages*	*Total Outage Index*	*Average Index Per Outage*
1	73	611.8	8.4
2-5	54	90.8	1.7
Total	127	702.6	5.5

6.1.3 Average Outage Duration by Population Category

Table 25 shows the average outage duration for Population Categories 1 and 2 through 5. The average outage duration for Population Category 1 is slightly longer than that for the other population categories.

Table 25
Average Cellular Outage Duration
by Population Category

Population Category	*Total No. of Outages*	*Sum of Outage Duration (Min.)*	*Average Outage Duration (Min.)*
1	73	6,770	92.7
2-5	54	4,526	83.8
Total	127	11,296	88.9

6.1.4 Demographic Summary

Table 26 and Figure 8 summarize the comparisons of outage frequency, outage duration, and outage index by population category for the wireless cellular segment. For all three metrics, the PMT observed that the outage rate in Population Category 1 is somewhat higher than that for Population Categories 2 through 5.

Table 26
Cellular Outage Frequency, Average Index Per Outage, and Average Outage Duration by Population Category

Population Category	*No. of Outages/ Switch (10)*	*No. of Outages/ Person (M)*	*Average Index per Outage*	*Average Outage Duration (Min.)*
1	7.2	1.1	8.4	93
2-5	4.1	2.7	1.7	84
Total	5.4	1.5	5.5	89

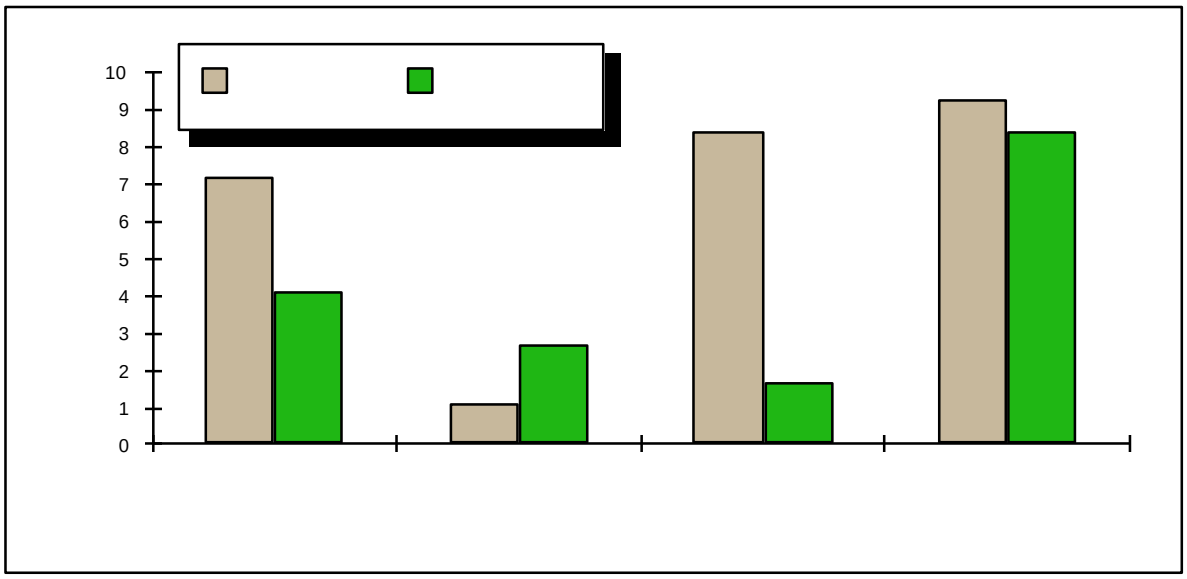

Figure 8
Cellular Outage Frequency, Average Index Per Outage, and Average Outage Duration by Population Category

6.2 Geographic and Regional Analysis of Cellular Outage Frequency, Outage Index, and Average Outage Duration

Table 27 andFigure 9 give the cellular outage frequency, average index per outage, and average outage duration for the four census regions. The outage frequency per switch is about the same across the four regions. The average index per outage is below the national average for the Midwest and South regions and above average for the Northeast and West regions. The average outage duration is higher for the West Region than for the other three regions. Note that the West region has a smaller fraction of shorter outages (and a larger fraction of longer outages)

than the other three regions. Because the average outage duration could be affected by a few outliers, it was decided to also compute the median outage durations. The median outage duration is 60 minutes for the West region and 27 to 45 minutes for the other regions.

Table 27
Cellular Outage Frequency, Average Index per Outage, and Average Outage Duration by Region

Region	*No. of Outages/ Switch (10)*	*No. of Outages/ Person (M)*	*Average Index per Outage*	*Average Outage Duration (Min.)*	*Median Outage Duration (Min.)*
Midwest	6.7	1.7	3.0	53	27
Northeast	5.9	1.6	7.7	72	44
South	5.4	1.6	3.6	83	45
West	4.4	1.1	9.4	146	60
All	5.4	1.5	5.5	89	45

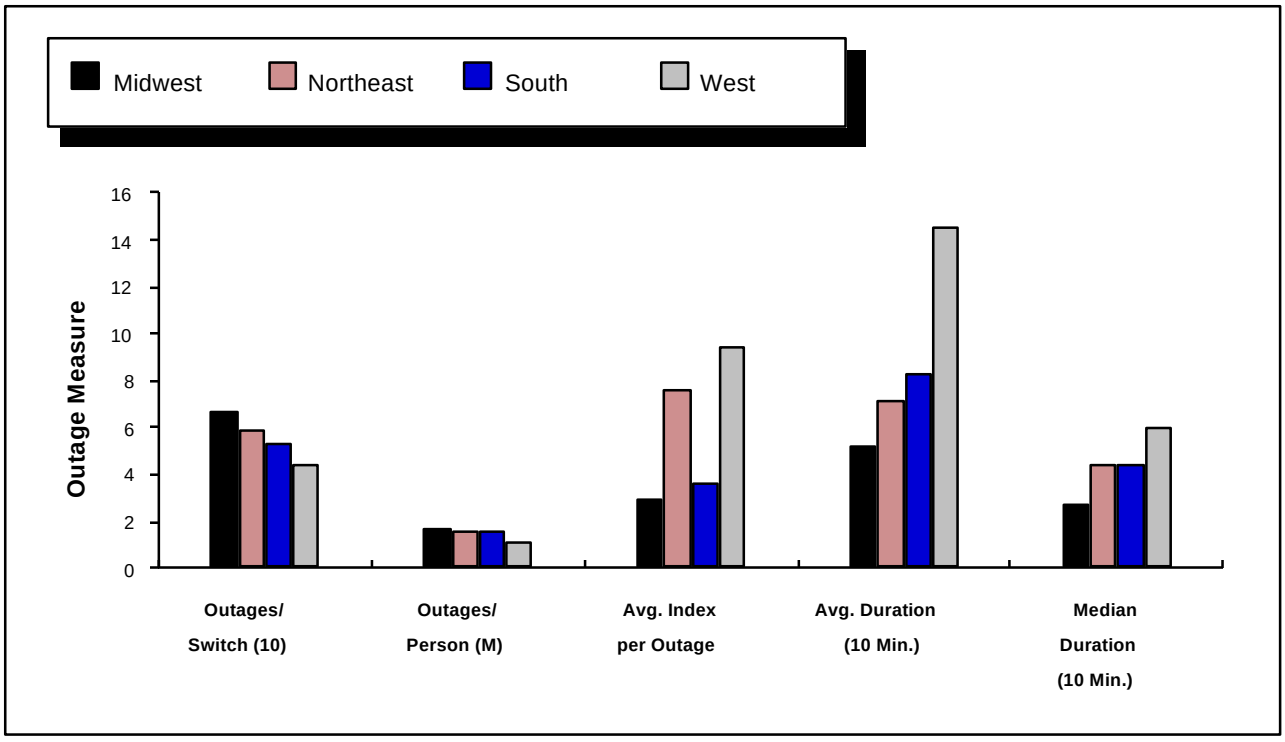

Figure 9
Cellular Outage Frequency, Average Index per Outage, and Average Outage Duration for Each Region

6.3 National Analysis of Cellular Outages by Cause Code

Table 28 and Figure 10 give the cellular outage frequency, average index per outage, and average outage duration by cause code. Software Design (Code 6), Hardware Failure (Code 8), and Procedural Error - System Vendor (Code 4) are the predominant causes of cellular carrier failure. The average outage duration for Software is about twice that for the other two predominant causes. The outage cause was not specified for 35 percent of the cellular outages, and 24 percent of the outages had other causes.

Table 28
Cellular Outage Frequency, Average Index per Outage, and Average Outage Duration by Outage Cause

Outage Cause	*No. of Outages*	*Average Index Per Outage*	*Average Outage Duration (Min.)*
Software Design (Code 6)	27	8.7	114
Hardware Failure (Code 8)	15	5.1	70
Proc. Error - System vendor (Code 4)	10	3.7	46
Other	31	2.4	93
Unreported	44	6.5	87
All	127	5.5	89

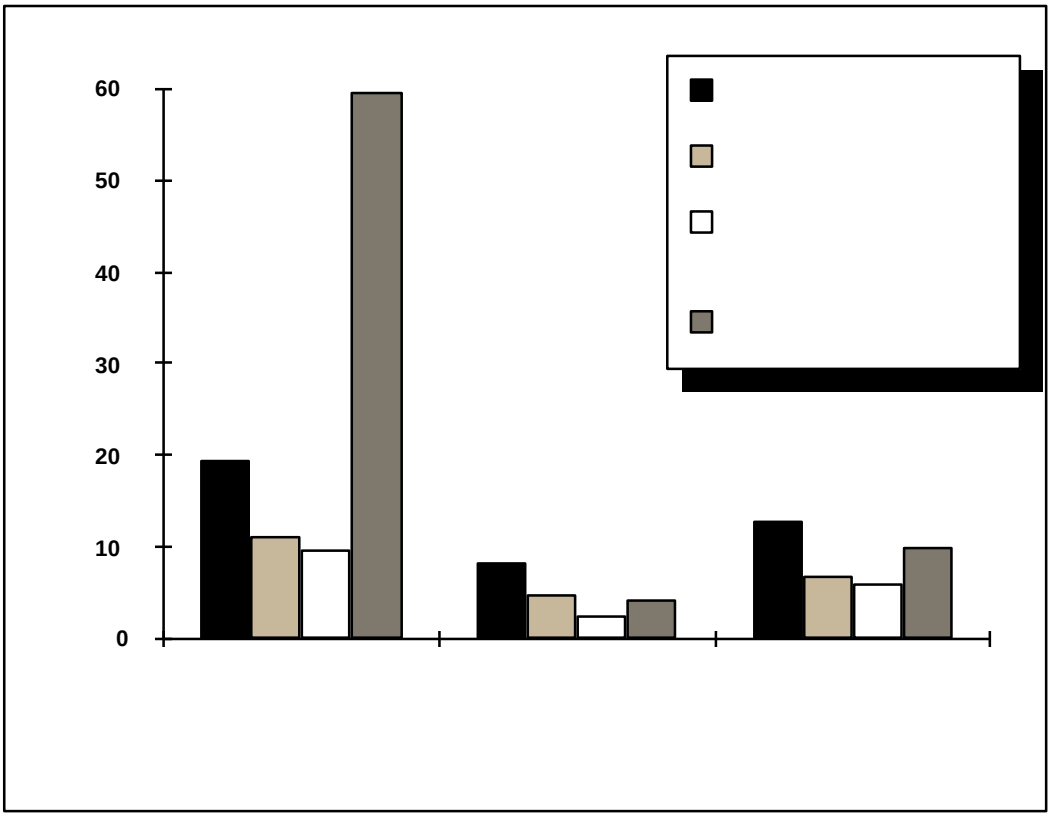

Figure 10
Cellular Outage Frequency, Average Index Per Outage, and Average Outage Duration by Outage Cause

7. RESULTS OF OTHER INDUSTRY SEGMENTS

No quantitative analysis was conducted on the CATV and satellite industry segments because of incomplete or unavailable data. The lack of available, usable data from these two segments may be partly because they are relatively new entrants to the telecommunications business and have not yet established standard field outage data collection procedures.

7.1 CATV Perspective

Because the CATV companies did not provide any individual company outage or equipment location data, no demographic or geographic analysis could be completed. Instead, the National Cable Television Association (NCTA) provided a summary of CATV headend outages affecting 30,000 or more subscribers. Table 29 is a limited regional summary based on those NCTA-provided data.

Table 29
Frequency and Duration of Cable Outages by Region

Region	*No. of Outages*	*Duration in Minutes*		*Median No. of Subscribers Affected*
		Average	*Median*	
Northeast	3	37	40	57,107
Midwest	13	50	35	52,000
South	13	51	41	49,000
West	32	82	42	65,462
All	51	55	39.5	55,892

7.2 Satellite Perspective

Although several designated satellite companies did provide equipment location and outage data, the data lacked completeness regarding the extent of the outages. Consequently, the data was not usable for this study.

8. SUMMARY AND CONCLUSIONS

8.1 Wireline LEC/IC Telecommunications Industry

The analyses conducted on the data provided by the LECs and ICs indicate that there are little or no differences in network reliability from a demographic and geographic perspective. The excellent response rate to the data request from these industry segments provided the PMT with a strong basis from which to draw the wireline conclusions summarized below.

- The results of the wireline LEC/IC demographic analysis indicate:
  - The outage frequency per switch is about the same for all population categories regardless of the population size of the category.
  - The outage index consistently decreases as one progresses from larger to smaller population categories.
  - The outage duration is similar for Population Categories 2 through 7.
  - The largest population category has longer outages than the other categories primarily because of facility outages.
- The results of the wireline LEC/IC geographic and regional analysis indicate:
  - There are no major disparities in network reliability among the four census regions based on the outage index results.
  - The outage frequency per switch is about the same for all four census regions.
  - The outage duration is similar for all census regions.
  - There is no significant difference in network reliability experienced by people living in the four census regions.
- The results of the analysis on the causes of wireline outages indicate:
  - The major causes of switch-related outages are Hardware failures (Code 8) and Software Design failures (Code 6). In addition, Procedural Errors are cited as high contributors.
  - The outage duration and outage index for facility-related outages is higher for Population Category 1 than the other population categories.

8.2 Wireless Cellular Summary

The data provided by the wireless cellular segment was not as robust as that for the LEC/IC segment. Therefore, the PMT recommends that the findings stated below be considered as preliminary, and should not be viewed as cause for concern. However, the findings do suggest that there should be increased attention given to switch failure root cause analysis. In addition, there should be increased supplier focus on software reliability.

- The results of the wireless cellular demographic analysis indicate:

- The outage frequency per switch is slightly higher in Population Category 1 than Categories 2 through 5.
- The average index per outage for Population Category 1 is about 5 times that for Population Categories 2 through 5.
- The average outage duration for Population Category 1 is slightly longer than that for the other population categories.

• The results of the wireless cellular geographic and regional analysis indicate:

- The outage frequency per switch is about the same across the four census regions.
- The average outage duration is higher for the West region than for the other three census regions. For example, the median outage duration is 80 minutes for the West region and 35 minutes for the other three regions.

8.3 Other Industry Segments Summary

No analysis was performed on the CATV and satellite industry segments because of unavailable or incomplete data. Consequently, no conclusions can be drawn at present regarding these two segments.

Providers in these and other new industry segments seeking to provide telecommunications services are encouraged to review the recommendations of the Outage Reporting and Customer Notification Team regarding the establishment of formal field outage data collection, root cause analysis, and information sharing processes.

8.4 Conclusions and Recommendations

This study fulfills the task set forth in the FCC's revised charter for NRC II to evaluate the reliability of network services on a local and regional basis, and to determine the extent to which network outages have disproportionate demographic or geographic impacts.

Based on the completed study work for the wireline LEC/IC network, the PMT concludes that there are little or no demographic and geographic network reliability differences. The PMT encourages the wireline carriers to sustain their data collection and root cause analysis efforts. The PMT also endorses the efforts underway by the Network Reliability Steering Committee (NRSC) Facility Solutions Team, and supports the team's efforts to provide periodic readouts to the industry regarding recommendations to minimize the effect of fiber-related outages.

With regard to the wireless cellular networks, the PMT considers the study results to be preliminary, and encourages cellular providers to continue their focus on performing root cause analysis on switch-related outages, and to increase their attention on software reliability. As for the CATV and satellite industry segments, no analysis was completed because of unavailable or incomplete data; therefore, the PMT is unable to draw any network reliability conclusions for these segments. The PMT, however, does encourage providers in these and other industry segments seeking to provide telecommunications services to review and implement (where applicable) the recommendations of the Outage Reporting and Customer Notification Team.

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Appendices