Network Reliability Steering Committee

Annual Report 2000

Network Reliability
Steering Committee

Sponsored by the Alliance for
Telecommunications Industry
Solutions

To the Telecommunications Industry:

This Annual Report reviews the health of the wireline telecommunications networks for the year 2000, as well as trends observed over the last eight years of outage reporting to the FCC. It was a dynamic year in the industry and in the NRSC as well. However, our commitment to the reliability of service to the American public was sustained.

Through his years of service and dedication, Ray Albers, former NRSC Chair, has exemplified this commitment. I would like to take this opportunity to thank Ray, on behalf of the NRSC and the industry.

In considering the extent of the data that has been collected and analyzed over the last eight years, the NRSC has endeavored to make its analysis more useful to the industry in improving network reliability. These changes include expansion of the baseline level for control limits to cumulative data from January 1, 1993 through December 31, 1999, and making the annual report period cover a calendar year.

During the past year the frequency of outages and the outage index, a measure of impact on customers, were above the baseline level, although they remain within the "green" area of the control charts. These results are consistent with those observed in recent years, and demonstrate continued overall reliability of telecommunications networks and services. However, analysis within failure categories shows some atypical results. Central Office (CO) Power and Tandem Switch had the highest ever outage frequency, and Common Channel Signaling (CCS) was at its highest level since 1993, and Digital Cross-connect Systems (DCS) was above its baseline level for a fourth consecutive year. At the same time, the two categories that have historically accounted for more than 60% of all outages—Facility and Local Switch—each recorded their second lowest outage frequency ever.

Analysis of outage data over the course of the eight-year data history shows that total outage frequency is increasing at a rate of 2.2% per year, which still less than the annual growth of the network in lines or calls. It should be noted that within failure categories, the outage frequency rate of increase for CO Power is 14% per year, DCS is 21% per year, and CCS is 11% per year. Also, the frequency of outages with a Procedural Error as a root cause is increasing at a rate of 8% per year.

In the previous Annual Report, it was noted that a large, and unfortunately increasing, number of incidents reported each year can be traced to a failure to apply best practices. I want to reinforce this message, and encourage all service providers and vendors to review the best practices documents available on the NRSC web site ("Fixing Facilities Damages", "Procedural Outage Reduction Report", and "NRIC IV Analysis and Recommendations on Best Practices"). The URL is http://www.atis.org/atis/nrsc/nrschome.htm .

Looking to the future, the challenges of ensuring the reliability of public telecommunications networks seem sure to increase. It is only though our continued effort and cooperation that we will be able to meet these challenges. I look forward to working on this collaborative effort with the dedicated industry, consumer, and government representatives that make up the NRSC.

PJ Aduskevicz
Chair

TABLE OF CONTENTS

INTRODUCTION

This report provides an analysis of U.S. telecommunications network performance based on outage reports to the FCC made by service providers from January 1, 1993 through December 31, 2000. While service providers are required to make such reports for outages meeting various criteria, the vast majority of reports are made for outages that potentially affect 30,000 or more customers for 30 minutes or more. The analysis presented herein is primarily focused on those outages reported on the basis of these 30,000 customer/30 minute thresholds. A discussion of other reportable incidents is included in a section on "Special Outages."

The Network Reliability Steering Committee (NRSC) was established under the auspices of the Alliance for Telecommunications Industry Solutions (ATIS) to monitor network reliability utilizing major outage reports filed with the Federal Communications Commission (FCC) pursuant to Part 63.100 of the FCC Rules. The NRSC's mission is to analyze network outage data reported by companies, to identify trends, make recommendations aimed at improving network reliability, and make the results publicly available, and where applicable refer matters to other industry fora for further action.

During 2000 members of the NRSC included:

Association for Local Telecommunications Services (ALTS)
AT&T
BellSouth
Cellular Telecommunications and Internet Association (CTIA)
Consumer Representative
International Communications Association (ICA)
Lucent Technologies
National Association of Regulatory Utility Commissioners (NARUC)
National Communications System (NCS)
Nortel Networks
Qwest
Siemens ICN
SBC
Telcordia Technologies
United States Telecom Association (USTA)
Verizon

Other organizations participating in the NRSC and its various sub-committees included:

Associated General Contractors of America (AGC)
Dow Chemical
Federal Communications Commission (FCC)
Motorola
National Utility Locating Contractors Association (NULCA)
So-Deep Inc.
Union Pacific Railroad
United States Department of Transportation (USDOT)

MAJOR FINDINGS

- Outage frequency is increasing at a rate of 2.2% per year, still less than the annual growth of the network in lines or calls.

- The frequency of CO Power outages was greater in 2000 than in any prior year and is increasing at the rate of 14% per year. The annual aggregated outage index of CO Power outages has been higher on average since 1997.

- The frequency of Tandem Switch outages was greater in 2000 than in any prior year and significantly higher than its baseline level. The annual aggregated outage index of Tandem Switch outages has been higher on average since 1997.

- The frequency of CCS outages was significantly higher in 2000 than its baseline level and is increasing at the rate of 11% per year. The annual aggregated outage index for CCS outages was greater than in any prior year.

- Since 1994, DCS outage frequency is increasing at a rate of 21% per year. The annual aggregated outage index of DCS outages has been higher on average since 1997.

- The number of outages with a Procedural Error as root cause was significantly higher than its baseline level and matched its highest annual total to date. The frequency of outages with a Procedural Error as a root cause are increasing at a rate of 8% per year.

- The annual aggregated outage index for Facility outages was lower than in any prior year and significantly lower than its baseline level. The Facility category had its lowest annual share of outages (34%) and of aggregated outage index (29%) to date.

- Outages had the lowest annual median duration to date, indicative of more relatively shorter duration outages in 2000 than in the past.

BACKGROUND

THE NETWORK RELIABILITY (AND INTEROPERABILITY) COUNCILS

Following the major network disruptions of 1991, the Network Reliability Council (NRC) was established by the FCC to bring together leaders of the telecommunications industry and experts from academia and consumer groups to explore and recommend measures that would enhance network reliability. At the end of its term in June 1993, the original NRC published *"Network Reliability: A Report to the Nation,"* a compendium of technical papers prepared by the various NRC Focus Groups. This compendium became known as the "Purple Book" and the recommendations therein became known as "Best Practices." The NRC encouraged the industry to study and assess the applicability of these recommendations for implementation in their companies. It was at the request of the NRC that ATIS established the NRSC in May 1993.

In April 1996, the second NRC published another compendium of technical papers, *"Network Reliability: The Path Forward."* This report was prepared in response to the question "How do we continue to keep the public switched network reliable and, at the same time, accomplish increased interconnection, and introduce major new technologies into the network?" The first of these papers was prepared by a group composed of the NRSC and augmented by participants from cellular, cable, and satellite service providers.

In July 1997, the third NRC (now renamed the Network Reliability and Interoperability Council (NRIC)) produced a report on implementing Section 256 of the Telecommunications Act of 1996. Section 256 has as its fundamental purpose the promotion of additional competition, innovation, and deregulation in telecommunications. The report entitled *"Network Interoperability: The Key to Competition"* presents findings and recommendations related to network connectivity and planning oversight, and the FCC's role in the standards setting process.

In October 1998 NRIC-IV was launched. The primary role of this effort was to provide advice to the FCC on Year 2000 issues affecting telecommunications. However, other national network reliability issues were also addressed. The first of these was to report on the reliability of public telecommunications network services in the United States; the second was to determine whether "Best Practices" previously recommended should be modified or supplemented; and the third was to develop a proposal to extend these best practices to other industry segments not presently included in the current practices. The results of these efforts may be found on the NRSC web page at www.atis.org/atis/nricgr3.htm.

The fifth Council began in March 2000. In the area of Network Reliability the Council will continue to evaluate and report on the reliability of public telecommunications network services in the United States, including the reliability of packet switched networks. The Council will also evaluate existing outage reporting requirements and make recommendations for improving, or initiating, reporting requirements for both those carriers currently required to report outages and those not currently required to report service outages. In addition, the Council will continue to develop Best Practices recommendations and refine or modify, as appropriate, Best Practices recommendations developed by previous Councils, and continue to evaluate and report on the extent to which telecommunications common carriers are using best practice recommendations.

THE NRSC FACILITIES SOLUTION TEAM

In the first years after the formation of the NRSC, the frequency and impact of facility outages grew at an alarming rate. In response to this growth, the Facilities Solution Team was chartered in January 1995 to determine the major causes of facility outages and recommend ways to reduce their number and impact.

The Facilities Solution Team (FST) focused its efforts in three areas:

- Analysis of facility related network outages reported to the FCC
    - FST analyses are used to influence regulatory agencies and ultimately to reduce damages to facilities.
    - FST analyses were a key ingredient in getting Federal One-Call legislation passed in June of 1998
- Provision of input to cross industry groups aimed at facility damage prevention
    - The FST was represented on the Steering Team and on the Linking Team that directed the Office of Pipeline Safety's Common Ground study.
- Development and evolution of best practices. Best practices developed by the FST are contained in the following documents;
    - *Keeping the Network Alive and Well: Solving the Problem of Cable Dig-Ups*, February 1996
    - *Fixing Facility Outages: Building the Tools to Make it Happen*, November 1997
    - *Fixing Facility Damages: Sharpening the Focus on Prevention*, December 2000
    - *Model State One-Call Bill*, December 2000

At the end of 2000, with Federal One-Call Legislation in effect, an umbrella organization representing all parties involved in underground activities in place (i.e., Common Ground Alliance), model state one-call legislation available for use, numerous best practices developed and published to reduce the number and impact of facility outages, and with representatives of the NRSC/FST participating in the ongoing work of the NTDPC, the FST was disbanded by the NRSC.

STATE OF THE NETWORK

The network performance described below is based on an analysis of network outages reported to the FCC that impact 30,000 or more customers for 30 minutes or longer. The analysis compares network outage data from January 1, 1993 through December 31, 2000. Cumulative data from January 1, 1993 through December 31, 1999 are used as a baseline for control limits. The average value for a metric is referred to as the metric's *baseline level*. The years 1993 through 1999 are referred to as the *Baseline Years*.

In general, network performance remained within control limits in 2000. However, 2000 saw departures from these limits in several areas. In particular,

- The number of Tandem Switch outages was greater in 2000 than in any prior year and significantly higher than its baseline level.
- The number of CCS outages was significantly higher than its baseline level.
- The number of outages with a Procedural Error as root cause was significantly higher than its baseline level and matched its highest annual total to date.
- The annual aggregated outage index for Facility outages was lower than in any prior year and significantly lower than its baseline level.

Network performance areas in 2000 that remained within control limits but are still noteworthy include:

- The number of CO Power outages was greater in 2000 than in any prior year.
- The annual aggregated outage index for Local Switch outages was lower than in any prior year.
- The annual aggregated outage index for CCS outages was greater than in any prior year.
- The Facility category had its lowest annual share of outages (34%) and of aggregated outage index (29%) to date.
- Outages had the lowest annual median duration to date, indicative of more relatively shorter duration outages in 2000 than in the past.

Several trends are noted over the course of the eight-year data history:

- Outage frequency is increasing at a rate of 2.2% per year, still less than the annual growth of the network in lines or calls.
- CO Power outage frequency is increasing at a rate of 14% per year.
- The frequency of outages with a Procedural Error as a root cause is increasing at a rate of 8% per year.
- Since 1994, DCS outage frequency is increasing at a rate of 21% per year.
- Since 1994, CCS outage frequency is increasing at a rate of 11% per year.
- The annual aggregated outage index of DCS outages has been higher on average since 1997.
- The annual aggregated outage index of CO Power outages has been higher on average since 1998.
- The annual aggregated outage index of Tandem Switch outages has been higher on average since 1998.

Unless specified otherwise, all statistical tests in these analyses were performed at the 0.05 level of significance. This means that statements of the form "A is statistically significant" imply that less than a 5% chance exists that A is not true.

Control charts in this section are coded to indicate whether the network is "under control." The control charts measure outages occurring in a particular quarter against normal variation in the Baseline Years. 95% and 99% tolerance limits are used for the control ranges. Values in the "Green" region (below the upper 95% tolerance limit) are "under control." Values in the "Yellow" region (between the upper 95% and 99% tolerance limits) require very close scrutiny. Values in the "Red" region (above the 99% tolerance limit) should trigger immediate investigative action by the NRSC.

PERFORMANCE BY OUTAGE FREQUENCY

Annual outage frequencies are shown in **Figure 1**. The baseline level for annual outage frequency is 171.7. While the outage frequency in 2000 was above this level, it remained in the "Green". This was the fifth consecutive year above the baseline level.

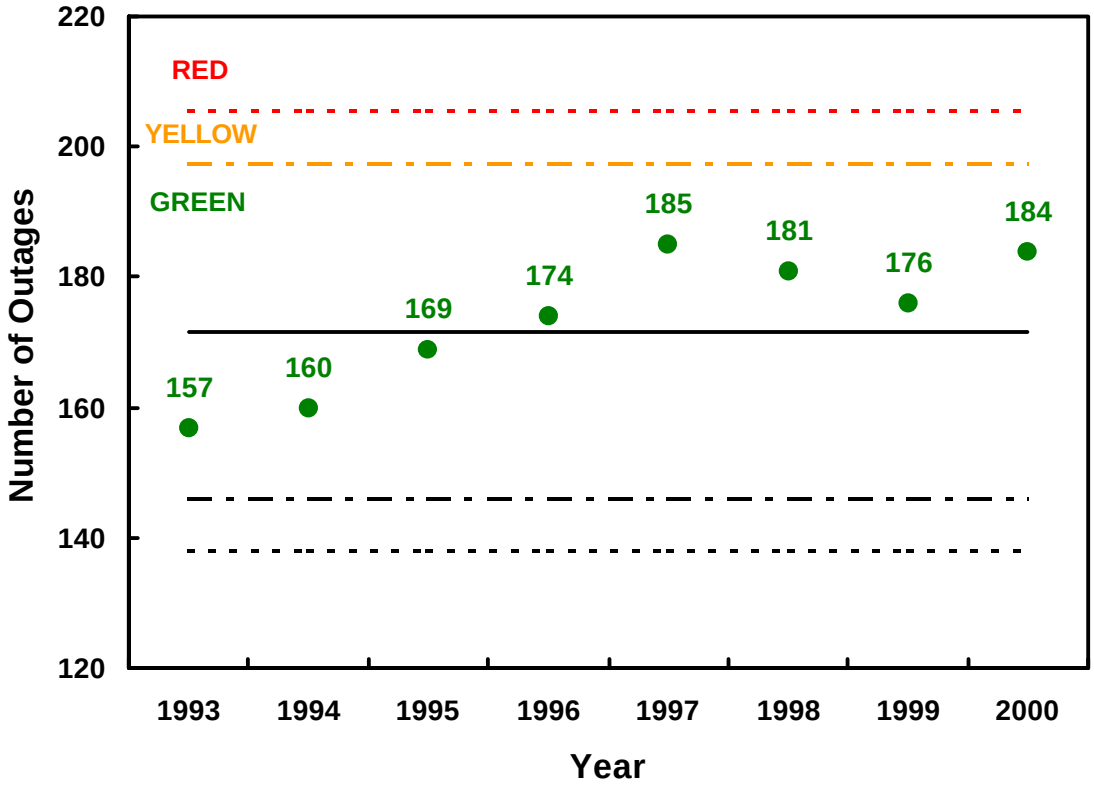


Figure 1: Outage Report Annual Frequency Control Chart

Figure 2 is a control chart for outage frequency by quarter. The number of outages in each quarter of 2000 were within the acceptable range of this control chart. A fit to these data indicates a statistically significant increasing trend in outage frequency over time (2.2% annually). Outage frequency has been highest in the third quarter (48.25 outages per quarter on average) while the other three quarters have about 42 outages on average. However, these differences in seasonal outage frequency are not statistically significant.

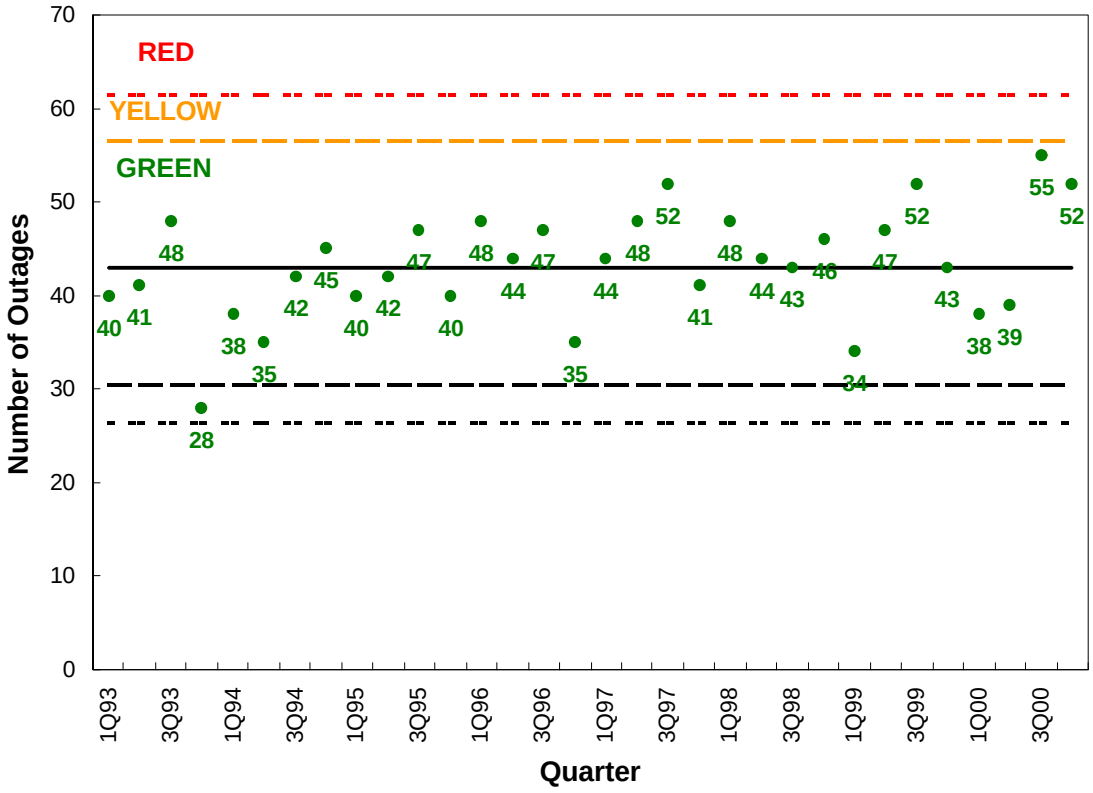


Figure 2: Outage Report Quarterly Frequency Control Chart

Figure 3 provides the distribution of outage frequency by outage category: Conclusions based on these data are:

- *Facility*
  The frequency of Facility outages dropped in 2000 to the lowest level since 1993. Facility outages do not have a statistically significant trend and display no significant seasonality effects. Facility outage frequencies in 2000 (63) and over all years (77 outages per year) are significantly higher than in any other category.
- *Common Channel Signaling (CCS)*
  In 2000, CCS outage frequency reached its highest level (30) since 1993 and it was significantly higher than the baseline level. Since 1994, CCS outage frequency has demonstrated a statistically significant increase of 11.1% per year.
- *Local Switch*
  In 2000, Local Switch outages had their lowest frequency (22) since 1995. Nonetheless, Local Switch outage frequencies over all years (28.5 outages per year) remain significantly higher than in any other category (apart from Facility).
- *Tandem Switch*
  In 2000, Tandem Switch outage frequency reached its highest level to date (31), almost 50% higher than any previous year and significantly higher than the baseline level.

- *Central Office (CO) Power*
  In 2000, CO Power outage frequency reached its highest annual level (22 outages) to date. This was the fourth consecutive year that CO Power outage frequency was above the baseline year level. CO Power outage frequency demonstrates a statistically significant trend (14.3% increase per year) and seasonality (63% of outages occur in the warmer half of the year).
- *Digital Cross-connect System (DCS)*
  In 2000, DCS outage frequency was above the baseline level for the fourth consecutive year. DCS outages exhibit a statistically significant upward trend in their frequency (21.4% per year) since 1994.

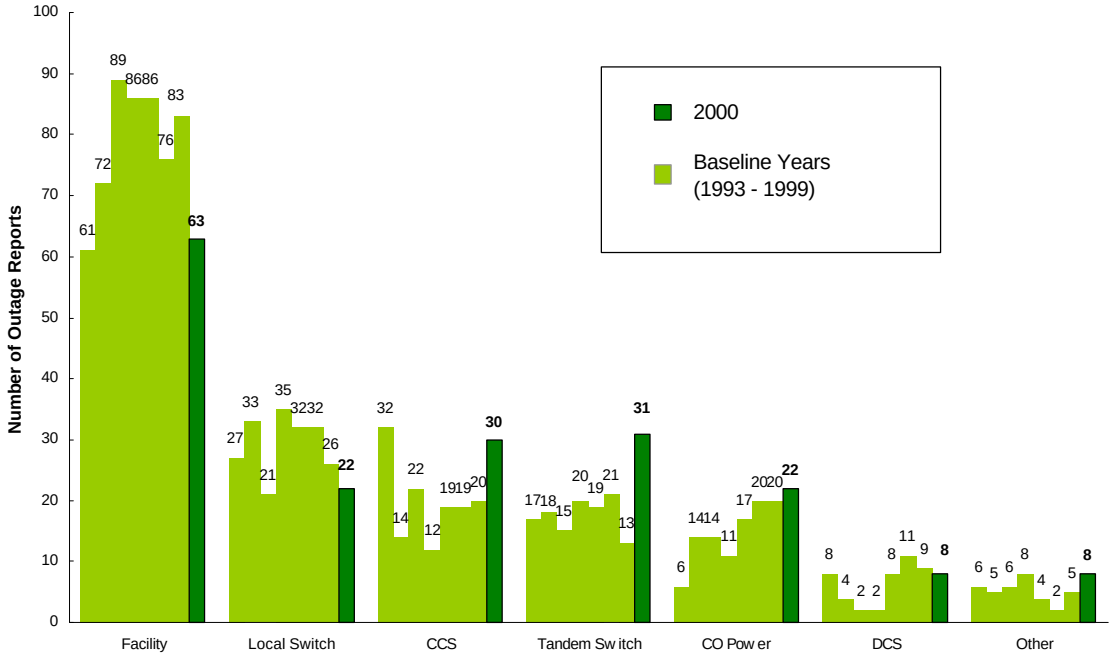


Figure 3: Number Of Outage Reports By Failure Category

PERFORMANCE BY OUTAGE DURATION

Table 1 provides a summary of the distribution of outage duration for the eight years of reporting. A percentile indicates what percent of the outages have duration less than that value. For example, 90% of FCC-reportable outages in 2000 had durations less than 12.79 hours. Percentiles of the outage distribution are used because statistics like the mean outage duration are severely altered by one or two very long outages. Outages in 2000 had the lowest median duration (2.23 hours) to date. However, several very long outages (including one with a duration of 720 hours) also produced the highest mean duration of outages (8.53 hours) to date.

Table 1: Outage Durations (Hours)

Year	Median	Mean	90th %ile
1993	2.58	4.67	10.61
1994	2.50	4.28	11.08
1995	3.72	8.52	14.00
1996	2.93	6.00	9.83
1997	3.38	4.74	9.87
1998	2.98	5.88	10.69
1999	2.62	5.52	8.61
2000	2.23	8.53	12.79
Baseline	2.92	5.67	10.65

Additional analyses of duration by failure category as shown in **Table 2** give the following results:

- Facility outages have a statistically significant longer median duration than other types of outages.
- Other, CO Power, DCS, and Tandem Switch outages have statistically significant longer median durations than CCS and Local Switch outages.

Table 2: Outage Duration (Hours) By Failure Category

Failure Category	# of Outages	Median	Mean	90th %ile
Facility	616	4.91	7.44	13.32
Other	44	3.30	11.59	16.62
Tandem Switch	154	2.41	10.74	11.48
DCS	52	2.38	3.47	7.03
CO Power	124	2.37	4.14	8.85
CCS	168	1.26	2.20	5.71
Local Switch	228	1.26	2.50	4.34
Overall	1386	2.87	6.05	10.77

PERFORMANCE BY CUSTOMERS POTENTIALLY AFFECTED

Table 3 depicts the major statistics for the number of customers potentially affected per outage for each year from 1993 to 2000. The median describes the number of customers potentially affected in a typical outage. The 90th percentile measures the number of customers affected for a relatively large outage (an outage bigger than 90% of all outages). The table shows that the size of outages increased in 2000 over 1999 and was close to baseline levels. The number of customers potentially affected does not demonstrate a statistically significant trend over time.

Table 3: Number Of Customers Potentially Affected

Year	Median	Mean	90th %ile
1993	52,100	167,100	450,500
1994	53,100	132,100	252,100
1995	58,100	94,000	205,000
1996	57,600	102,300	194,000
1997	56,000	109,600	215,100
1998	57,200	160,300	263,400
1999	53,700	123,200	196,300
2000	55,800	132,900	250,500
Baseline	56,000	126,900	230,300

Additional analyses of duration by failure category as shown in **Table 4** give the following results:

- DCS and Tandem Switch outages potentially affected significantly higher numbers of customers than CO Power, CCS, and Local Switch outages. Tandem Switch outages also potentially affected significantly higher numbers of customers than Facility outages.
- Local Switch outages potentially affect significantly less customers than outages in all other categories.

Table 4: Number Of Customers Potentially Affected (By Failure Category)

Failure Category	# of Outages	Median	Mean	90th%ile
DCS	52	76,900	305,700	682,900
Tandem Switch	133	75,000	204,000	502,100
Facility	576	64,700	106,300	195,800
Other	41	54,600	185,200	580,000
CO Power	121	52,500	156,700	363,300
CCS	158	48,100	131,800	139,500
Local Switch	228	45,000	68,300	93,600
Overall	1309	56,000	127,700	231,000

PERFORMANCE BY OUTAGE INDEX

Committee T1 Report No. 42 defined an outage index created by Working Group T1A1.2 to provide a single measure that describes the overall severity of a single outage or collection of outages. The index combines the duration of the outage, the number of customers affected, and the services affected into one single measure. Also, the outage indexes of a collection of outages can be summed to provide a measure of the collection's severity.

In this report, *outage index* will be used for the severity of an individual outage. *Aggregated outage index* will be used for the severity of a collection of outages. The outage index is calculated using the following data items:

- Outage duration
- Customers potentially affected
- Date and time that the outage started
- Services affected (i.e., intraoffice, interoffice intraLATA, interoffice intraLATA, 911).

The outage index is a quantitative scale measuring outage impact. A higher number indicates a more severe outage (e.g., an outage with an index of 8 is twice as bad as one with an index of 4). To obtain a feeling for the index, note the following:

- The maximum possible index for an outage is 333.33.
- An outage of a Local Switch with 30,000 lines in which all services (intraLATA intraoffice, intraLATA interoffice, interLATA interoffice, and 911) are lost for 30 minutes during daytime hours of a weekday has an outage index of 1.92.
- A Tandem Switch outage that blocks 90,000 interLATA interoffice calls over a period of 30 minutes has an outage index of 0.48.
- A Facility outage that blocks 220,000 intraLATA interoffice and interLATA interoffice calls over a period of 5.5 hours has an outage index of 6.06.

AGGREGATED OUTAGE INDEX DISTRIBUTIONS

Annual aggregated outage indexes are given in **Figure 4**. The baseline level for annual aggregated outage index is 1587. The aggregated outage index in 2000 was slightly below this level. This decrease is not statistically significant.

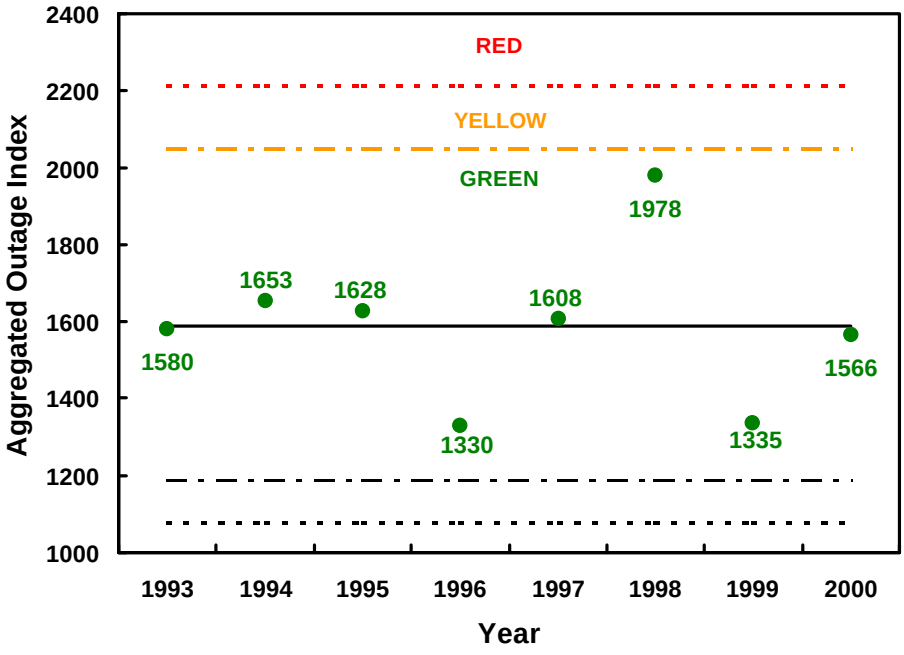


Figure 4: Annual Aggregated Outage Index Control Chart

Figure 5 provides a control chart of the quarterly aggregated outage index from 1993 to 2000. The baseline level for the annual aggregated outage index is 1587. All four quarters of 2000 were within control.

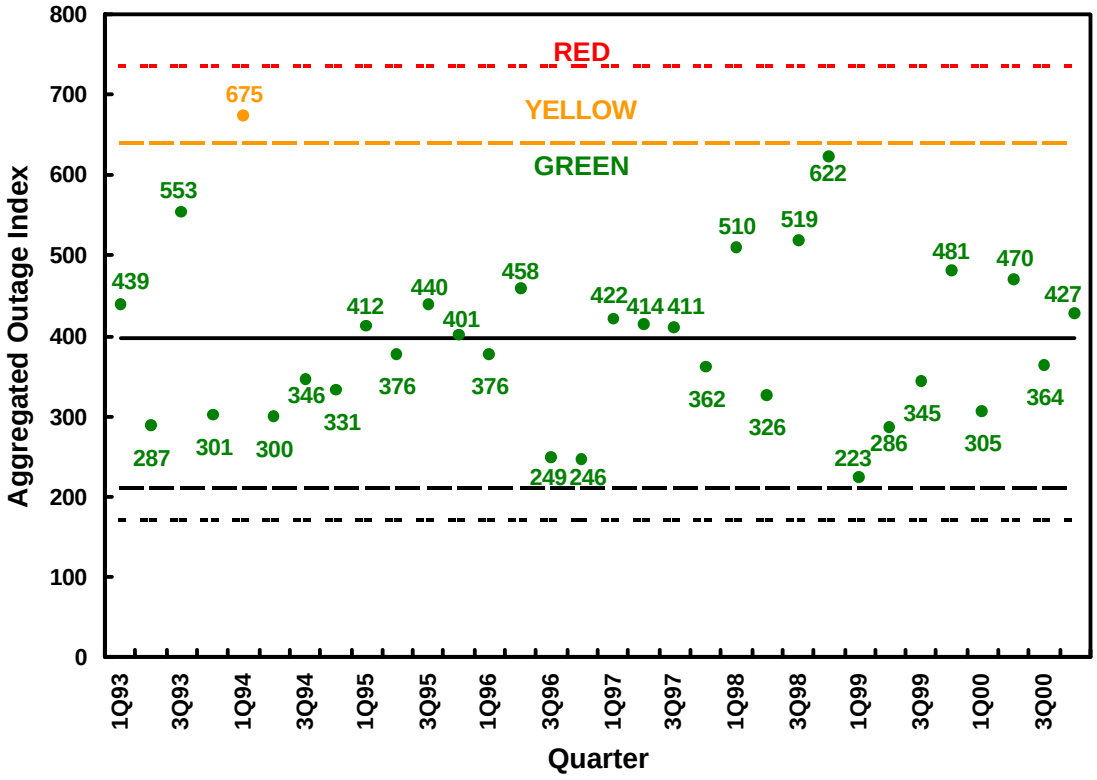


Figure 5: Quarterly Aggregated Outage Index Control Chart

The annual aggregated outage index for each failure category is given in **Figure 6**. In 2000, the Facility category had its lowest annual aggregated outage index to date; the difference between this total (449) and the average baseline level (800) was statistically significant. The annual aggregated outage index for Local Switch outages (107) was also the lowest to date and the third consecutive year below the baseline level (156). On the other hand, the CCS failure category had its highest annual aggregated outage index to date; however, the increase from the baseline level (111) was not statistically significant. Since 1993,

- The aggregated outage index for Facility outages is significantly higher than in any other failure category.
- The aggregated outage index for DCS outages was significantly lower than in any other failure category (except CCS and Other).

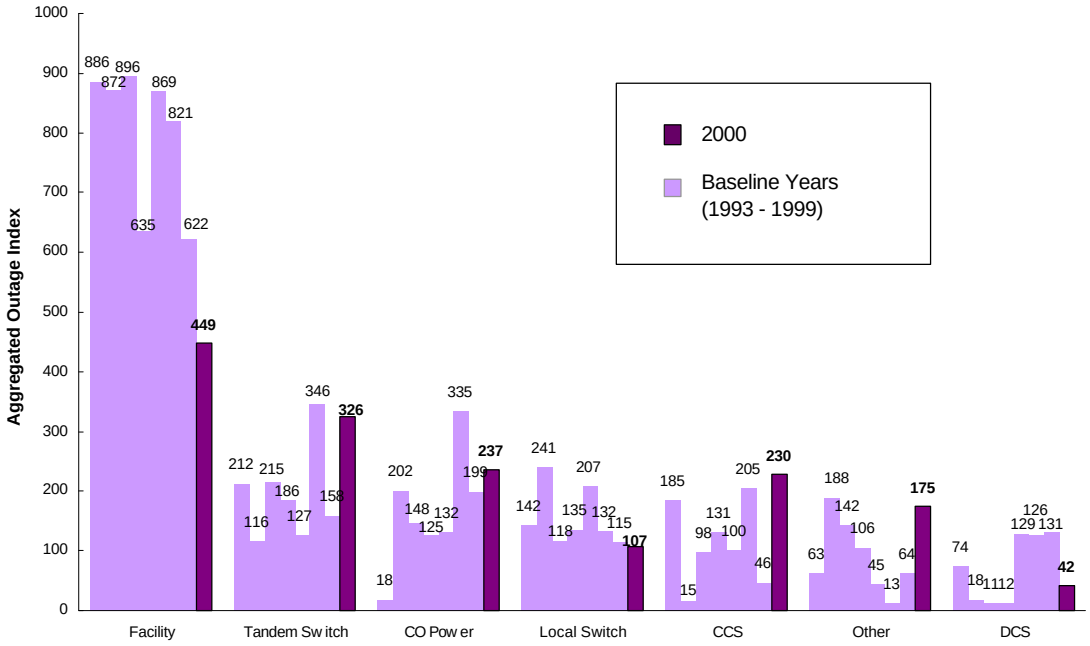


Figure 6: Annual Aggregated Outage Index By Failure Category

In addition:

- The aggregated outage index for DCS outages has been significantly higher from 1997-2000 (107 per year) compared to 1993-1996 (29 per year).
- The aggregated outage index for CO Power outages has been significantly higher from 1998-2000 (257 per year) compared to 1993-1997 (125 per year).
- The aggregated outage index for Tandem Switch outages has been significantly higher from 1998-2000 (277 per year) compared to 1993-1997 (171 per year).

OUTAGE INDEX DISTRIBUTIONS

In the analysis of outage trends, an important question is whether the severity of the average outage has changed over the years. The outage index measures the severity of that outage. **Table 5** presents summaries of the outage index distribution by year. In 2000, the outage index per outage was not statistically different than in the baseline years. Overall, there has been no statistically significant difference in the outage index per outage in the period from 1993 to 2000.

Table 5: Outage Index

Year	Median	Mean	90th %ile
1993	3.33	10.07	29.86
1994	3.33	10.33	32.63
1995	4.84	9.64	25.78
1996	3.16	7.64	23.43
1997	3.72	8.69	26.99
1998	4.02	10.93	31.18
1999	4.00	7.59	18.67
2000	3.90	8.51	21.97
Baseline	3.79	9.24	26.36

Another important question is whether the severity of outages varies by failure category. **Table 6** presents the distribution of outage indexes by failure category:

Table 6: Outage Index By Failure Category

Category	# of Outages	Median	Mean	90th %ile
Other	44	7.17	18.08	54.78
Tandem Switch	154	5.36	10.95	29.51
Facility	616	5.06	9.82	26.99
CO Power	124	4.17	11.26	34.79
DCS	52	3.78	10.44	34.12
Local Switch	228	2.71	5.25	13.29
CCS	168	0.68	6.02	15.77
Overall	1386	3.79	9.15	26.17

Table 6 shows that:

- CCS outages have a very low median outage index. It is significantly lower than in all other categories. This means that the typical FCC-reportable CCS outage has less customer impact than outages in other categories.
- Local Switch outages also have a low median outage index. It is significantly lower than in the Facility, Tandem Switch, CO Power, and Other categories.

Analysis of the data provides the following additional observations:

- In 2000, DCS outages had the lowest median outage index (2.0) and mean value (5.2) since 1994. This is the third consecutive year that the median index has declined.
- In 2000, Facility outages had their lowest mean outage index value (7.1) to date.
- In 2000, the median Local Switch outage index rose for the third consecutive year to a value of 3.4. This was its highest value since 1994.
- In 2000, Other outages had their highest median value (20.0) to date and their highest mean value (21.8) since 1995.

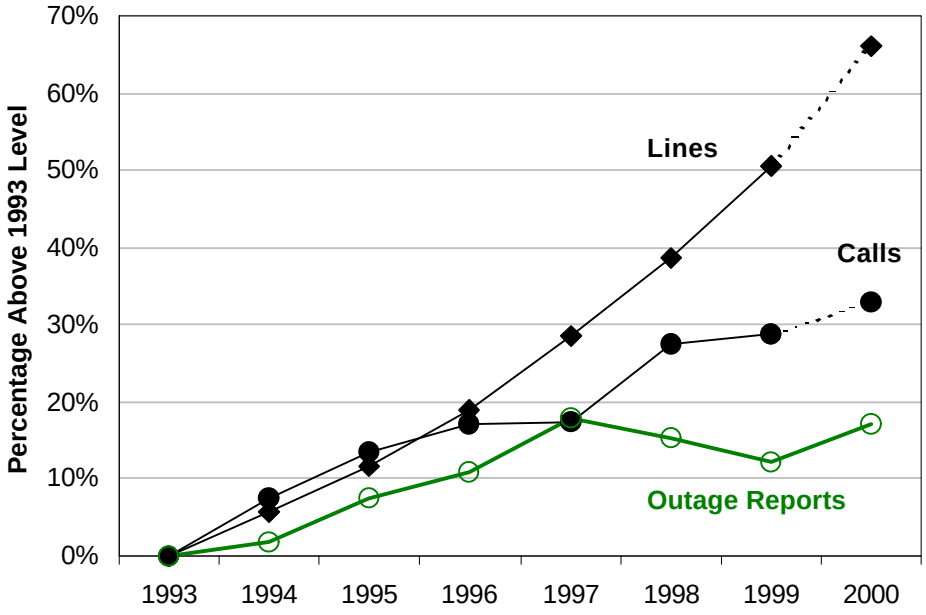
OUTAGE METRICS RELATIVE TO NETWORK GROWTH

The public telecommunications network is continually growing and changing. More lines and facilities are added, switches are centralized or decentralized, the signaling network is expanding, etc. **Table 7** presents two metrics for network growth (see *FCC Statistics of Common Carriers, Table 2.10*) in absolute terms and relative to the Baseline Year. These two metrics are relevant particularly to FCC-reportable outages because of the use of subscriber lines potentially affected and blocked calls in determining the reportable status of outages relative to FCC-defined thresholds.

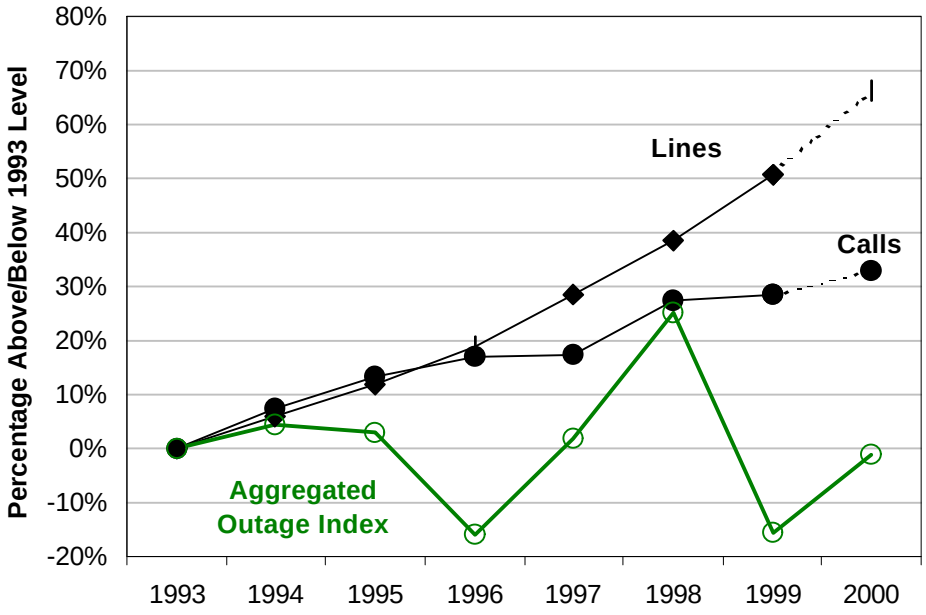
Table 7: Network Growth Metrics

Year	Total (Millions)	
	Lines (on 12/31)	Calls (1/1 - 12/31)
1992	140.3	505,700
1993	149.0	510,000
1994	157.2	548,600
1995	166.0	578,200
1996	177.9	597,300
1997	193.6	598,400
1998	207.7	649,500
1999	227.9	656,100

Figure 7 plots the annual network growth data in Table 7 and annual network outage metrics from Figures 1 and 4 (relative to their 1993 levels) versus year. The dashed lines indicate extrapolation to the year 2000. Figure 7a indicates that, in every year, annual outage frequency has been less than network size as measured by the number of subscriber lines after these values have been scaled relative to 1993 levels. This statement also holds with respect to the number of calls in every year except 1997. Figure 7b indicates that, in every year, the annual aggregated outage index has been less than network size as measured by the number of subscriber lines or by annual call volume after these values have been scaled relative to 1993 levels. Generally, the figure indicates that network outage measures have increased at a slower rate than standard measures of network size and call volume since 1993.



(a) Outage Frequency and Network Growth



(b) Aggregated Outage Index and Network Growth

Figure 7: Annual Network Growth And Outage Metrics Over Time

ROOT CAUSE ANALYSIS

This section provides a root cause analysis of Facility, Local Switch, CCS, Tandem Switch, CO Power, and DCS failures. Steps to prevent recurrence of these failures are identified in:

- the FCC's Network Reliability Council (NRC) *"Network Reliability: A Report to the Nation,"* and *"Network Reliability: The Path Forward"*
- the ATIS/NRSC *"Keeping the Network Alive and Well -- Solving the Problem of Cable Dig-Ups,"* and *"Fixing Facility Outages -- Building Tools to Make it Happen"*
- The FCC's Network Reliability and Interoperability Council (NRIC-IV) Focus Group 3 *"Analysis and Recommendations on Best Practices."*

Figures 3 and **5** in the previous section depict the major contributors by outage frequency and outage index, respectively. In particular, Facility, Local Switch, Tandem Switch, CCS, and CO Power are the five major contributors to outage frequency and to the aggregated outage index (over the eight-year reporting period). Following is an analysis of the root causes of some of the major contributors as well as failures from procedural errors.

FACILITY

The Facility category is the major contributor to both the outage frequency (44%) and the aggregated outage index (49%) during the past eight years. In 2000, Facility outage frequency and aggregated outage index were below the baseline level in every quarter. Overall, Facility outage frequency in 2000 (63) was 20% below the baseline level (79). The aggregated outage index for Facility failures in 2000 (449) was 44% below the baseline level (800); this decrease was statistically significant. In 2000, the Facility category had its lowest annual share of outages (34%) and of aggregated outage index (29%) to date.

Further analysis of the data revealed the major sub-categories, shown in **Figures 8** and **9**, for the number of outages and aggregated outage index, respectively.

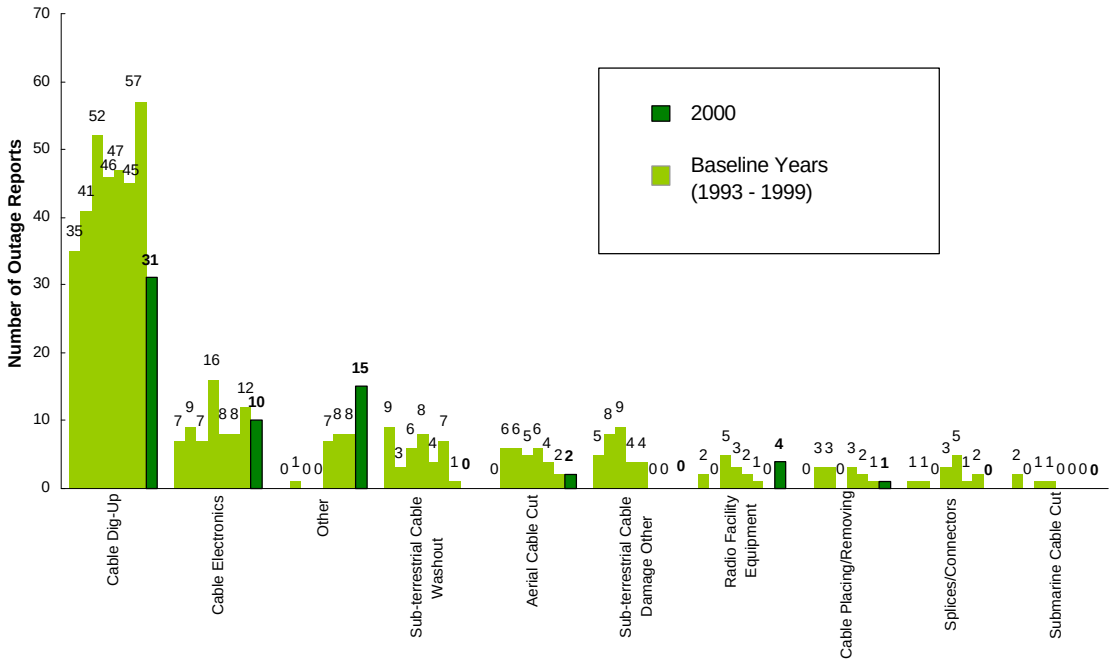


Figure 8: Number of Outage Reports by Facility Failure Sub-Category

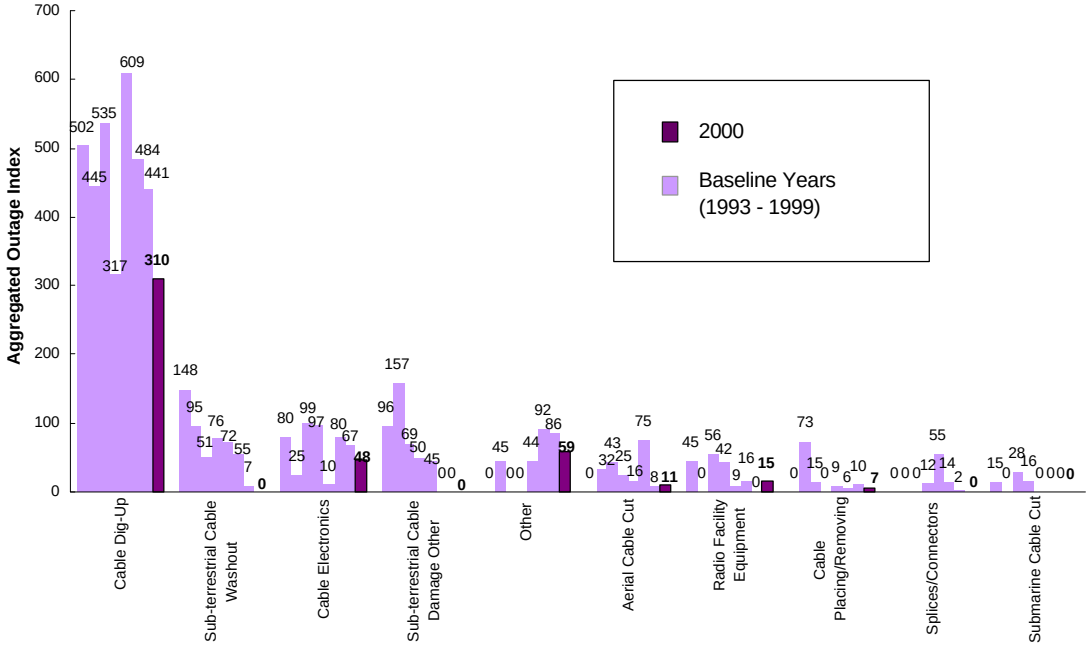


Figure 9: Outage Index Aggregated Annually By Facility Failure Sub-Category

While they continued to dominate Facility failure subcategories in 2000, the Cable Dig-up (DU) subcategory had its lowest annual frequency (31) to date; this was significantly lower than the baseline level (46.1) and aggregated outage index to date (310). Cable DU outages demonstrate a statistically significant seasonality effect; about 1/3 less Cable DU outages occur in the first quarter as compared to the rest of the year. The Sub-terrestrial Cable Damage Other sub-category has a statistically significant decreasing trend in outages since 1993 (32% decline per year). The Sub-terrestrial Cable Washout sub-category demonstrates a statistically significant seasonality effect; first quarters have about 3 such outages per year, third quarters about 1 per year, and second and fourth quarters average .5 per year. Sub-terrestrial Cable Washout also has a statistically significant decreasing trend in outage frequency (18% decline per year). In the last four years, the Other sub-category has had 38 outages compared to one in the first four years; this difference is statistically significant. In the last three years, more Facility outages have occurred in the Other sub-category than in any other sub-category aside from Cable DU.

Cable DUs dominate Facility outages from the outage index perspective as well. However, in 2000, the annual aggregated outage index (310) for Cable DU outages was the lowest observed to date. The Sub-terrestrial Cable Damage Other and the Sub-terrestrial Cable Washout sub-categories demonstrate statistically significant decreasing trends in annual aggregated outage index since 1993.

CABLE DIG-UP

Cable Damage was by far (88%) the largest root cause of Cable Dig-Up incidents during the eight-year reporting period. Looking at the root cause subcategories of Cable Damage Facility outages, Inadequate/No Notification has been the biggest contributor (44%). However, in 2000, the number of Cable Damage outages attributed to Inadequate/No Notification was at its lowest level (9) to date; this is significantly lower than the baseline level (18.1). In 2000, Digging Error had its lowest number of outages since 1993; it also was significantly lower than its baseline level (13.3). Despite this decrease, Digging Error annual outage frequency has been rising at the statistically significant rate of 9% per year. In 2000, Inaccurate Cable Locate outage frequency also had its lowest value (3) observed to date.

The aggregated outage index for Inadequate/No Notification also was at its lowest level to date (83) in 2000. The Digging Error annual aggregated outage index declined for the third consecutive year. **Figures 10** and **11** present the number of outages and aggregated outage index for the Cable Damage root causes of Cable DU.

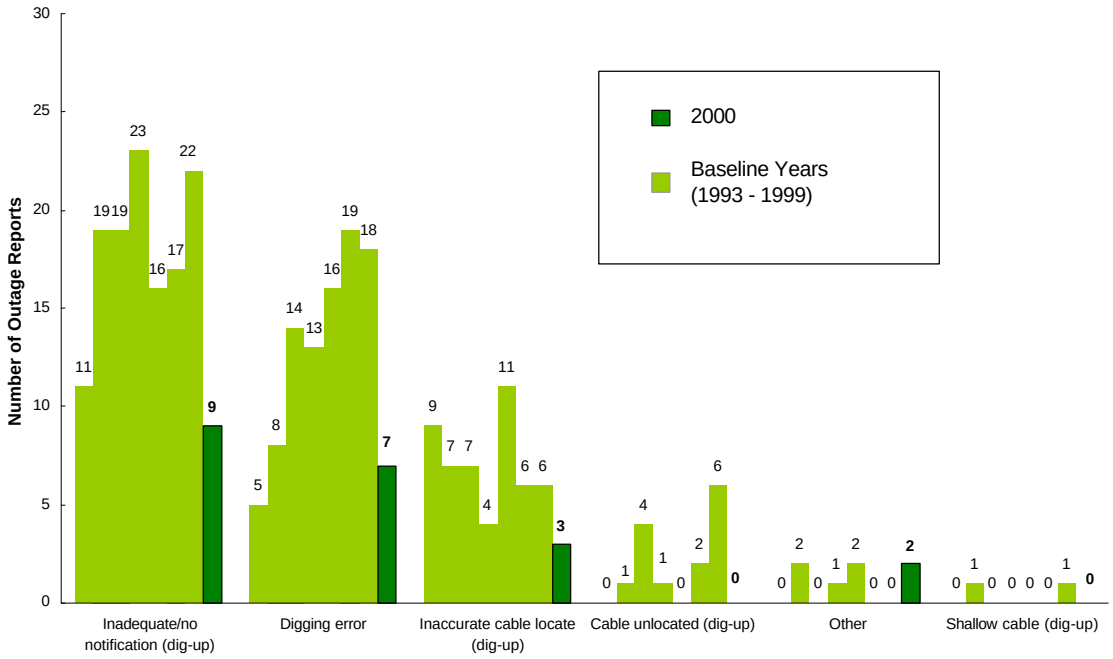


Figure 10: Number of Outage Reports
By Cable Damage Root Cause Sub-Categories of Cable Dig-Up (DU) Facility Failures

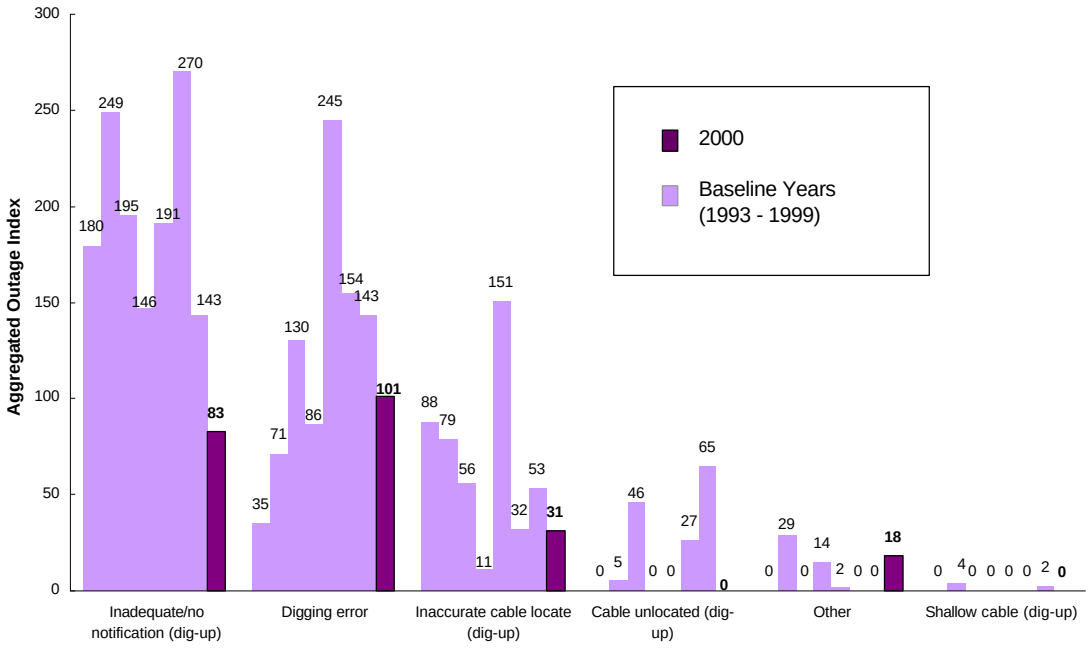


Figure 11: Annual Aggregated Outage Index For
Cable Damage Root Cause Sub-Categories of Cable Dig-Up (DU) Facility Failures

CABLE ELECTRONICS

The major root causes of the Cable Electronics[1] attributed facility outages are: Procedural Errors (46%), Design Hardware (19%), Hardware Failure (14%), and Design Software (12%). Hardware Failure outage frequency has been significantly higher in the last three years than from 1993 through 1997. When considering the aggregated outage index, Procedural Service Provider is the dominant root cause (52%) followed by Design Hardware (28%) and Hardware Failure (10%). Hardware Failure had its highest aggregated outage index in 2000 (27) to date. It accounted for 58% of he Cable Electronics aggregated outage index in 2000.

LOCAL SWITCH

In 2000, Local Switch outages continued the decline in frequency since 1996 (see Figure 3). As shown in Figure 6, the aggregated outage index for Local Switch outages in 2000 was the lowest observed to date.

The major failure sub-categories for Local Switch outages have been Hardware (44%), Software (27%), and Translations (21%). Software outages have averaged 4.5 per year in the last two years; this is significantly lower than the average in the first six years (10.6 per year). Other outages have occurred significantly more frequently in the past three years than in the first five years (4.7 versus 0.8 per year). The annual aggregated outage index for Hardware outages demonstrates a statistically significant decreasing trend over the course of the eight-year history.

Procedural Errors continue to be the major root cause of Local Switch outages in 2000 from both the outage frequency and the outage index perspective (53% and 50% respectively). However, in 2000, the number of Procedural Error outages and their aggregated outage index declined to their lowest levels (9 and 42 respectively) since 1995. On the other hand, Design Software had its highest frequency and aggregated outage index (6 and 40 respectively) since 1996.

COMMON CHANNEL SIGNALING (CCS)

In 2000, CCS outages occurred more frequently than in any year since 1993 (see Figure 3). The aggregated outage index was higher in 2000 than in any prior year as shown in Figure 6.

Isolation is the dominant failure subcategory (71%) for CCS outages, followed by STP Equipment and Link(set)s (10% each). The number of CCS failures attributed to Isolation rose to its highest level (21) since 1993 (see **Figure 12**); this is significantly greater than the average level over the preceding four years (11.25 over 1996 – 1999). Over the last three years, the number of CCS outages attributed to Link(set)s (4.2 per year) was significantly higher than the 0.6 annual rate observed in the five prior years.

Procedural Service Provider (35%) and Design Software (21%) have been the dominant root cause categories. In 2000, Procedural Service Provider had its highest frequency (12) to date. This is the fourth consecutive year that Procedural Service Provider has been above its baseline level. Considering all three Procedural Error root categories as a group, the frequency of Procedural Error CCS outages was significantly higher in 2000 (16) than the baseline level (9.1 per year). Design Software has been declining as a root cause category at the statistically significant rate of 25% per

[1] It includes repeaters, multiplexers (add/drop, M31, SONET), demultiplexers, regenerators, timing source interface unit, BITS interface card, voltage control oscillator (VCXO) fuses, power unit for facility, etc.

year. In 2000, Design Hardware was the root cause category for more CCS outages (8) than in any year to date.

From the outage index perspective (see **Figure 13**), Isolation (45%), STP Equipment (28%), and SCP Equipment (17%) are the dominant failure sub-categories. In 2000, Isolation had its highest annual aggregated outage index to date (124). Procedural Service Provider (45%) and Design Software (21%) have been the primary root cause contributors to CCS aggregated outage index. In 2000, the CCS aggregated outage index attributed to Procedural Service Provider reached its highest level to date (130).

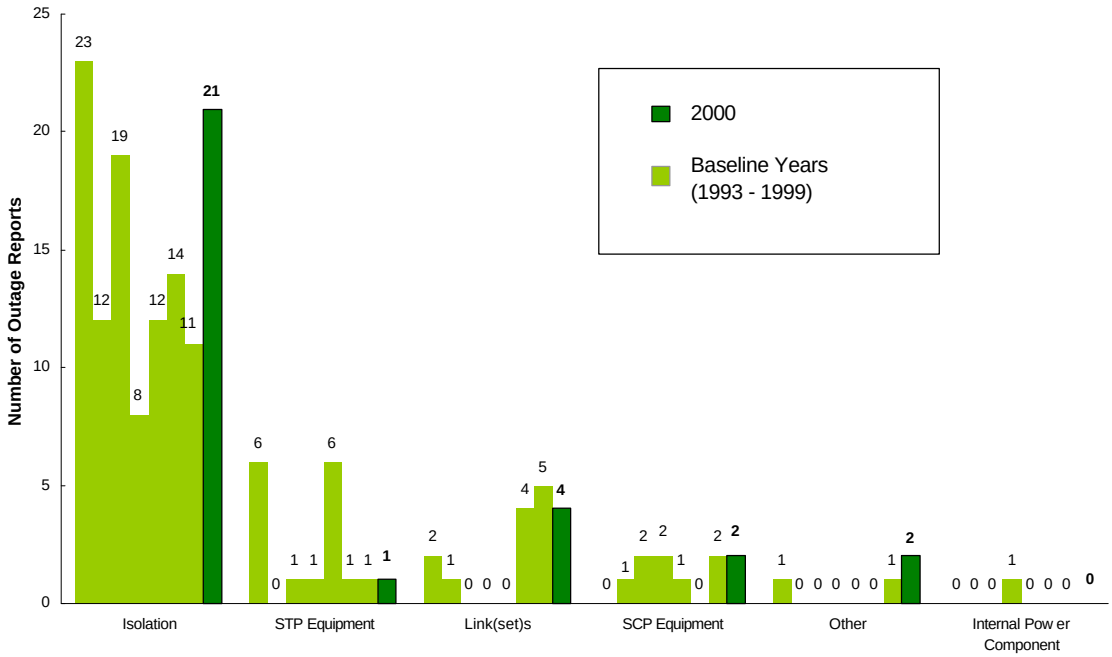


Figure 12: Number of Outage Reports By CCS Failure Sub-Category

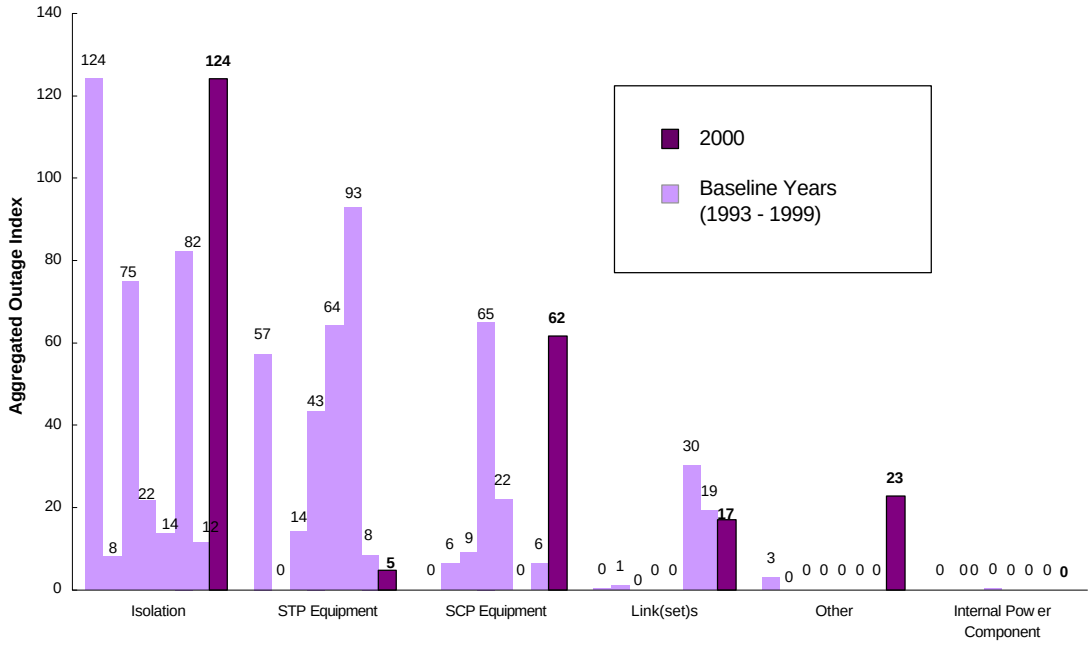


Figure 13: Annual Aggregated Outage Index By CCS Failure Sub-Category

TANDEM SWITCH

Tandem Switch outage frequency reached its highest level (31) in 2000. The Tandem Switch aggregated outage index was at its second highest level (326). It should be noted that when a Class 5 switch is equipped to function as a 911 tandem, and an outage is reportable due to loss of that functionality, the NRSC considers that outage to be a Tandem outage. During 2000 there were eight (8) such outages reported.

Software is the major failure sub-category (38%) of the number of Tandem Switch outages followed by Translations (31%) and Hardware (25%). In 2000, outage frequency was generally high in all sub-categories. Software matched its highest level (10). Translations matched its second highest level (8). Hardware had its second highest number (7). Other had six times as many (6) as in any prior year; this difference is statistically significant. Software is the major failure sub-category (42%) with respect to the aggregated outage index for Tandem Switches followed by Translations (31%), and Hardware (22%). The annual Hardware aggregated outage index displays a statistically significant increasing trend after 1993.

Procedural Service Provider (44%) and Design Software (32%) have been the dominant root causes of Tandem Switch outages. In 2000, Design Software (11), Hardware Failure (5), and Procedural System Vendor (5) all had their highest frequencies to date; all three were significantly higher than their baseline levels (5.4, 1.3, and 1.3 per year respectively). Tandem Switch outages caused by Procedural Errors (Service Provider and Vendor) have been increasing at the statistically significant rate of 5.4% annually. Procedural Service Provider (43%) and Design Software (34%) are also dominant with respect to aggregated outage index. Hardware Failure had its highest aggregated outage index to date (60).

CENTRAL OFFICE (CO) POWER

2000 had the highest number of CO Power outages in any year to date (22). CO Power outages are further categorized by the NRSC into the following six sub-categories: DC Plant, DC Distribution, Building AC, Standby Generator, Commercial, and Other. Examination of the distribution of outages across these sub-categories shows that the major contributors are: DC Plant (28%), DC Distribution (25%), Other (19%), and Standby Generator (15%). Standby Generator outages have a statistically significant increasing trend of 39% per year.

The impact of the CO Power outages in 2000 (237) was above the baseline level for the third year in a row. The major contributors, by sub-category, to the CO Power aggregated outage index are: DC Plant (29%), Standby Generator (22%), and DC Distribution (21%).

Procedural Service Provider (39%) and Commercial and/or Back-Up Power Failure (37%) are the primary root cause categories among CO Power outages. However, in the last three years, Commercial and/or Back-Up Power Failure has been the primary root cause (11 per year), significantly higher than its level over the first five years (2.6 per year). In 2000, more CO Power outages were caused by Commercial and/or Back-Up Power Failure (13) than in any previous year, significantly higher than the baseline level (4.7 per year). In the last two years, Procedural System Vendor has caused 3 CO Power outages per year compared to an average of 0.7 per year in the first six years; this is a statistically significant difference. In 2000, Procedural Service Provider caused less CO Power outages (4) than in any year since 1993. With respect to the aggregated outage index, Commercial and/or Back-Up Power Failure is the dominant root cause category (42%) followed by Procedural Service Provider (26%).

DIGITAL CROSS-CONNECT SYSTEMS (DCS)

In 2000, there were eight Digital Cross-connect System (DCS) outages. Hardware (47%) and Software (35%) are the two major failure sub-categories for DCS outages. However, in 2000, Software had the highest frequency (5) to date and accounted for the majority of DCS outages. In the last four years, Software outages have occurred with significantly higher frequency (3.5 per year) compared to the first four years (1 per year). With respect to the aggregated outage index, the three major failure sub-categories are Hardware (46%), Software (28%), and Other (21%). However, in 2000, 95% of the DCS aggregated outage index was in the Software sub-category.

Looking at the root causes of DCS outages, 28% are attributed to Design Software, 25% to Procedural System Vendor, 19% to Procedural Service Provider, and 12% to Hardware Failure. In 2000, Design Software was the root cause for more DCS outages (5) than in any previous year and significantly higher than the baseline level (1.4 per year). Over the last three years, Design Software has caused 3.7 DCS outages per year compared to 0.8 per year in the first five years; this is a statistically significant difference. Also, in the last three years, Hardware Failure has caused 2 DCS outages per year compared to none in the first five years; this is a statistically significant difference. With respect to the aggregated outage index, Design Software accounts for 39% of the DCS aggregated outage index, Procedural Service Provider 28%, and Procedural System Vendor 12%.

PROCEDURAL ERROR OUTAGES

Three root cause categories can be grouped as *Procedural Errors (PE)*:

1. Procedural Service Provider,
2. Procedural System Vendor, and
3. Procedural Other Vendor.

Procedural Error root cause categories account for 35% of the number of outages and 30% of the aggregated outage index. The significantly largest share of the PE outages is attributable to the Procedural Service Provider (79%) as opposed to the Procedural System Vendor (18%) or Procedural Other Vendor (3%); their shares of the aggregated outage index are close to these values as well.

Figure 14 presents the number of Procedural Error outages in each year. The frequencies of PE outages have been increasing at the statistically significant rate of 8% annually. In 2000, Procedural Error outage frequency matched 1998 with the highest annual total to date (76). This is significantly higher than the baseline level (58.6).

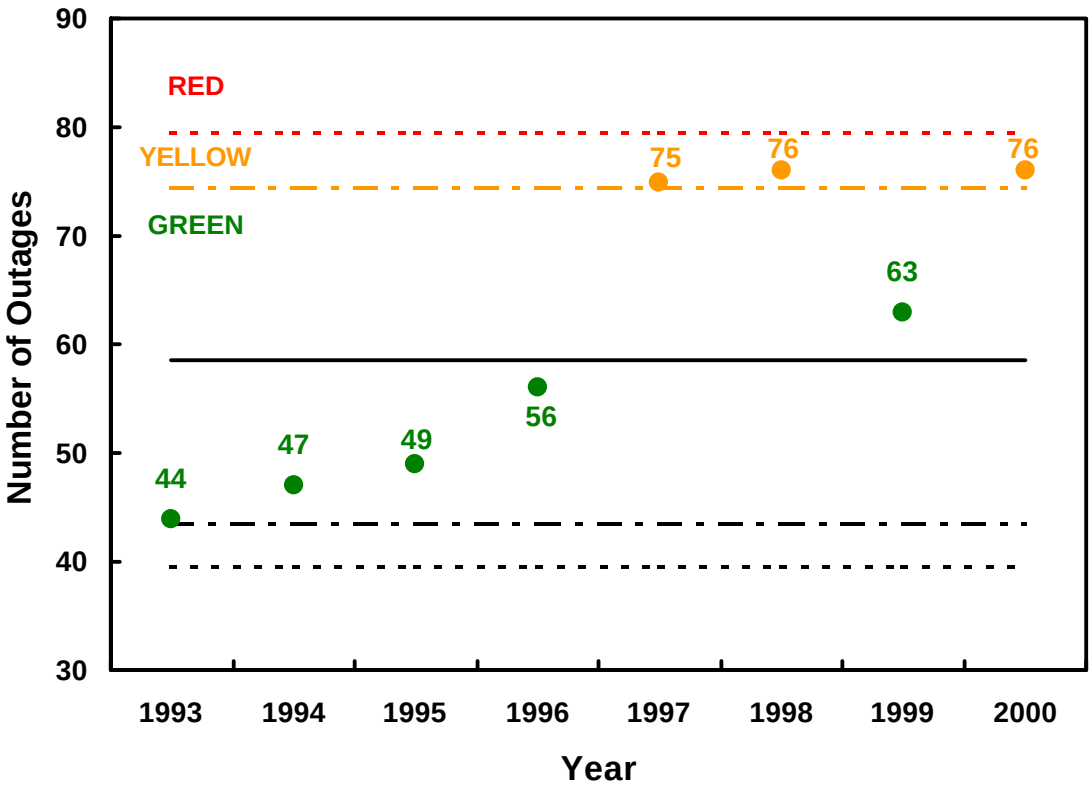


Figure 14: Annual Frequency Control Chart for Procedural Error Outage Reports

Figure 15 shows the frequency of PE outages by root cause subcategory. The three major root cause subcategories are Insufficient Supervision/Control (33%), Documentation/Procedures (unavailable, unclear, incomplete) (27%), and Insufficient Training (27%). In 2000, the number of PE outages caused by Insufficient Supervision/Control (27) was significantly higher than the baseline level (19.3). Despite a decline for the second consecutive year, the frequency of PE outages caused by

Insufficient Supervision/Control has been rising at the statistically significant rate of 4% per year over the last eight years. On the other hand, Documentation/Procedures (unavailable, unclear, incomplete) outage frequency has been declining at the statistically significant rate of 9% per year. In 2000, PE outages caused by Documentation/Procedures (out-of-date, unusable, impractical) occurred more frequently than in any other year (5). Beginning in 2000, the NRSC reclassified outages attributed to Cable Unlocated and Inaccurate Cable Locate from "Cable Damage" to "Procedural." In 2000 there were two and four PE outages respectively in these categories.

In 2000, the annual aggregated outage index of Procedural Errors was the second highest to date (619). The annual aggregated outage index of Insufficient Supervision/Control outages has risen at the statistically significant rate of 47% annually. Counterbalancing this trend to some degree is the statistically significant decline (20% annually) in the annual aggregated outage index of Documentation/Procedures (out-of-date, unusable, impractical) outages. In 2000, the aggregated outage index of PE outages attributed to Insufficient Training reached its highest value to date (221), significantly higher than its baseline level (86).

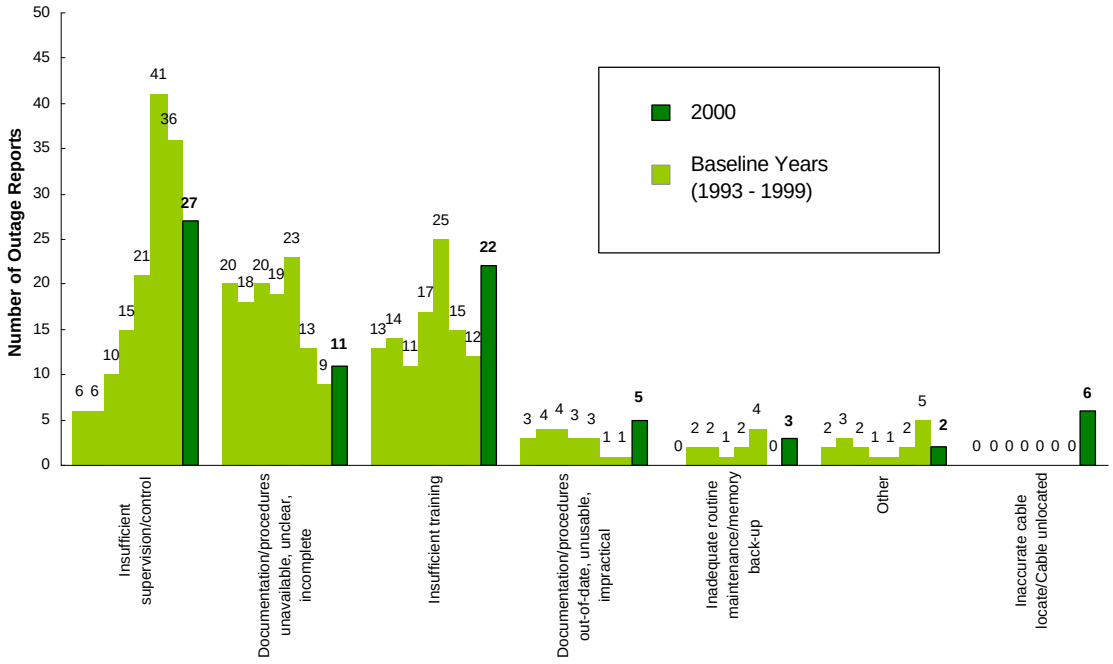


Figure 15: Number Of Outage Reports By Procedural Error Root Cause Subcategory

"SPECIAL" OUTAGES

In addition to those outages that impact 30,000 or more customers for more than 30 minutes, carriers are also required to report outages below the 30,000 customer threshold that affect major airports, major military installations, key government facilities, nuclear power plants, and 911 service. Carriers are also required to report fire-related incidents which impact 1,000 or more lines for 30 minutes or longer. During 2000 there were eighteen (18) outages that fell in these categories.

Of these eighteen outages, three (see below) should not have been reported (i.e., none of the reporting criteria were met) and another was as a result of the forest fire in Los Alamos, New Mexico, which will be discussed separately. Of the remaining fourteen (14) outages, three (3) were reportable because of their impact on major airports (and in one case media coverage of the impact to an airline) and eleven (11) were reportable fire-related incidents. A PASP isolation, which by itself would not have been reportable, also occurred during one of the fire-related outages.

Five (5) outages affected major airports including two of very short duration (2 minutes and 3 minutes respectively, which should not have been reported). Both of these outages involved the Uninterrupted Power Source (UPS). The first occurred as the result of failure of the surge protection module in the Redundant Control Unit (RCU), and the second was due to a procedural error that tripped a circuit breaker during a maintenance operation. Two other outages occurred (a) when a building fire destroyed aerial fiber cable that served FAA circuits and local pair gain systems; and (b) when a contractor working to complete repairs to the damaged cable again fractured the fiber cable. The average duration of these last two outages (both of which were classified as Facility outages) was 7.88 hours as compared to the average duration of 7.44 hours for all (larger) Facility outages reported over the eight years of reporting. The average number of customers effected by these two outages was 600. By definition, these outages affect less than 30,000 customers and therefore comparison of the number of customers impacted to larger reported outages is meaningless. The fifth outage did not affect a major airport—it impacted a major airline—and was reported because of its media attention.

Of the eleven (11) outages caused by fire, two (2) occurred in manholes, one was the result of a transformer explosion, one occurred as the result of a gas line igniting during construction activities, two (2) were the result of vehicular accidents, one was the caused by a wildfire, and four (4) because of fires in non-telephone buildings. Ten (10) of these eleven outages were classified as Facility-Other with a root cause of External Environment-Fire. One was classified as Facility-Cable Electronics when fire damaged an aerial cable and two DS3's failed to switch to protect due to a bad input conditioner. The average duration of these outages was in excess of 60 hours, far more than the 7.44 hours average for the larger Facility outages. In almost all cases multiple cables had to be replaced (in one outage 31 cables) and in many cases repairs were delayed (by as much as 38 hours) when access to the area was delayed by local fire officials, generally due to the need for hazardous material removal. The average number of customers affected was 4,999. However, one outage accounted for more than 49% of the total customers affected by all the outages. If that outage is not included, the average number of customers affected drops to 2,772.

THE LOS ALAMOS WILDFIRE

On May 4, 2000, the National Park Service at Bandolier National Monument ignited a prescribed fire. Sporadic wind changes caused loss of control on the fire line and the fire was declared a wildfire on May 5, 2000. Continuing high winds caused the fire to burn further out of control, crossing fire lines to the north, south and east, and entering Los Alamos Canyon. On May 10, 2000, the towns of Los Alamos and White Rock were evacuated. The fire continued to burn over 48,650 acres. Four hundred families were displaced as a result of fire damage to their homes.

On May 10, 2000, the U S WEST Disaster Recovery Team activated a local Emergency Operations Center (EOC) in Los Alamos and a supporting EOC in Denver, Colorado to identify damage prevention tactics and recovery processes.

- Technicians in Los Alamos and White Rock made back up tapes and transported them to a secure location.
- 911 for Los Alamos and White Rock were rerouted to 7-digit local numbers until the fire was contained.
- Additional generators and battery strings were deployed to Los Alamos to support the Central Offices in the event of loss of commercial power.
- Identified critical services to be patched to existing microwave radio if toll service was lost; arranged for deployment of additional radio service, if needed. Developed plan for internal communication if access to Central Offices was lost.
- Trees and foliage in the area of the Central Office were removed. Vehicles were removed from the area. Roof top drainage systems were plugged and flooded with three inches of water. Water tanker trucks were deployed and remained on site until the fire danger had passed. Air intake to buildings was restricted to prevent smoke from entering.
- Placed four Quick Start radios adjacent to the damaged area, including pair gain systems. Deployed portable coin trailers to the radio sites. Provided immediate telephone service to fire fighters and other emergency personnel.
- Additional lines for local emergency personnel, FEMA, Red Cross, insurance companies and the Los Alamos Labs were installed as needed.
- PCS wireless phones were deployed and as customers returned to Los Alamos they could request a PCS wireless phone. Their local land line number was then forwarded to the PCS wireless phone, with voice mailboxes included. A separate trunk group was installed from Los Alamos to the Phoeniz, Arizona PCS switch to handle the additional traffic.

While this outage was not preventable, steps have been taken to mitigate the effect of such events in the future. In Los Alamos, some areas will not be rebuilt; the areas will be converted to parks or open space to provide buffer zones. As permanent cables were replaced, where possible, buried cable, rather than aerial cable was installed

CONCLUSION

The NRSC's analysis of major network outages reported in 2000 presents a mixed picture of the nation's network reliability. Two outage categories—Central Office (CO) Power and Tandem Switch—recorded their highest ever frequency. One category—Common Channel Signaling (CCS)—was at its highest level since 1993; and a fourth category—Digital Cross-connect Systems (DCS)—was above its baseline level for a fourth consecutive year. At the same time, the two categories that have historically accounted for more than 60% of all outages—Facility and Local Switch—each recorded their second lowest level ever. The NRSC's primary measures—overall outage frequency and overall outage index—also provide a mixed message. Overall outage frequency, while continuing to perform within the limits by which it is measured, nonetheless exhibits an increasing trend, although less than the increase in lines and calls, while the overall outage index exhibits neither an increasing nor decreasing trend.

During 2000, the NRSC formed an ad hoc study group to review CCS outages to identify possible causes for the increase in this type outage. The findings of this group indicate that these outages could have been prevented or their impact mitigated had previously identified Best Practices been followed. Also, both the NRSC and the Best Practices team of NRIC-IV have in the past investigated CO Power outages, with similar findings. As such, ***the NRSC urges all service providers and equipment vendors to review all best practices for application in their operations.***

While the results presented in this annual report may suggest a shift in emphasis by the industry in its continuing campaign to combat network outages, what remains clear is the strong commitment of both service providers and equipment vendors to sustain and improve the reliability and stability of the nation's networks.