Network Reliability Steering Committee

Annual Report 2004

October 2005

Network Reliability Steering Committee

Sponsored by the Alliance for Telecommunications Industry Solutions

TO: Stakeholders of the Telecommunications Industry in the United States

This Annual Report reviews the health of the wireline telecommunications networks for the year 2004, as determined by statistical analysis of major outages reported by service providers to the FCC. This analysis is intended to advise the various stakeholders of the telecommunications industry on the network reliability results that were observed during the previous year from a very special perspective. While any individual company can analyze their own major outage events, only the NRSC brings the industry together in a non-competitive setting to *objectively analyze* the macro outage data for the United States wireline telecommunications industry, and when necessary, *cooperatively bring to bear the industry's resources* when problems are identified. The statistical analysis techniques employed by the NRSC are objective methodologies that were developed and approved by the ANSI accredited ATIS Standards Group on Network Reliability and Performance. These techniques provide many benefits. Some examples include:

1. **Decision Support:** IF IT WERE POSSIBLE, INDUSTRY WOULD PREVENT ALL OUTAGES. Failing that, if it were possible, industry would devote infinite resources to stopping every identified class of failure. Unfortunately, it is impossible to prevent all outages and obviously there are finite resources available to be devoted to correcting the causes of outages. The answer is to devote the finite resources to preventing/reducing those outages that have the most severe impact, thus gaining the most "bang for the buck". The NRSC assists in this process by analyzing major outages and alerting the stakeholders to ongoing and emerging problems on the basis of statistical analysis. Not conjecture. Not opinion. Not guesses. The reports written by the NRSC are intended to identify areas which merit special attention, based on objective statistical analysis.
2. **Appropriate Response:** The Statistical Process Control (SPC) methodologies employed by the NRSC are longstanding and proven methods of statistical analysis that are able to identify major shifts in network reliability due to systemic causes from the normal variation in the frequency and impact of outage events. This allows the NRSC to focus its efforts on significant reliability issues that are due to systemic causes rather than overreacting to normal random fluctuation in outage frequency or impact.
3. **Density of Information:** Failure events (outages) that are due to systemic causes will occur over and over again, forming a trend over time. The length of time that it takes to recognize a trend depends on how often the events occur. Some event types occur very infrequently and it can be extremely difficult to recognize a trend. By aggregating all of the outage data for the United States as a whole, these rare event types can be identified more quickly by the NRSC than by a telecommunications service provider working alone.
4. **Control Limits and Trends:** The NRSC is committed to identifying network reliability problems as quickly as possible. To that end, it uses control limits based on historical performance to establish an alarm threshold and identify any sudden, undesirable changes in outage frequency or impact. In this way, the NRSC can sound the alarm or suggest a response to a quickly emerging problem. However; reliability problems are not always so extreme as to be immediately detectable. It may take time and the accumulation of data over time to identify a problem. For this reason, the NRSC also examines outage frequency, impact, duration, and extent over the long term to identify troubling trends over time, even those that may not exceed the control limits. This diversity in analysis provides dual protection in the identification of network reliability problems both immediately and over the long term.

Some particularly notable measurements and trends for 2004 were:

- The lowest number of outages ever observed.
- Facility outages at a record low in terms of both number of events and impact (i.e., outage index).
- Lowest number of local switch outages ever observed.
- Second lowest frequency ever for tandem switch outages.
- A five-year trend of 19% annual reduction in total outage frequency.
- An eight-year trend of 13% annual reduction for facility outage frequency.

Based on the 12-year outage reporting history, 2004 was definitely a great year for network reliability as measured by outage frequency. Consistent with its practice for over a decade, the NRSC reports this and other factual observations, but stops short of offering interpretation as to why this happened. For those inclined to ponder why things have improved, an outline of possible influencing factors is provided in the Summary and Conclusion section of this report. As to the question of what impact NRSC activities have had on the positive performance observed in 2004, there is certainly ample evidence to suggest that the many years of study and numerous process improvements have been positive ones. Additional insights to this question can be gleaned from the NRSC studies at http://www.atis.org/nrsc (particularly the documents: "Timing Outages Task Group Report", "Fixing Facilities Damages", and "Procedural Outage Reduction") and the Network Reliability and Interoperability Council (NRIC) website at http://www.nric.org where the NRIC Best Practices can be found.

2004 was a milestone year. Several key personnel in the area of network reliability chose to retire. P. J. Aduskevicz, Chair of the NRSC from 2000-2003 and Jim Lankford, Chair of the NRSC for 2004 both decided to retire last year. P.J. and Jim are giants in the field of network reliability who had enviable records of achievement and leadership. They will be missed.

Beginning in 2005, major changes to the outage reporting process were implemented by the FCC. New rules went into effect that fundamentally changed what outages would be reported, and how the data would be handled. The new rules expand outage reporting beyond the wireline segment to include the wireless, cable, paging, and satellite segments of the industry. Unfortunately, the language in the new rules that was intended to protect outage data from potential abuse by enemies of the United States has been interpreted by the FCC as prohibiting access by the NRSC. The work of the NRSC over the past 12 years has been a repeated cycle of analyzing data, identifying areas for focused study, and making recommendations to industry on how to improve network reliability. The work of the NRSC takes place in an environment where competition and marketplace rivalries are put aside. The focus is on improving the reliability of the national telecom infrastructure for the benefit of all users of communications services in the United States and communicating network reliability information to the public. This process is a proven model that has increased the reliability of communications for all consumers in the United States. Unfortunately, at this time, the NRSC's network reliability improvement cycle has halted because insufficient access to outage data has restricted its capability to provide this service to the nation. The NRSC stands ready to work side by side with the FCC to resolve the data access issue, and continue the efforts to improve the reliability of telecommunications services for everyone in the United States.

Archie McCain
Chair NRSC

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INTRODUCTION

This report provides an analysis of U.S. telecommunications network performance based on outage reports made by service providers to the FCC from January 1, 1993 through December 31, 2004. While service providers were required to make such reports for outages meeting various criteria, the vast majority of reports were made for outages that potentially affect 30,000 or more customers for 30 minutes or more.

The report is divided into four sections. The analysis results presented in the first two sections were limited to those outages reported on the basis of the 30,000 customer/30 minute thresholds. The first section describes network performance overall and within failure categories. The second section provides further breakdown analyses of failure subcategories and root cause categories within each failure category. In both sections, the major metrics examined are number of outages and aggregated outage index. The first section also examines the number of customers potentially affected and outage duration per outage.

The "Special" Outages section addresses reports below the 30,000 customer threshold that affect major airports, major military installations, key government facilities, nuclear power plants, and 911 service, as well as fire-related incidents that impact 1,000 or more lines, but less than 30,000 lines, for 30 minutes or longer.

The Summary and Conclusion section provides a summary of 2004 and reviews the accomplishments of the NRSC prior to the revision of the FCC outage reporting requirements in 2005.

During 2004, members and participants in the NRSC included:

AT&T
AT&T Wireless
BellSouth
Cingular Wireless
Cellular Telecommunications & Internet Association (CTIA)
Cox Communications
Department of Homeland Security (DHS)
e-Commerce & Telecommunications User Group (eTUG)
Federal Communications Commission (FCC)
Institute for Law and Public Safety
Juniper Networks
Lucent Technologies
Marconi Communications
MCI
National Emergency Number Association (NENA)
Nortel Networks
NYC DOITT
Puerto Rico Telephone
Qwest
SBC
Spectrasite
Sprint
Telcordia Technologies
Union Pacific Railroad
Verizon

MAJOR FINDINGS

In general, network performance remained within control limits in 2004. However, 2004 saw statistically significant departures from these limits in several areas. In particular,

- 2004 had the lowest number of outages to date, 45% lower than the Baseline Level.
- Facility outages had their lowest frequency and aggregated outage index[1] to date, both 61% lower than their Baseline Levels.
- Local Switch outage frequency dropped to its lowest level to date, 62% lower than its Baseline Level.
- Tandem Switch outage frequency dropped to its second lowest level to date, 53% lower than its Baseline Level.
- The aggregated outage index of Other outages rose to its highest level to date, 210% greater than its Baseline Level.
- Procedural Error outage frequency dropped to its lowest level to date, 65% lower than its Baseline Level.

Significant trends noted over the course of the twelve-year data history include:

- Outage frequency has been decreasing at a rate of 19% annually since 2000.
- The overall annual aggregated outage index over the last three years has been 23% less than in prior years.
- Facility outage frequency has been decreasing at a rate of 13% annually since 1997. Its aggregated outage index has been decreasing at a rate of 8% annually over the 12-year history.
- Over the last four years, Local Switch outage frequency and aggregated outage index have been on average 65% and 62% less respectively than in prior years.
- Over the last three years, Tandem switch outage frequency has been on average 54% less than in prior years. Over the last two years, its annual aggregated outage index has been on average 61% less than in prior years.
- In the last three years, CO Power outage frequency has been 47% less than in the peak 1997-2001 period.
- DCS outage frequency has been decreasing 18% annually since 1998. However, the DCS aggregated outage index remained 193% higher over the last eight years than in prior years.
- Over the last five years, the annual aggregated outage index of Other outages has been 185% higher than in prior years.
- Procedural Error outage frequency has been decreasing 28% annually since 2000. Its aggregated outage index has been 42% less in the last three years than in prior years.
- Outage durations and outage indexes have been higher in the last four years than in prior years.

[1] The aggregated outage index is the sum of the outages indexes for the individual outage reports. Consequently, the aggregated outage index is related to the number of outages.

STATE OF THE NETWORK

The network performance described below is based on an analysis of network outages reported to the FCC. The analysis compares network outage data from January 1, 1993 through December 31, 2004. Data from January 1, 1993 through December 31, 2003 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 2003 are referred to as the Baseline Years.

In general, network performance remained within control limits in 2004. However, 2004 saw statistically significant departures from these limits in several areas. In particular,

- 2004 had the lowest number of outages to date, 45% lower than the Baseline Level.
- 3Q04 and 4Q04 had the highest and lowest aggregated outage indexes of any quarters to date, 108% higher and 74% lower respectively than the Baseline Level.
- Facility outages had their lowest frequency and aggregated outage index to date, both 61% lower than their Baseline Levels.
- Local Switch outage frequency dropped to its lowest level to date, 62% lower than its Baseline Level
- Tandem Switch outage frequency dropped to its second lowest level to date, 53% lower than its Baseline Level.
- The aggregated outage index of other outages rose to its highest level to date, 210% greater than its Baseline Level.
- Procedural Error outage frequency dropped to its lowest level to date, 65% lower than its Baseline Level.

Network performance areas in 2004 that remained within control limits but still noteworthy include:

- The median number of customers potentially affected by an outage was the highest to date, 22% higher than the Baseline median.
- 2004 was the first year Tandem Switch outages had the lowest aggregated outage index among failure categories.
- The CCS aggregated outage index was below its Baseline Level for the first year since 1999.
- The DCS aggregated outage index rose to its highest level since 1999.
- The mean and 90th percentile of outage indexes were the highest of any year to date, 13% and 51% greater respectively than their Baseline values.

Several statistically significant trends are noted:

- Outage frequency has been decreasing at a rate of 19% annually since 2000.
- The overall annual aggregated outage index over the last three years has been 23% less than in prior years.
- Facility outage frequency has been decreasing at a rate of 13% annually since 1997. Its aggregated outage index has been decreasing at a rate of 8% annually over the 12-year history.
- Over the last four years, Local Switch outage frequency and aggregated outage index have been on average 65% and 62% less respectively than in prior years.

- Over the last three years, Tandem Switch outage frequency has been on average 54% less than in prior years. Over the last two years, its annual aggregated outage index has been on average 61% less than in prior years.
- In the last three years, CO Power outage frequency has been 47% less than in the peak 1997 – 2001 period.
- DCS outage frequency has been decreasing 18% annually since 1998. Nevertheless, the DCS aggregated outage index remained 193% higher over the last eight years than in prior years.
- Over the last five years, the annual aggregated outage index of Other outages has been 185% higher than in prior years.
- The Procedural Error outage frequency has been decreasing 28% annually since 2000. The Procedural Error aggregated outage index has been 42% less in the last three years than in prior years.
- Outage durations and outage indexes have been higher in the last four years than in prior years.

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. In this report, the shorter term "significantly" is applied to statements that are statistically significant.

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 number of outages in 2004 (87) was lower than in any year to date. The Baseline Level for annual outage frequency is 158.9. The difference between the 2004 outage frequency and the Baseline Level is statistically significant.

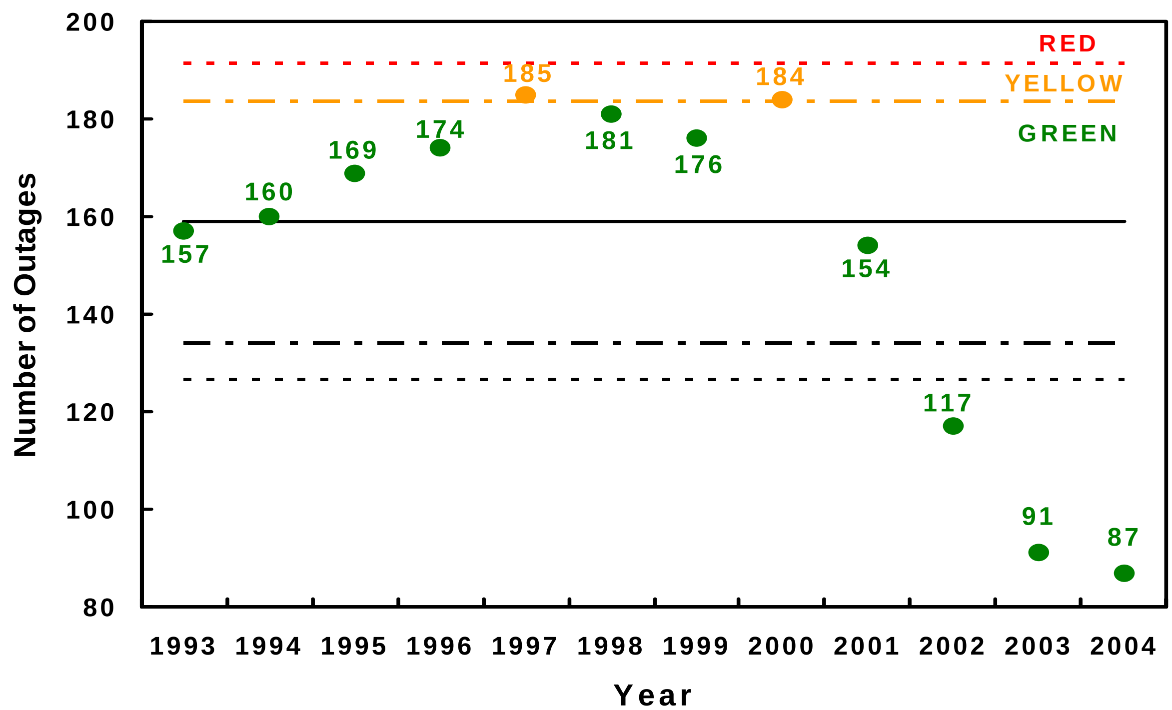


Figure 1: Annual Control Chart for Outage Frequency

Figure 2 is a control chart for outage frequency by quarter. For each quarter of 2004, the number of outages was below the quarterly Baseline Level (39.7); all quarters except 3Q04 were below the lower 95% tolerance limit indicating that these quarters had outage frequency significantly below the quarterly Baseline Level. The blue line plotting a spline fit to the quarterly data indicates a decreasing trend in outage frequency since 2000. A fit to data from 2000 to 2004 indicates this decreasing trend in outage frequency (19% annually) is statistically significant. Outage frequency has been highest in the third quarter (44.5 outages per quarter on average) while the other three quarters each have about 36.1 outages on average; these differences in seasonal outage frequency are statistically significant.

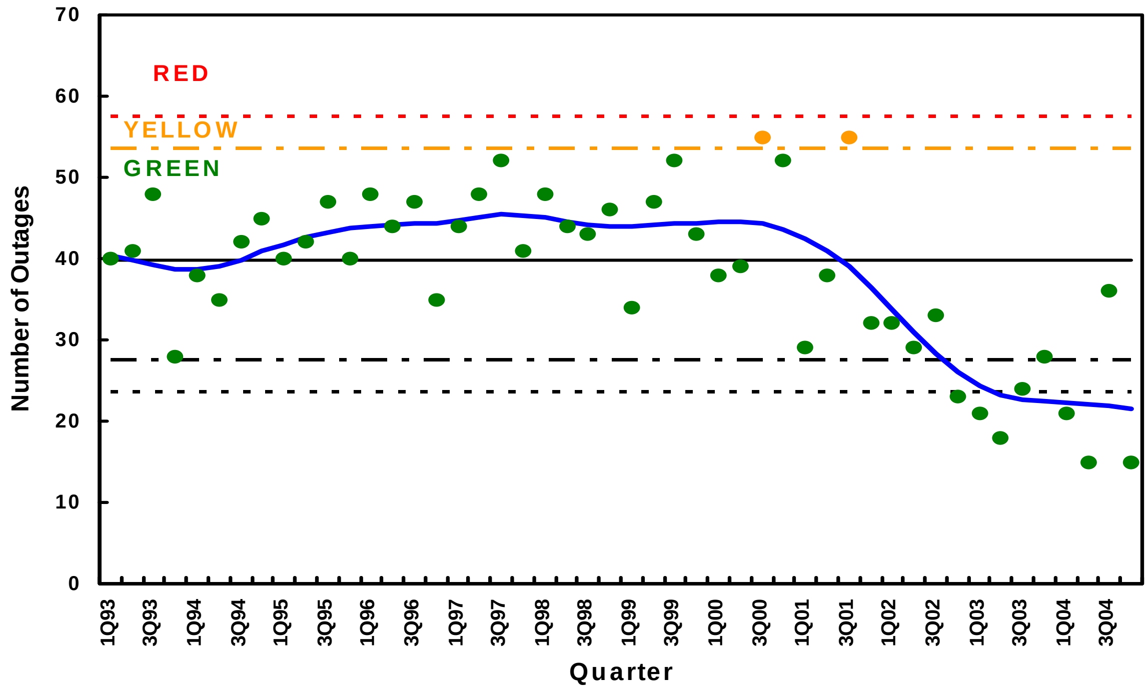


Figure 2: Quarterly Control Chart for Outage Frequency

Figure 3 provides the distribution of outage frequency by failure category: In 2004, the number of outages for each failure category was within its Green region. Conclusions based on these data are:

- *Facility*
  The number of Facility outages (27) dropped in 2004 (for the fifth consecutive year) to its lowest level to date. The difference from the Baseline Level (69.5) was statistically significant, below the 99% lower tolerance limit for the third consecutive year. It was below the Baseline Level for the fifth consecutive year. The frequency of Facility outages demonstrates a statistically significant decreasing trend (13.3% annually) since 1997. Facility outage frequency has been highest in the third quarter (19.5 outages per quarter on average) while the other three quarters each have about 15.5 outages on average; these differences in seasonal outage frequency are statistically significant. Over the 12-year history, Facility outage frequencies (65.9 outages per year, 43% of the total) are significantly higher than in any other category; this was the case in 2004 except that Facility and CCS outage frequencies were not significantly different.

- *Local Switch*
  In 2004, Local Switch outages dropped to their lowest annual frequency to date (9). The difference from the Baseline Level (23.5) was statistically significant, below the 99% lower tolerance limit for the fourth consecutive year. It was below the Baseline Level for the fifth consecutive year. The average annual frequency of Local Switch outages over the last four years (10.0) has been significantly less than in the first eight years (28.5). Over the 12-year reporting history, Local Switch outages have the second highest frequency (22.3 outages per year, 15% of the total), significantly higher than all categories except Facility and CCS. However, since 2000, it has had a lower frequency (12.4 outages per year, 10% of the total) than any category apart from DCS and Other.

- *Common Channel Signaling (CCS)*
  In 2004, the number of CCS outages declined for the fourth consecutive year to 20, near the Baseline Level (22.1). While oscillating from a high of 32 in 1993, to a low of 12 in 1996, and back to a recent high of 30 in 2000, the average annual frequency of CCS outages has no statistically significant overall trend. Over the 12-year history, the number of CCS outages has averaged 21.9 annually, 14% of the total. In 2004, CCS outage frequency was the second highest among failure categories for the fourth consecutive year. CCS outage frequency has been significantly higher than any failure category (other than Facility) over the last seven years (23.4 outages per year, 17% of all outages). CCS outages demonstrate a statistically significant seasonality effect; on average, fourth quarters have 7.0 CCS outages while the other three quarters average 5.0 CCS outages.

- *Tandem Switch*
  In 2004, the number of Tandem Switch outages was at its second lowest level to date (8). The difference from the Baseline Level (17.2) was statistically significant, below the 95% lower tolerance limit. Over the last three years, the frequency of Tandem Switch outages has been significantly less than in the first nine years (8.7 versus 19 per year). Out of all outages over the 12-year history, 11% are Tandem outages.

- *Central Office (CO) Power*
  In 2004, CO Power outage frequency (10) was below the Baseline Level (15.2) for the third consecutive year; however, the difference from its Baseline Level is not statistically significant. In the last three years, the frequency of CO Power outages has been significantly less than in the preceding peak five years 1997-2001 (10.7 versus 20.0 per year). CO Power outage frequency demonstrates statistically significant seasonality (65% of outages occur in the warmer half of the year). Out of all outages over the 12-year history, 10% are CO Power outages.

- *Digital Cross-connect System (DCS)*
  In 2004, DCS outage frequency (4) was below its Baseline Level (6.0) but this difference is not statistically significant. The frequency of DCS outages has been decreasing at the statistically significant rate of 18% annually since reaching its peak (11) in 1998. DCS outage frequency over all years (5.8 outages per year, 4% of the total) is significantly lower than in any other failure category (apart from Other).

- *Other*
  In 2004, Other outage frequency (9) was at its second highest level to date. It was above its Baseline Level (5.5), but this difference is not statistically significant. Other outage frequency has no statistically significant trend. Other outage frequency over all years (5.8 outages per year, 4% of the total) is significantly lower than in any other failure category (apart from DCS). Six of the nine Other outages in 2004 were in the Natural Disaster subcategory, significantly higher than the Natural Disaster Baseline Level (1.3 per year).

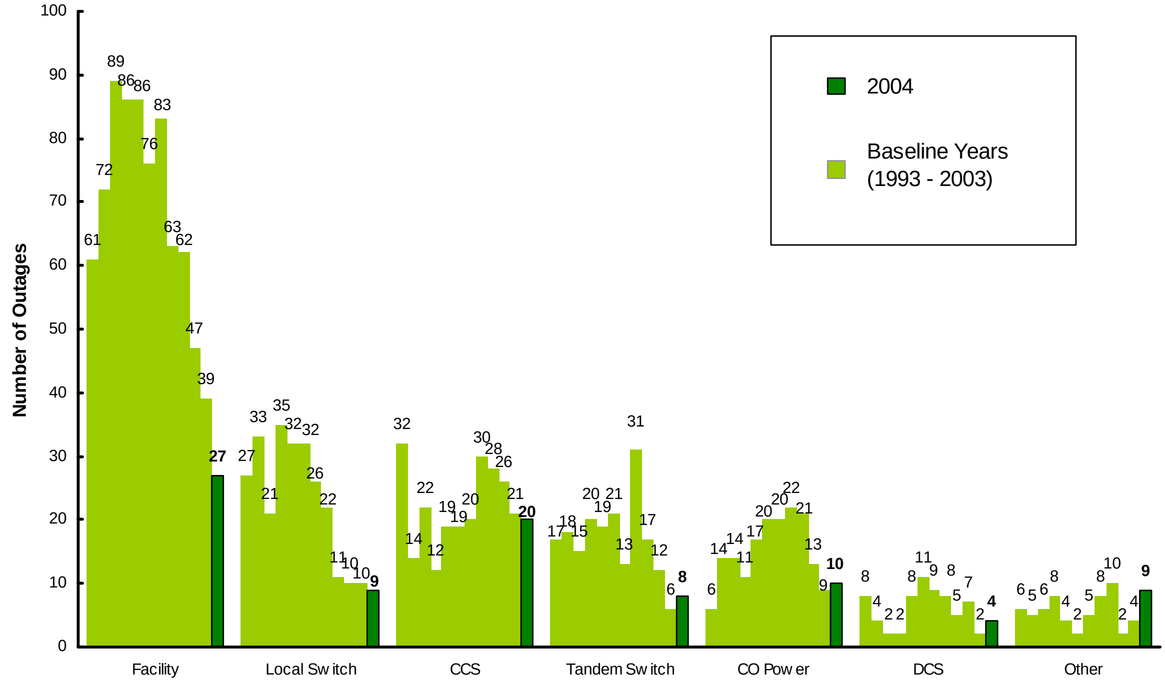


Figure 3: Number of Outages by Failure Category

PERFORMANCE BY OUTAGE DURATION

Figure 4 provides a summary of the distribution of outage duration for the twelve 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 the Baseline Years had durations less than 10.8 hours. Percentiles of the outage duration distribution are useful because statistics like the mean are severely altered by one or two very long outages. In 2004, the median (3.1 hours), mean (14.3 hours), and 90th percentile (14.3 hours) of the outage duration distribution were all higher than their Baseline values (3.0, 7.0, and 10.8 hours respectively); the 2004 mean and 90th percentile had their highest annual values to date. Median outage duration in the last four years has been significantly higher than in the first eight years (3.30 versus 2.86 hours).

Analyses by failure category (Figure 5) show that Facility outages have significantly longer durations than outage durations in other failure categories (except Other) while Local Switch and CCS outages have significantly shorter durations.

Analysis of the data provides the following additional observations:

- The median Tandem Switch outage duration over the last three years (3.5 hours) is significantly longer than over the first nine years (2.4 hours).
- In 2004, CCS outages had their highest median duration to date (2.6 hours). Over the last five years, their median duration has been significantly longer than in the first seven years (1.73 versus 1.25 hours)

- In 2004, the median duration of Facility outages dropped to its lowest value to date (3.9 hours); over the last six years (1999-2004), the duration of Facility outages has been significantly lower (median 4.5 hours) than in the first six years (median 5.2 hours).
- In 2004, the median duration of CO Power outages reached its highest value to date (5.5 hours), significantly higher than their Baseline median (2.4 hours). The median duration over the last two years (3.9 hours) has been significantly higher than the median over the first ten years (2.4 hours).
- In 2004, the median duration of Other outages was the second longest of all years (34 hours), significantly greater than the Baseline median (3.6 hours). Three of the six longest Other outage durations to date occurred in 2004 including the second longest of 17 days. Over the last four years, Other outages (median 8.9 hours) have been significantly longer than in the first eight years (median 3.3 hours).
- 2004 had an outage with the second longest duration among Local Switch outages to date (46 hours, 4 minutes).

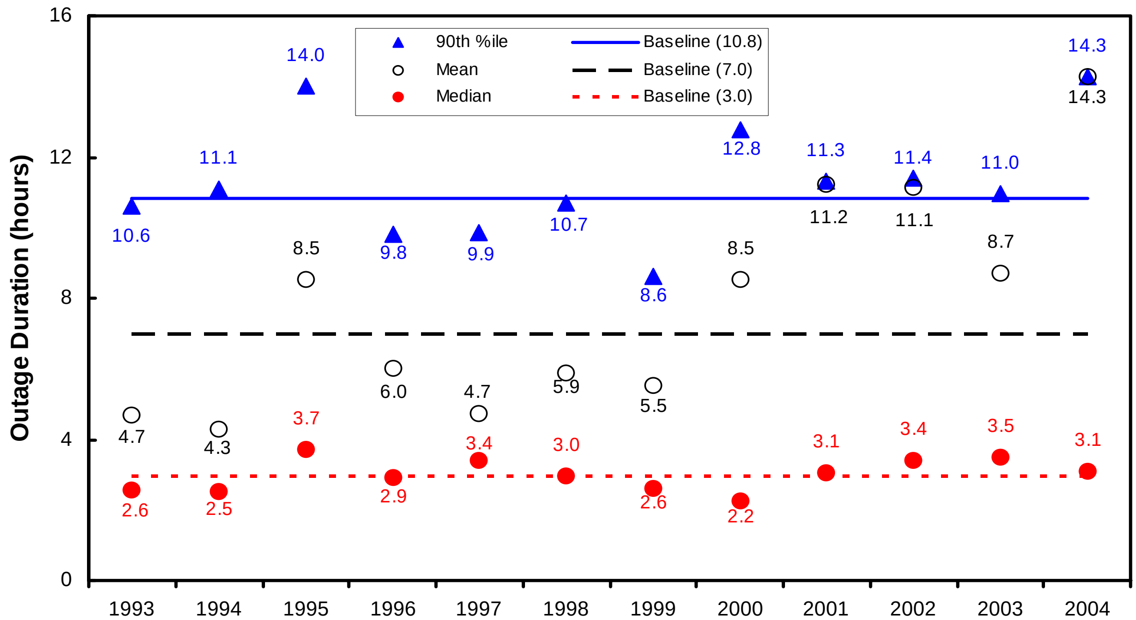


Figure 4: Annual Distributions of Outage Durations

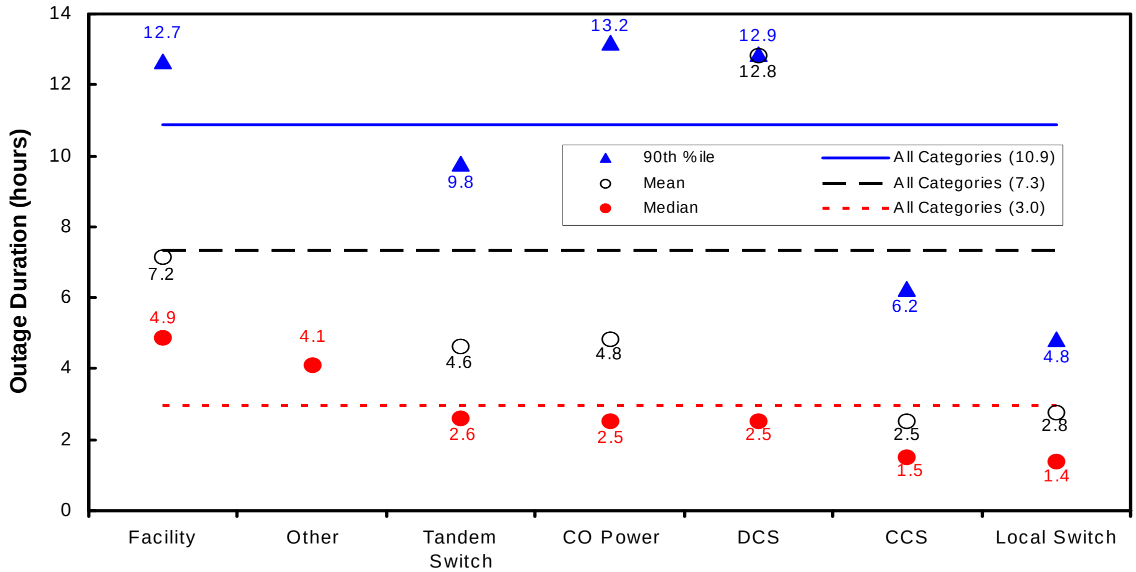


Figure 5: Distributions of Outage Durations by Failure Category
(Not Shown: Other Mean – 39.3 hours, Other 90th %ile – 140.7 hours)

PERFORMANCE BY CUSTOMERS POTENTIALLY AFFECTED

Figure 6 depicts the major statistics for the number of customers potentially affected per outage for each year from 1993 to 2004. 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). In 2004, the median (67,100), mean (175,000), and 90th percentile (373,300) of the customers potentially affected distribution were all higher than their Baseline values (55,200, 157,800, and 230,400 respectively). The 2004 median was the highest annual median to date.

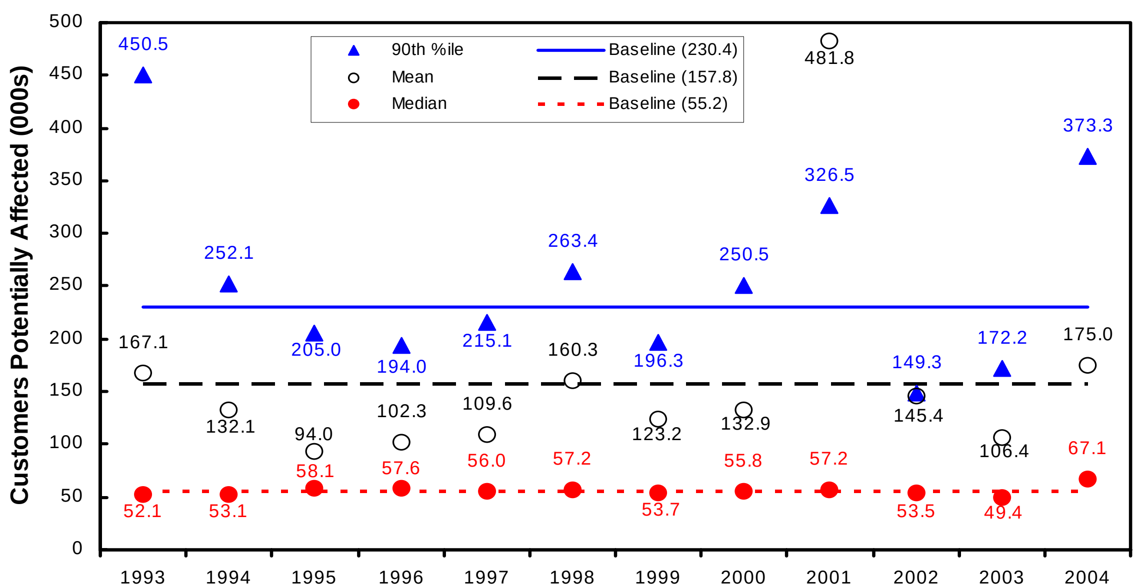


Figure 6: Annual Distributions of Customers Potentially Affected per Outage

Analyses by failure category (Figure 7) show that Tandem Switch and DCS outages potentially affect significantly more customers than do outages in other failure categories (except Other) while Local Switch and CCS outages affect significantly less customers.

Analysis of the data provides the following additional observations:

- In 2004, CO Power outages had their highest median customers potentially affected to date (111,800).
- In 2004, Facility outages had their highest median customers potentially affected since 1995 (69,200). Nevertheless, the median over the last three years (51,900) has been significantly less than in the first nine years (64,700).
- In 2004, the median number of customers potentially affected by CCS outages dropped to its lowest level to date (43,200).
- Over the last five years, the median number of customers potentially affected by Other outages has been significantly greater than in the first seven years (123,900 versus 50,000).
- 2004 had an outage with the greatest number of customers potentially affected among Local Switch outages to date (2.9 million).

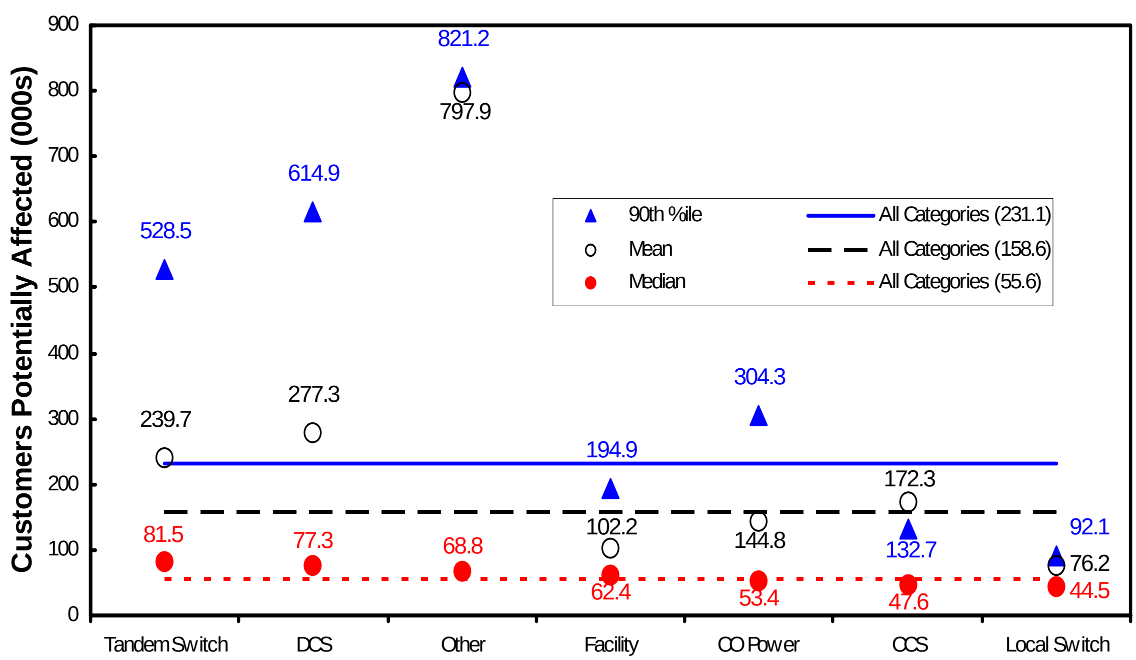


Figure 7: Distributions of Customers Potentially Affected by Failure Category

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 combined the duration of the outage, the number of customers affected, and the services affected into a 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 sum of the individual outage indexes in that collection. 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

Annual aggregated outage indexes are given in Figure 8. The Baseline Level for annual aggregated outage index is 1551. The aggregated outage index in 2004 was below this level at its second lowest value to date (1269); this difference is not statistically significant. While the aggregated outage index does not have a statistically significant trend, the annual average over the last three years (1245) has been significantly lower than in the first nine years (1621).

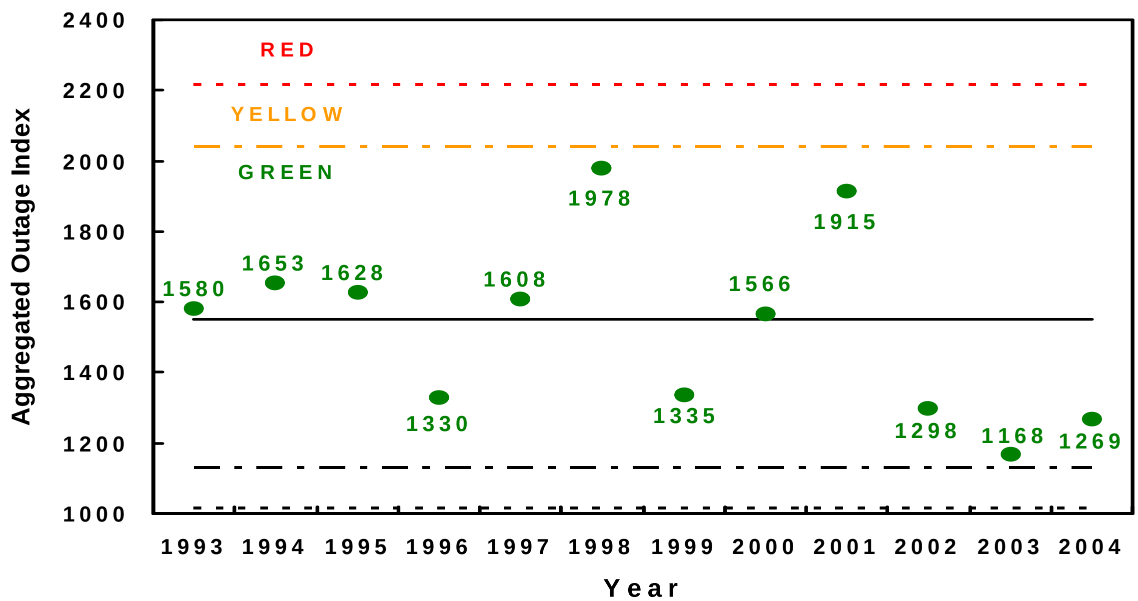


Figure 8: Annual Aggregated Outage Index Control Chart

Figure 9 provides a control chart of the quarterly aggregated outage index from 1993 to 2004. The blue line is a spline fit to the data. 4Q04 had the lowest aggregated outage index of any quarter to date (101). Along with 2Q04, it was significantly below the quarterly Baseline Level (388). 3Q04 had the highest quarterly aggregated outage index to date (808), significantly higher than the Baseline Level. 3Q04 had three of the nineteen highest aggregated outage indexes to date; all three were Other outages from Natural Disasters, (Hurricane Charley (169), Hurricane Frances (81), and Hurricane Jeanne (68)).

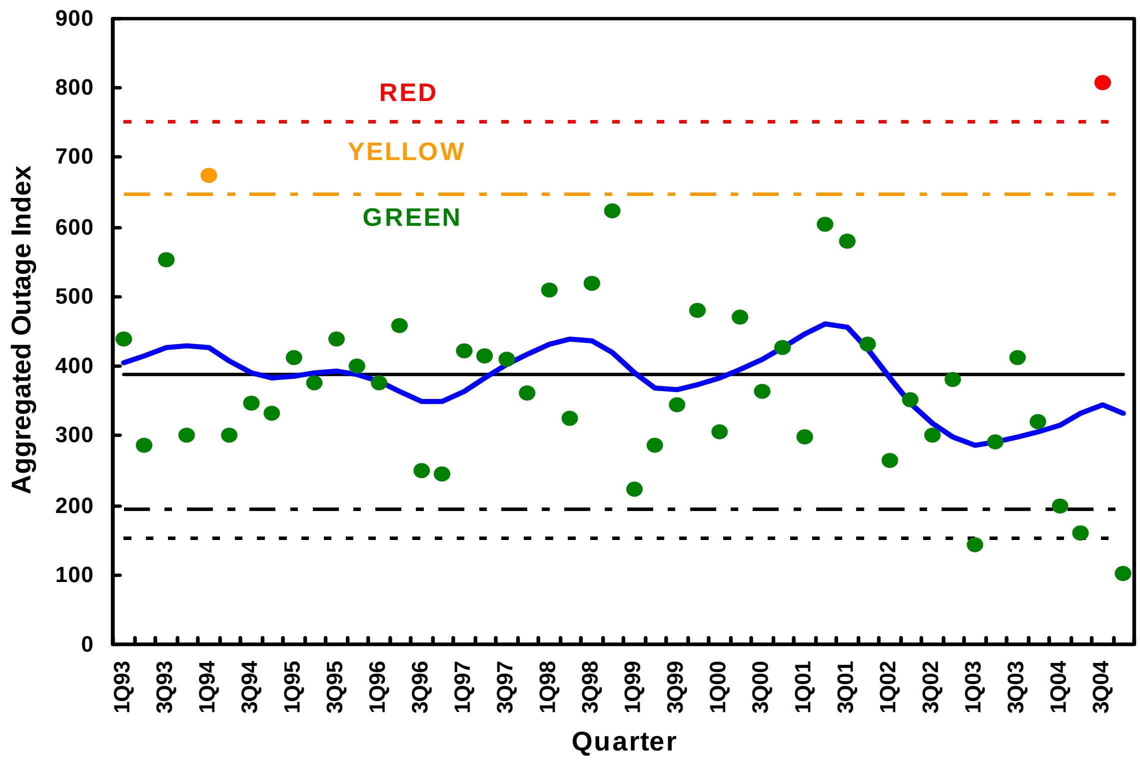


Figure 9: Quarterly Aggregated Outage Index Control Chart

The annual aggregated outage index for each failure category is given in Figure 10. In 2004, the aggregated outage index for each failure category (except Other) was within its Green region.

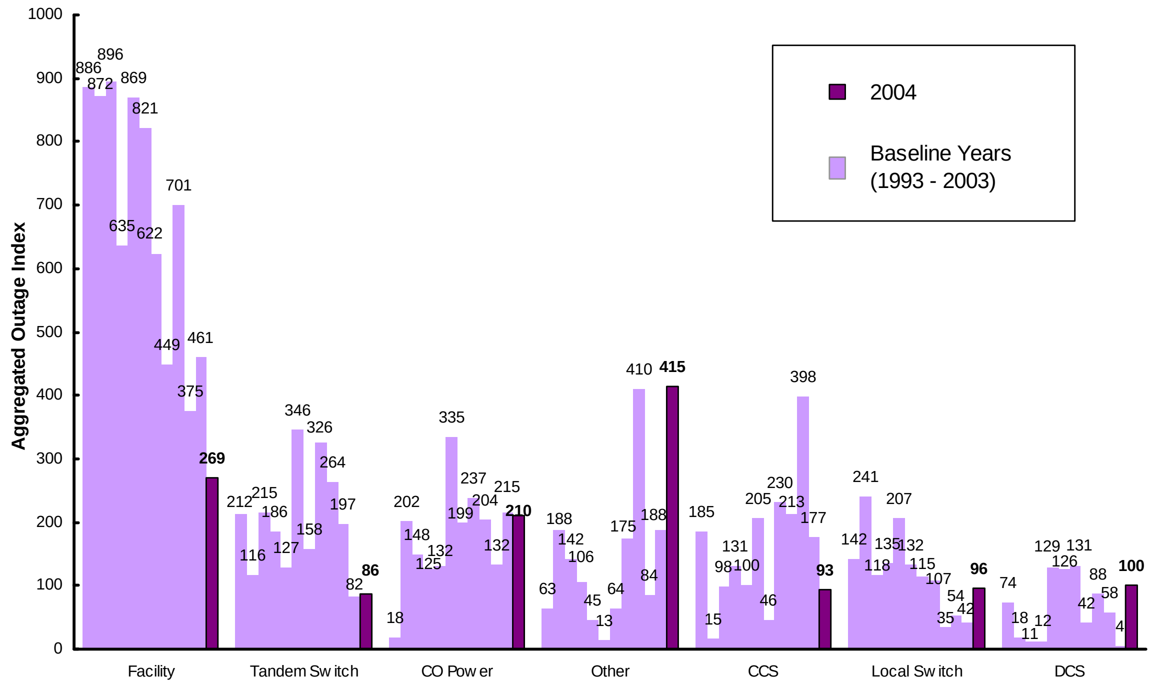


Figure 10: Annual Aggregated Outage Index by Failure Category

Conclusions based on these data are:

- *Facility*
  In 2004, the annual aggregated outage index for Facility outages (269) was at its lowest level to date, significantly lower than its Baseline Level (690). It has a statistically significant decreasing trend of 8% per year over the entire 12-year history. Over the 12-year history, the aggregated outage index for Facility outages is significantly higher than in any other failure category (655 annually, 43% of the total).

- *Tandem Switch*
  The 2004 annual aggregated outage index for Tandem Switch outages was at its second lowest level to date (86), but not significantly below its Baseline Level (203). Tandem Switch aggregated outage index has no statistically significant overall trend, but in the last two years, the annual average has been significantly lower (84) than it was in the first 10 years (215). Over the 12-year history, Tandem Switch outages have the second highest aggregated outage index among failure categories (13% of the total aggregated outage index), but 2004 was the first year that Tandem Switch outages had the lowest aggregated outage index.

- *Central Office (CO) Power*
  In 2004, CO Power aggregated outage index (210) was above its Baseline Level (177) for the sixth year out the last seven years; however, this difference was not statistically significant and there is no statistically significant overall trend. Over the 12-year history, CO Power outages account for 12% of the total aggregated outage index.

- *Common Channel Signaling (CCS)*
  The 2004 CCS aggregated outage index (93) was below the Baseline Level (163) for the first year since 1999; this difference is not statistically significant. Its annual aggregated outage index has

no statistically significant trend. Over the 12-year history, CCS outages account for 10% of the total aggregated outage index.

- *Other*
  In 2004, the Other aggregated outage index (415) was at its highest level to date, significantly greater than its Baseline Level (134). Three of the seven highest Other outage indexes occurred in 2004 including the highest (169). The average annual aggregated outage index for Other outages has been significantly higher over the last five years (254) compared to the first seven years (89). Over the 12-year history, Other outages account for 10% of the total aggregated outage index; however, in 2004, Other outages had the highest aggregated outage index among all failure categories for the first time (32% of the 2004 aggregated outage index). In 2004, 89% of the Other aggregated outage index was from Natural Disaster outages (371), significantly higher than the Natural Disaster Baseline Level (51 per year).

- *Local Switch*
  In 2004, Local Switch outages had their highest annual aggregated outage index since 2000 (96). The index was below the Baseline Level (121) for the sixth consecutive year, but the difference was not statistically significant. The Local Switch annual aggregated outage index has been significantly lower over the last four years (57) compared to the first eight years (150). Since 1998, the Local Switch aggregated outage index (83 annually, 6% of the total) has been significantly lower than all failure categories except DCS. Local Switch outages account for 8% of the total aggregated outrage index over all years.

- *Digital Cross-connect System (DCS)*
  The 2004 DCS aggregated outage index rose to its highest level since 1999 (100). It was higher than its annual Baseline Level (63), but not significantly. 2004 had an outage with the second highest outage index to date among DCS outages (57). Over the entire 12-year history, the aggregated outage index for DCS outages (66 annually, 4% of the total) was significantly lower than in any other failure category. The average annual DCS aggregated outage index has been significantly higher over the last eight years (85) compared to the first four years (29).

OUTAGE INDEX DISTRIBUTIONS

Assuming that a FCC-reportable outage occurs, an important question is whether the severity of that outage has changed over the years. The outage index for an outage measures the severity of that outage. Figure 11 presents summaries of the outage index distribution by year. In 2004, the median (4.5), mean (14.6), and 90th percentile (42.0) of the outage index distribution were all higher than their Baseline values (4.0, 9.8, and 27.8 respectively); the mean and 90th percentiles were the highest of any year to date. This is the fourth consecutive year that the median, mean, and 90th percentile of the annual outage index distributions have been above their Baseline Levels; over the last four years, outage indexes have been significantly greater than in the first eight years (4.7 versus 3.8 median). 2004 had an outage with the second highest outage index to date (169) resulting from Hurricane Charley in August 2004; the highest outage index to date is 206.

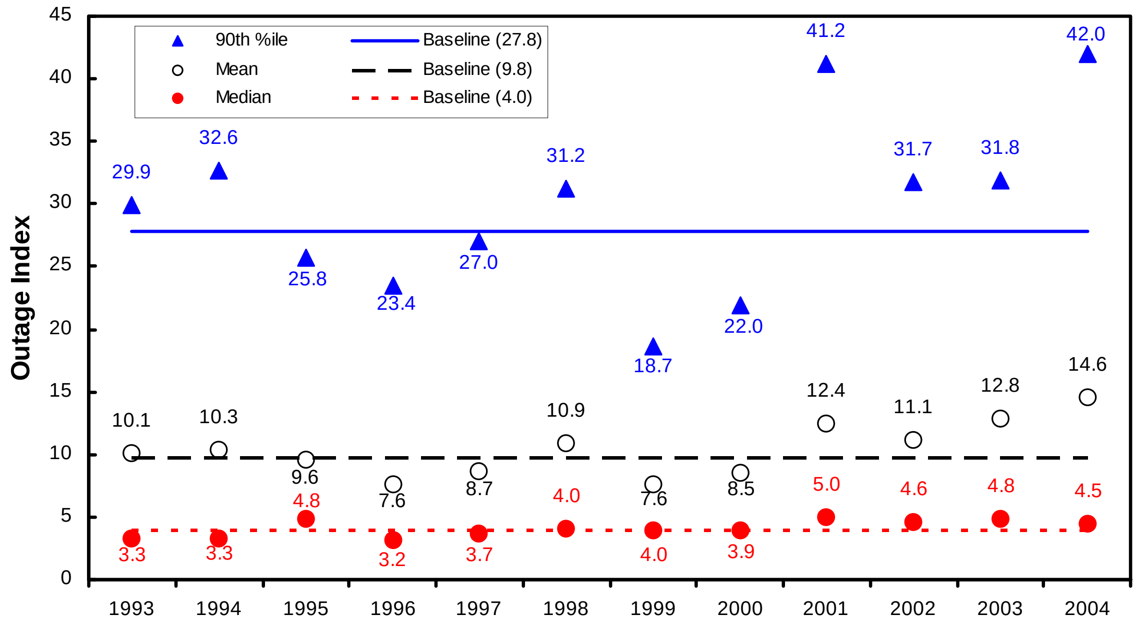


Figure 11: Annual Distributions of Outage Index per Outage

Analyses by failure category (Figure 12) show that Other outages have significantly higher indexes than do outages in other failure categories, while CCS outages have significantly lower indexes. Local Switch outages have significantly lower indexes than other categories except CCS.

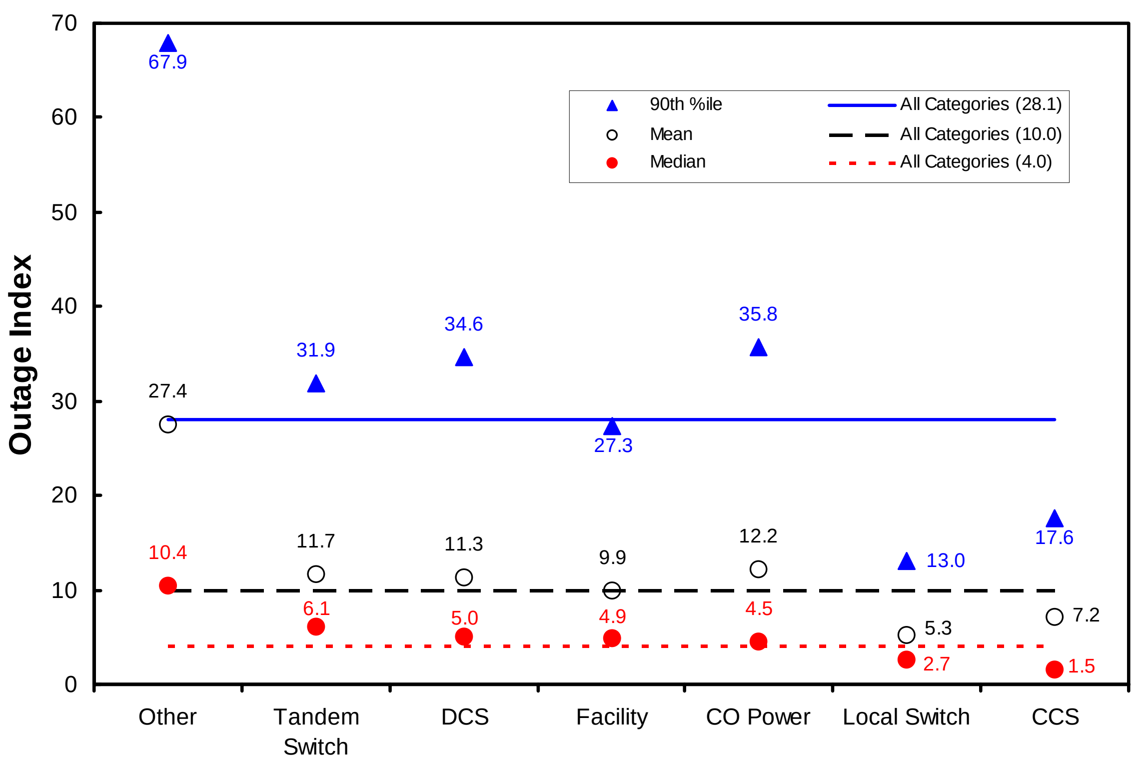


Figure 12: Distributions of Outage Index by Failure Category

Analysis of the data provides the following additional observations:

- The outage indexes for CCS outages have been significantly higher over the last three years than in the first nine years (3.8 versus 1.0 median).
- Over the last four years, the median index for Other outages (27.9) has been significantly greater than in the first eight years (7.2).
- In 2004, Facility outages had their lowest median outage index to date (3.1). Over the last nine years, Facility outage indexes have been significantly less than over the first three years (4.6 versus 7.1 median).
- In 2004, CO Power outages had their highest median outage index to date (22.1); outage indexes were significantly higher in 2004 than in the Baseline Years (4.3 median). Over the last two years, CO Power outage indexes have been significantly greater than over the first ten years (11.5 versus 4.2 median).
- In 2004, DCS outages had their highest median outage index to date (17.6), significantly greater than their median in the Baseline Years (4.1).
- In 2004, Local Switch outages had their highest mean outage index to date (10.6). The mean was heavily influenced by an outage with the highest Local Switch outage index to date (71); this outage potentially affected 2,900,000 customers over 105 minutes.

OUTAGE METRICS RELATIVE TO NETWORK CHANGE

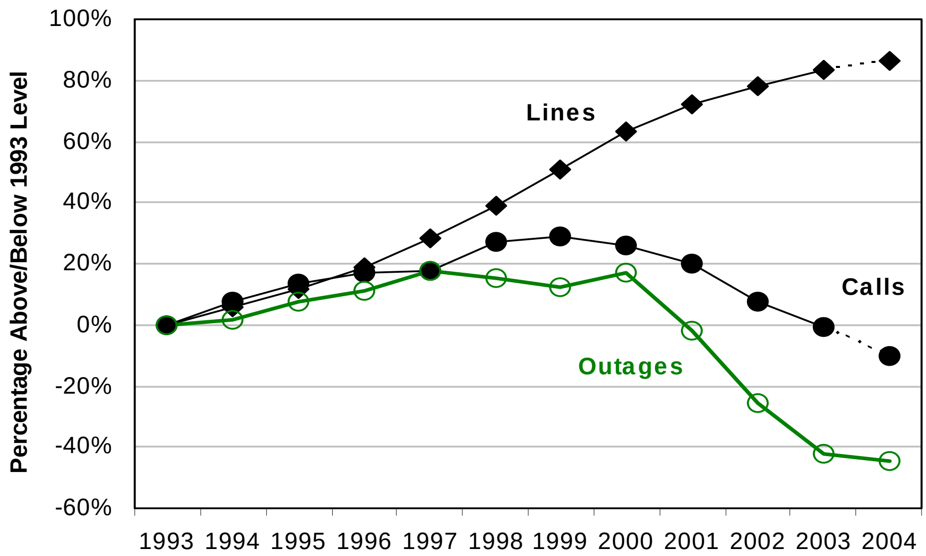
The public telecommunications network is continually changing. More lines and facilities are added, switches are centralized or decentralized, the signaling network is expanding, etc. Table 1 presents two metrics (lines and calls) for network change in absolute terms. These two metrics are relevant particularly 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.

The data in Table 1 reflects lines and calls reported exclusively by Incumbent Local Exchange Carriers (ILECs). Only recently have lines data from Competitive Local Exchange Carriers (CLECs) become available. No data is available on CLEC calls. Since CLEC data was incomplete, this analysis was performed with respect only to ILEC network change. As such, the results are conservative in the sense that network size is slightly underestimated.

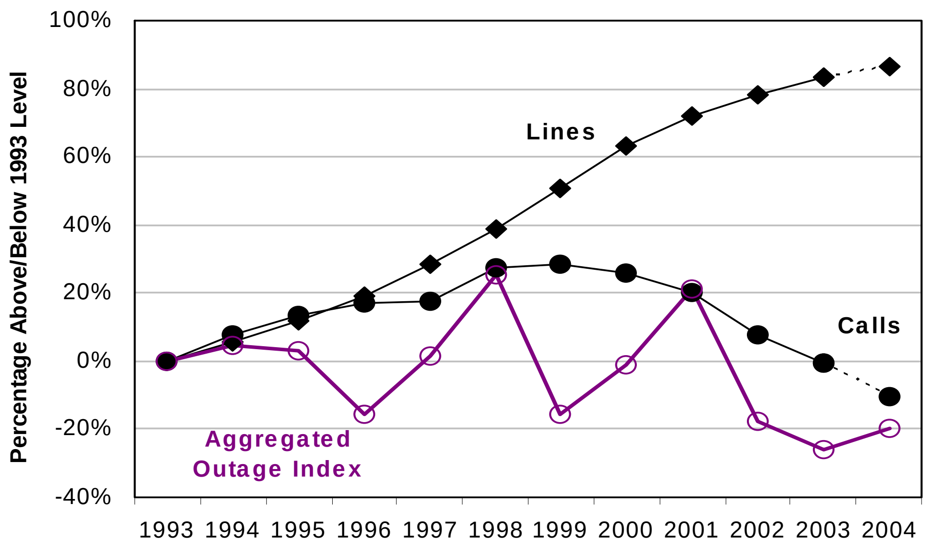
Table 1: Network Change Metrics

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
2000	244.8	642,500
2001	252.8	613,200
2002	262.2	549,300
2003	267.8	505,800

Figure 13 plots the annual network change data in Table 1 and annual network outage metrics from Figures 1 and 4 (relative to their 1993 levels) versus year. The 1993 call level (510 billion calls) is taken directly from Table 1; the 1993 line level is the average of the number of lines on December 31, 1992 and December 31, 1993 (144.7 million lines). (The dashed lines indicate extrapolation to the year 2004.[2])



(a) Outage Frequency and Network Change



(b) Aggregated Outage Index and Network Change

Figure 13: Annual Network Change and Outage Metrics over Time

[2] The extrapolation is based solely on data from past years in Table 1.

Figure 13a indicates that, in every year after 1993, 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 13b 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 (except 2001) after these values have been scaled relative to 1993 levels. Generally, the figure indicates that network outage measures have increased at a slower rate since 1993 than standard measures of network size and call volume.

In 1995, Working Group T1A1.2 developed normalization techniques that adjusted overall outage frequency and aggregated outage index subject to network change. These adjustments allowed the direct comparison of these metrics independent of the change in network size. The concept is similar in spirit to the way economists adjust prices or costs for inflation across years. These techniques were published in Committee T1 Technical Report No. 42 "A Technical Report on Enhanced Analysis of FCC-Reportable Service Outage Data." Past ATIS/NRSC annual reports (except 1998 – 2001) provided normalized outage frequency and aggregated outage index using these techniques. This report provides a normalized outage frequency and a normalized aggregated outage index for 2004. The normalization was performed relative to calendar year 1993.[3] That is, the 2004 normalized outage frequency may be compared to the 1993 outage frequency and the 2004 normalized aggregated outage index may be compared to the 1993 aggregated outage index. Normalizing relative to 1993, the Call Normalization Factor (CNF) is the total number of calls in 2004 divided by the total number of calls in 1993:

$$\text{CNF} = 457.5 \text{ billion} / 510.0 \text{ billion} = 0.897$$

and the Line Normalization Factor (LNF) is the total number of lines in mid-2004 divided by the total number of lines in mid-1993:

$$\text{LNF} = 269.73 \text{ million} / 144.66 \text{ million} = 1.865.$$

CNF and LNF are used to normalize the reporting thresholds for customers affected assuming that the thresholds were created based on the percentage of all customers in the nation affected. Under normalization, only those outages in which at least

30,000 x LNF = 30,000 x 1.865 = 55,950 subscriber lines were affected

or

90,000 x CNF = 90,000 x 0.897 = 80,730 calls were blocked

are counted in the 2004 normalized outage frequency. Only these outages are used in calculating the 2004 normalized outage index. In addition, each outage index is normalized by dividing CNF or LNF into customers affected in the determination of the Magnitude Weight. The 2004 normalized aggregated outage index is the sum of these individually normalized outage indexes.

Table 2 presents the results of normalization of 2002, 2003, and 2004 outage frequency and aggregated outage index. The results indicate that while these years demonstrate substantial

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[3] The normalization of outage frequency and aggregated outage index in the 1994 through 1997 annual reports was performed relative to the Baseline Year (July 1, 1992 through June 30, 1993). Since then, the annual reports have shifted to a calendar year basis.

improvement over 1993 based on the standard metrics, this improvement is even greater when adjustment is made for change in the network.

Table 2: Normalization of Outage Frequency and Aggregated Outage Index (2002 - 2004)

Year	Method	Number of Outages	Aggregated Outage Index
1993	Standard/Normalized	157	1580
2002	Standard	117	1298
	Normalized	91	950
2003	Standard	91	1168
	Normalized	65	843
2004	Standard	87	1269
	Normalized	66[4]	901

[4] With CNF less than 1 in 2004, the normalized blocked calls reporting threshold is less than 90,000 blocked calls. Thus, if the normalized threshold had been used for reporting requirements, several additional outages would have been required to be reported that were not reported. Such unreported outages would be those with (i) less than 30,000 customers, and (ii) with blocked calls greater than 80,730 and less than 90,000. Based on an analysis of outages reported in the Baseline Years, 2004 is expected to have had 2 additional outages of this type. Thus, the number of outages under normalization (66) presented in Table 2 is the sum of the 64 reported to the FCC that exceeded the normalized thresholds and the estimated two outages that would have been reported. No adjustment was made to the 2004 normalized aggregated outage index as the outage indexes for the two outages that would have been reported would be too small to increase the aggregated outage index significantly.

ROOT CAUSE ANALYSIS

This section provides a root cause analysis of outages in the major failure categories (Facility, Local Switch, CCS, Tandem Switch, CO Power, and DCS failures) as well as outages from Procedural Errors. 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."

FACILITY

Figures 14 and 15 display the annual number of outages and annual aggregated outage index with respect to Facility failure subcategories.

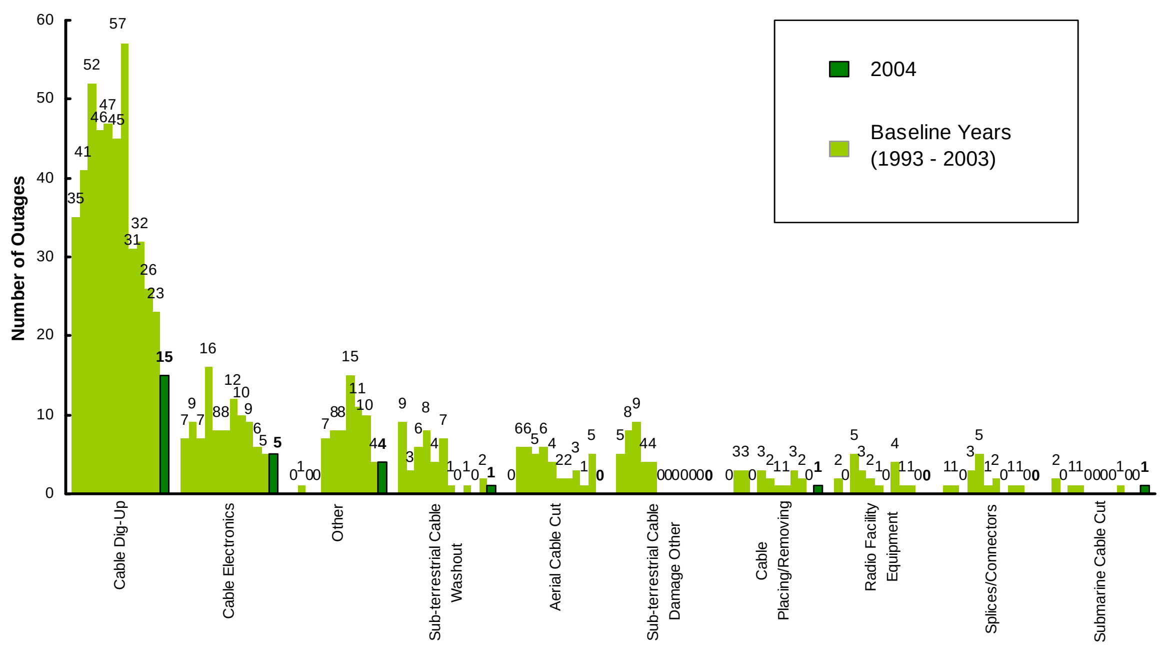

Figure 14: Number of Outages by Facility Failure Subcategory

Over the 12-year history, Cable Dig-up (57%), Cable Electronics (13%), and Other (9%) have been the dominant Facility failure subcategories. While they continued to dominate in 2004, the Cable Dig-Up (DU) subcategory had its lowest annual frequency to date (15), significantly lower than its Baseline Level (39.5 per year). Cable DUs demonstrate a statistically significant seasonality effect; 38% less Cable DU outages occur in the first quarter as compared to the rest of the year. Since 1998, the frequency of Cable Dig-Up outages has been decreasing at the statistically significant rate of 17% per year. The passage of One-Call legislation in June 1998 is a likely factor in this decrease. 2004 matched the fewest Cable Electronics outages to date (5); its frequency has dropped at the statistically significant rate of 18% annually since 1999. In 2004, the number of Other subcategory outages matched its lowest number (4) since 1996. The average Other outage frequency has been significantly less over the last two years (4 per year) than over the peak period 1997 – 2002 (9.8 per year). Nevertheless, over the last eight years, more Facility outages have occurred in the Other subcategory (8.3 per year) than in any other subcategory aside from Cable DU. In the last six years, the number of Sub-terrestrial Cable Washout outages (0.8 per year) has been significantly lower than in the first six years (6.2 per year); over the 12-year history, this subcategory demonstrates a statistically significant seasonality effect; first quarters have 1.9 such outages per year, second quarters 0.5 per year, third quarters 0.8 per year, and fourth quarters 0.3 per year. 2004 was the first year since 1993 with no Aerial Cable Cut outages; their frequency has been decreasing at the statistically significant rate of 13% annually since 1994. 2004 was the seventh consecutive year with no Sub-terrestrial Cable Damage Other outages; its outage frequency has been significantly less over that period than in the first five years (6 per year). For the second consecutive year, the Radio Facility Equipment subcategory had no outages in 2004; since reaching its peak in 1995 (5 outages), its frequency has declined at the statistically significant rate of 23% annually. The frequency of outages in the Splicers/Connectors subcategory has a statistically significant decreasing rate of 32% per year since 1996.

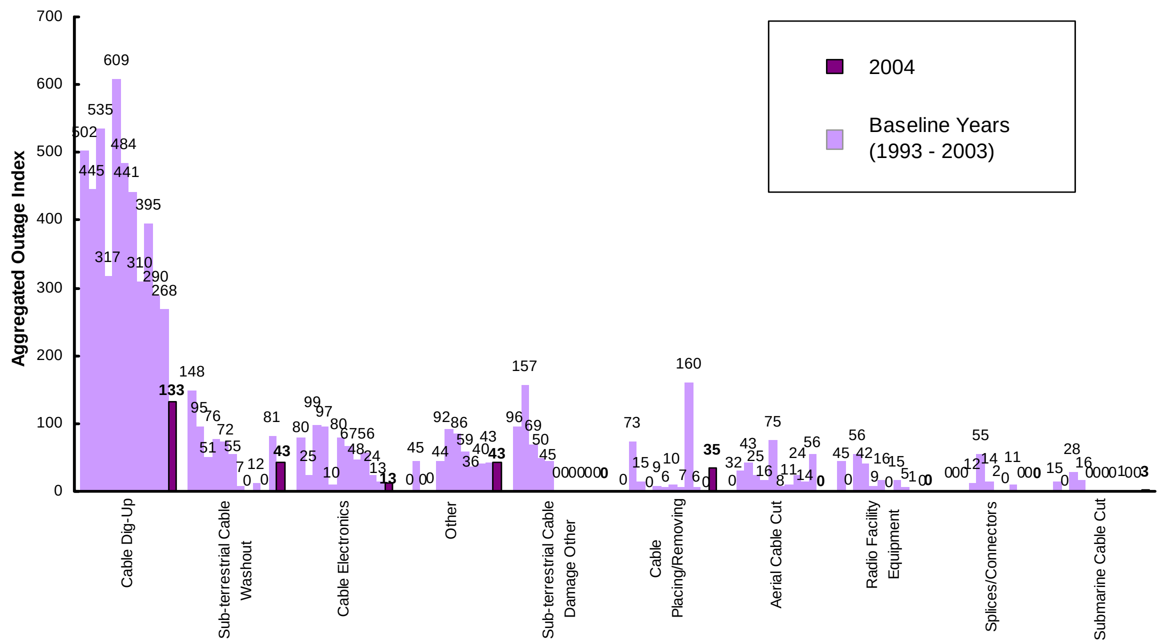

Figure 15: Outage Index Aggregated Annually by Facility Failure Subcategory

Cable DUs dominate Facility outages from the outage index perspective as well (60% over 12 years of reporting). In 2004, Cable DUs had their lowest aggregated outage index to date (133); it was significantly less than its Baseline Level (418). Since 1998, the aggregated outage index of Cable Dig-Up outages has been decreasing at the statistically significant annual rate of 15%. In 2004, the Cable Electronics aggregated outage index dropped to its lowest level 13.0 since 1997; the annual aggregated outage index for Cable Electronics outages has been decreasing at the statistically significant rate of 32% annually since 1998. In 2004, the Other subcategory aggregated outage index increased for the third consecutive year; however, it has remained close to its Baseline Level (40.5 per year) over that period. While it has been close to its Baseline Level (54 per year), the Sub-terrestrial Cable Washout aggregated outage index has been significantly higher in the last two years (62 per year) than in its low period 1999 – 2002 (5 per year). The Radio Facility Equipment subcategory aggregated outage index has been significantly lower in the last eight years than in the first four years (6 versus 36 per year).

The dominant root cause categories with respect to frequency are Cable Damage (41%), Procedural Service Provider (27%), and External Environment (14%);[5] these differences are statistically significant. However, over the last five years, the frequencies of Cable Damage and Procedural Service Provider outages are not significantly different (16.8 versus 15.2 per year respectively). 2004 had the lowest number of Cable Damage outages to date (10), significantly lower than its Baseline Level (28.9). In the last five years, the number of Cable Damage outages has been significantly less than in the first seven years (16.8 versus 34.9 per year). In 2004, the number of Facility outages attributed to the Procedural Service Provider root cause had its second lowest annual frequency to date (5), significantly lower than its Baseline Level for the second consecutive year (18.7 per year). The average number of Procedural Service Provider outages over the last two years (4.5 per year) has been significantly lower than over the first ten years (20.2 per year). The frequency of External Environment outages dropped to its lowest level to date in 2004 (2), significantly lower than its Baseline Level (9.7 per year). Over the last six years, the frequency of External Environment outages has been significantly lower than in the first six years (5.0 versus 13.2 per year). In 2004, Facility outages attributed to Design Hardware[6] had their highest frequency since 1997 (7)[7]. Since achieving a 12-year low of no outages in 1998, Design Hardware outage frequency has been increasing at the statistically significant rate of 27% annually over the last six years. Despite dropping to its lowest annual level since 1997 (1 in 2004); the frequency of Facility outages attributed to Hardware Failure has been significantly greater over the last seven years (3.9 per year) versus the first five years (1.0 per year). In addition, there was one outage attributable to Design Software and one attributable to Procedural Other Vendor.

The same three root causes are dominant with respect to the aggregated outage index over the 12 year history: Cable Damage (44%), Procedural Service Provider (24%), and External Environment (16%). 2004 had the lowest aggregated outage index for Cable Damage outages to date (45), significantly lower than its Baseline Level (307 per year); over the last 11 years, the annual aggregated outage index for Cable Damage outages has a statistically significant decreasing rate of 12% annually. The average aggregated outage index of Facility outages attributed to the Procedural Service Provider root cause over the last two years (71) has been significantly lower than over the first ten years (175 per year). 2004 had the lowest aggregated outage index for External Environment outages to date (19), significantly lower than its Baseline Level (114 per year); over the 12-year history, the annual aggregated outage index for External Environment outages has been decreasing at the statistically significant rate of 19% annually. In 2004, the aggregated outage index of Design Hardware outages reached its highest level since 1996 (92), significantly greater than its average over

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[5] In 2002, all outages with the Inaccurate Cable Locate and Cable Unlocated root cause subcategories were re-classified as having a Procedural Service Provider root cause category. This re-classification produced several differences in annual reports after 2001 relative to prior annual reports, particularly with respect to Facility outages and Procedural Error outages.

[6] Included in the Design Hardware root cause category are those outages with a root cause subcategory of insufficient redundancy/diversity, to include system design with unnecessary aggregation of component features and network design with unnecessary aggregation of systems or system/network deployment with single-point-of-failure configurations.

[7] Across all outage categories there were 12 Design Hardware outages in 2004 compared to an average of 10.6 per year in the Baseline Years—this difference is not statistically significant. Similarly, Design Hardware represented 7% of outages in the Baseline Years and 14% of outages in 2004. This apparent growth in Design Hardware outages is as a result of the drop in the overall number of outages in 2004.

the previous six years (17 per year). In 2004, the aggregated outage index for Facility outages attributed to Hardware Failure dropped to its lowest level since 1994 (2.4). The aggregated outage indexes for other Facility sub-categories were not noteworthy for 2004.

CABLE DIG-UP

Cable Damage (68%) and Procedural Service Provider (25%) are the dominant root causes of Cable Dig-Up outages. 2004 had the lowest number of Cable Damage outages of all years to date (9), significantly lower than its Baseline Level (27 per year). Over the last five years, Cable Damage frequency (15.8 per year) was significantly lower than in the previous seven years (32.4 per year). In 2004, the aggregated outage index of Cable Dig-Up outages attributable to Cable Damage also had its lowest value to date (42), significantly lower than its Baseline Level (283 per year); since reaching its peak value of 437 in 1997, its annual aggregated outage index has been decreasing at the statistically significant rate of 21% annually.

Looking at the root cause subcategories of Cable Damage Facility outages, Inadequate/No Notification (52%) and Digging Error (44%) have been the biggest contributors; there is no significant difference in the frequencies of these two subcategories over the 12-year history. In 2004, the number of Inadequate/No Notification outages dropped to its lowest value to date (1), significantly lower than its Baseline Level (14.4 per year); over the last five years, the frequency of these outages has been significantly less than in the first seven years (6.4 versus 18.1 per year). The frequency of Digging Errors has a statistically significant decreasing trend (16% annually) since its peak (19) in 1998.

With respect to the Cable Damage Facility aggregated outage index, the dominant root cause subcategories are also Inadequate/No Notification (56%) and Digging Error (41%). In 2004, the aggregated outage index for Inadequate/No Notification dropped to its lowest value to date (2), significantly lower than its Baseline Level (160). Over the last six years, the aggregated outage index for Inadequate/No Notification has been significantly less (88 per year) than in the first six years (205 per year). The Digging Error aggregated outage index has a statistically significant decreasing trend (24% annually) since 1997. Figures 16 and 17 present the number of outages and aggregated outage index for the Cable Damage root cause subcategories of Cable DU.

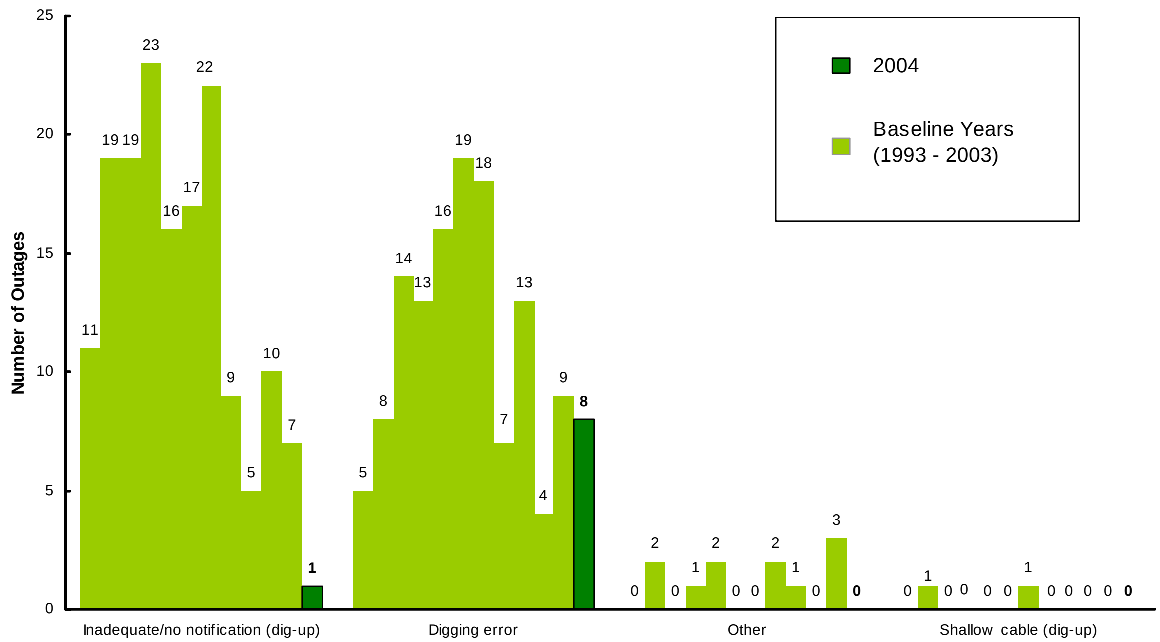

Figure 16: Number of Outages by Cable Damage Root Cause Subcategories of Cable Dig-Up (DU) Facility Outages

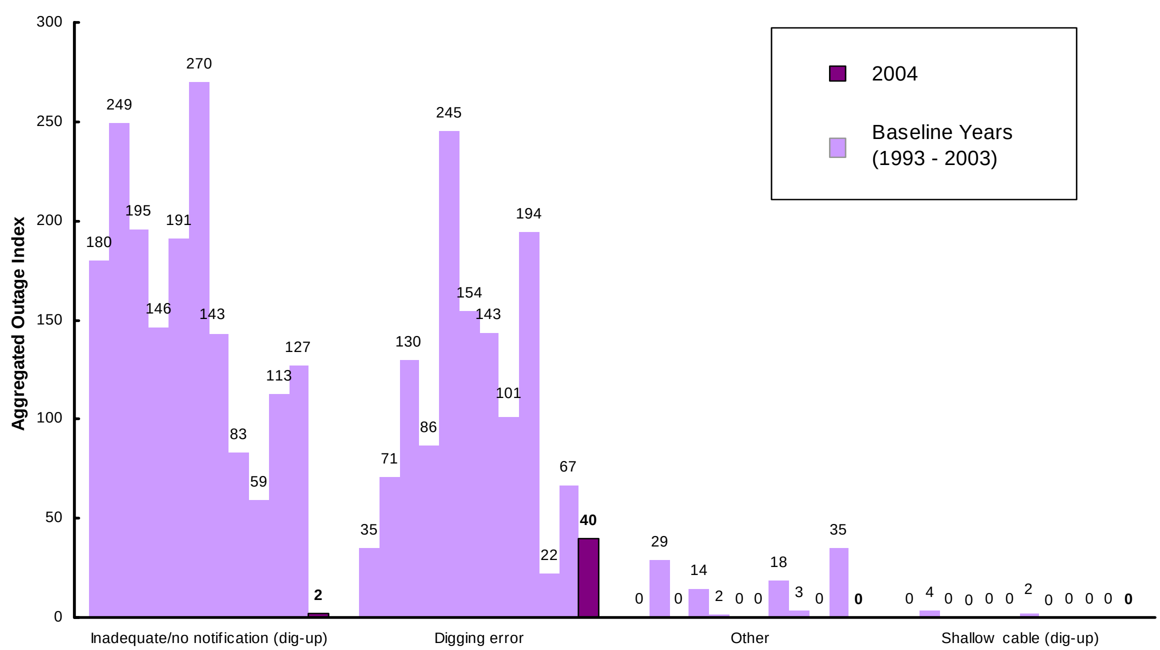

Figure 17: Annual Aggregated Outage Index for Cable Damage Root Cause Subcategories of Cable Dig-Up (DU) Facility Failures

CABLE ELECTRONICS

The major root causes of Cable Electronics[8] attributed Facility outages are: Procedural Errors (41%), Hardware Failure (23%), Design Hardware (18%), and Design Software (12%). However, over the last six years, Hardware Failure has had the highest percentage of these outages (36% versus 34%). Over the last three years, the number of Cable Electronics attributed Procedural Error outages has been significantly less than in the first nine years (1.0 versus 4.3 per year). Despite a drop to its lowest level (1) since 1997, Hardware Failure outage frequency has been significantly greater in the last seven years (2.9 per year) versus the first five years (0.6 per year). Design Hardware frequency has been significantly lower in the last seven years (0.7 per year) than in the first five years (2.6 per year). When considering the aggregated outage index, Procedural Service Provider is the dominant root cause (55%) followed by Design Hardware (24%) and Hardware Failure (14%).

LOCAL SWITCH

The dominant failure subcategory for Local Switch outages is Hardware (44%), which has significantly more outages than the Software (27%), Translations (21%), and Other (9%) failure subcategories. In 2004, Hardware outages matched their lowest frequency to date (3), significantly lower than its Baseline Level (10.4 per year). The frequency of Hardware outages has been significantly lower in the last three years (3 per year) than in the first nine years (12 per year). Software outage frequencies have decreased at the statistically significant rate of 21% per year since reaching their peak (14) in 1996. Over the last four years, the number of Translations outages (2.0 per year) has been significantly less than in the first eight years (5.9 per year). Since reaching a peak of 7 outages in 1998, Other outage frequencies have decreased at the statistically significant rate of 25% annually.

Hardware outages are less dominant with respect to aggregated outage index: Hardware (37%), Software (30%), Translations (28%), and Other (6%). Since 1996, Translations outages have had the highest aggregated outage index among Local Switch subcategories. The annual aggregated outage index for Hardware outages demonstrates a statistically significant decreasing trend over the course of the 12-year history (21% per year). The aggregated outage index for Software outages in the last eight years (23 per year) has been significantly lower than in the first four years (59 per year). In 2004, the aggregated outage index for Translation outages rose to its second highest level in the 12-year history (74), but the difference from the Baseline Level (29 per year) was not statistically significant. Over the last four years, the aggregated outage index for Other outages has been significantly less (4 per year) than in the peak years 1998 – 2000 (21 per year).

Procedural Errors have been the dominant root cause of Local Switch outages from both the outage frequency and the outage index perspective (50% from both perspectives). However, over the last four years, the percentage of Local Switch outages attributed to a Procedural Error (35%) has not been significantly higher than the percentages of those attributed to Design Software (25%) and Hardware Failure (28%). In 2004, the number of Procedural Error outages matched its lowest level to date (3), significantly lower than its Baseline Level (12.9). Procedural Error frequency has a

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[8] The Cable Electronics failure subcategory 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.

statistically significant decreasing trend since its peak in 1998 (33% annually). In 2004, the aggregated outage index of Procedural Error outages in 2004 (74) reached its highest level since 1998; nevertheless, over the last four years, its annual aggregated outage index (30 per year) has been significantly lower than in the first eight years (75 per year). Since reaching its peak in 1999, the number of Hardware Failure outages has been decreasing at the statistically significant rate of 28% annually. In 2004, Hardware Failure had its lowest aggregated outage index to date (2.7). Over the last eight years, the average frequency (3) and aggregated outage index (18) of Design Software outages have been significantly less than in the first four years (7 and 52 respectively).

Common Channel Signaling (CCS)

Over the 12-year reporting history, Isolation is the dominant failure subcategory (71%) for CCS outages, significantly greater than other failure subcategories; it is followed by Link(set)s (11%), STP Equipment (8%), and SCP Equipment (5%). 2004 had the lowest number of CCS outages attributed to Isolation (12) since 1999; nevertheless, over the last five years, the number of such Isolation outages (17.8 per year) has been significantly higher than in the previous six years (12.7 per year from 1994 through 1999) (see Figure 18). In the last two years, the number of CCS outages attributed to Link(set)s has been significantly less than in the peak years 1998 – 2002 (1.0 versus 4.8 per year). 2004 had the highest number of CCS outages attributed to the Other subcategory to date (3); the frequency of CCS outages in this subcategory demonstrates a statistically significant increasing rate of 30% annually over the 12-year history.

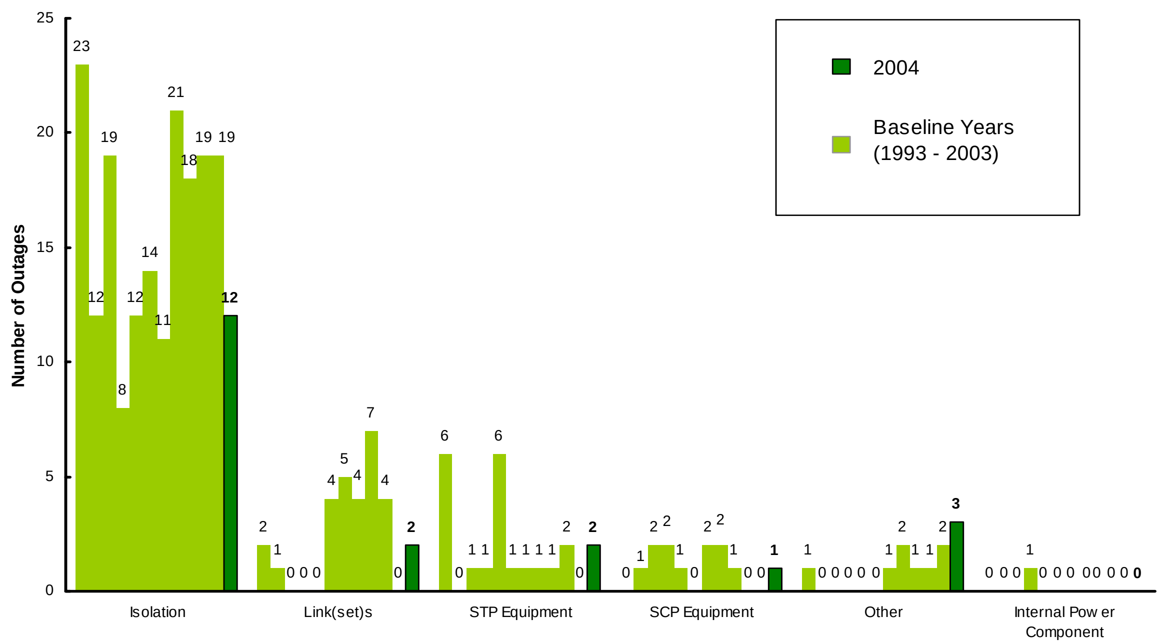

Figure 18: Number of Outages by CCS Failure Subcategory

From the outage index perspective over the 12-year reporting history (see Figure 19), Isolation is the dominant failure subcategory (50%), significantly greater than for other failure subcategories; it is followed by STP Equipment (19%), SCP Equipment (13%), and Link(set)s (9%). 2004 had the lowest aggregated outage index for CCS outages attributed to Isolation (31) since 1999; nevertheless, over the last five years, the aggregated outage index for such Isolation outages (120 per year) has been significantly higher than in the previous six years (35 per year from 1994 through 1999). Over the last seven years, the CCS aggregated outage index attributed to Link(set)s has been significantly greater than in the first five years (24 versus 0.3 per year); however, more recently, in the last two years, this aggregated outage index has been significantly less than in 2001 – 2002 (2 versus 51 per year). Despite having its lowest value (13) since 1999, the aggregated outage index attributable to the Other subcategory has been significantly higher in the last six years (33 per year) than in the first six years (0.4 per year).

Procedural Error (45%), Design Software (19%), Design Hardware (17%), and Hardware Failure (11%) have been the major root cause categories over the 12 year history. Despite declining for the second consecutive year to its lowest value since 1996 (8), in the last eight years, the number of CCS outages attributed to Procedural Error has been significantly greater than in the first four years (11.3 versus 7.3 per year). In particular, the frequency of Procedural Other Vendor outages has a statistically significant increasing rate of 25% annually. The frequency of CCS outages attributed to Design Software has been significantly less over the last nine years (2.9 per year) versus the first three years (8.3 per year). The frequency of CCS outages attributed to Design Hardware has been significantly higher over the last five years (6 per year) than over the first seven years (2 per year). 2004 had the most CCS outages attributed to Traffic/System Overload in the 12-year history (2); over the last five years, the frequency of such Traffic/System Overload outages has been significantly greater than over the first seven years (1 versus 0 per year).

With respect to the outage index, Procedural Error (48%), Design Software (22%), Traffic/System Overload (14%), and Design Hardware (8%) have been dominant over the 12 year history. In 2004, the Procedural Error aggregated outage index dropped to its lowest value since 1995 (26).

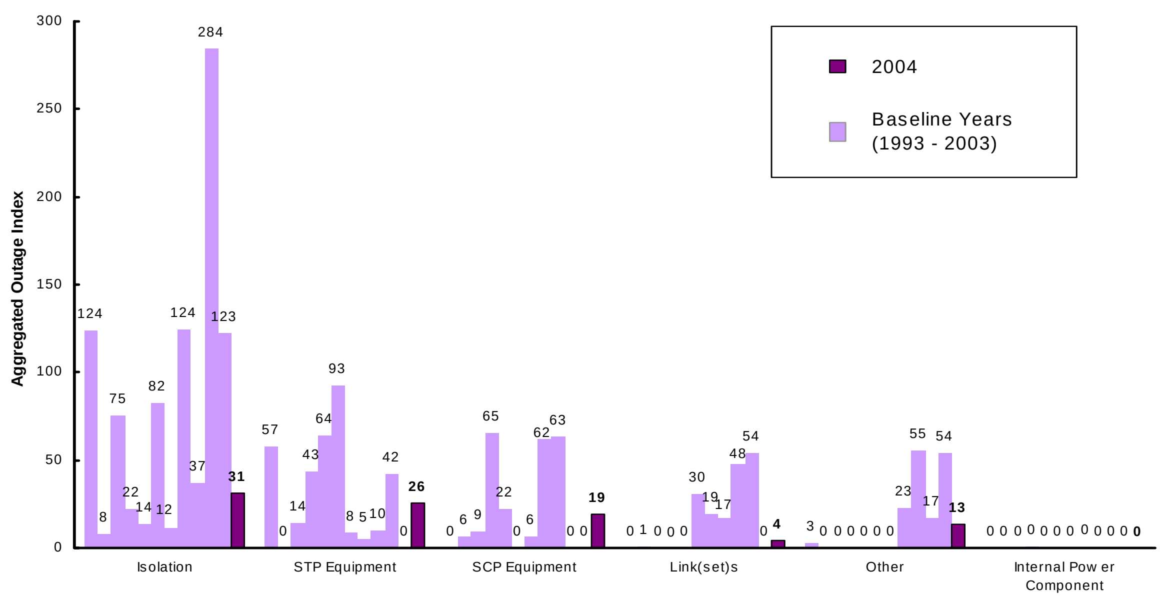

Figure 19: Annual Aggregated Outage Index by CCS Failure Subcategory

TANDEM SWITCH

The major failure subcategories of Tandem Switch outages are Software (38%), Translations (30%) and Hardware (25%). The aggregated outage index has a similar distribution among failure subcategories: Software (38%), Translations (36%), and Hardware (22%). 2004 was the second consecutive year in which the fewest Tandem Switch outages (1) were attributed to Software among failure subcategories, significantly lower than its Baseline Level (6.6 per year); over the last three years, the number of Software outages (1.3 per year) has been significantly less than in the first nine years (7.8 per year). Similarly, in 2004, the aggregated outage index for Software outages (17) was significantly less than its Baseline Level (78) for the second consecutive year; over the last two years, the aggregated outage index of Software outages has been significantly less (9 per year) than in the first ten years (86 per year). Over the last three years, the number of Translations outages has been significantly less than in the preceding eight years (2.7 versus 6.4 per year). Tandem Switch aggregated outage index attributed to Translations has been significantly greater over the last seven years than over the first five years (94 versus 34 per year). In the last two years, the frequency of Hardware outages has been significantly less (1.5 per year) than in the previous ten years (4.7 per year). In 2004, the aggregated outage index for Hardware outages (3) was significantly less than its Baseline Level (47).

Procedural Service Provider (44%), Design Software (33%), Hardware Failure (10%), and Procedural System Vendor (7%) have been the major root causes of Tandem Switch outages. The aggregated outage index has a similar distribution among failure subcategories: Procedural Service Provider (47%), Design Software (31%), Hardware Failure (9%), and Procedural System Vendor (7%). 2004 had the lowest number of Tandem Switch outages attributed to Procedural Service Provider of any year in the 12-year history (2), significantly lower than its Baseline Level (7.6 per year). Since its peak of 15 in 1998, the frequency of Tandem Switch outages attributed to Procedural Service Provider has declined at the statistically significant rate of 24% annually. The aggregated outage index for Procedural Service Provider outages over the last three years has been significantly less than in the four previous years 1998 - 2001 (57 versus 158 per year). In the last two years, the frequency of Tandem Switch outages attributed to Design Software has been significantly lower than in the first ten years (1.0 versus 6.3 per year); this is true also for the aggregated outage index (9 versus 70 per year). 2004 was the fourth consecutive year in which no Tandem Switch outages were attributed to Procedural System Vendor; over this period, the frequency was significantly less than in the first eight years (1.8 per year). 2004 had the highest number of Tandem Switch outages attributed to Internal Environment in the 12-year reporting history (2), significantly greater than its Baseline Level (0.1 per year); over the last three years, the frequency of Internal Environment outages has been significantly greater than in the first nine years (1 versus 0 per year).

CENTRAL OFFICE (CO) POWER

The distribution of outages across CO Power subcategories shows that over the 12 year history the major contributors are: DC Plant (30%), DC Distribution (25%), Other (20%), Standby Generator (14%), and Building AC (10%). In 2004, the number of CO Power outages attributed to DC Distribution dropped to its lowest level since 1993 (1); in the last two years, the frequency of DC Distribution outages has been significantly lower than in the peak years 1997 – 2002 (1.5 versus 5.0 per year). 2004 was the first year with no CO Power outages attributed to the Other subcategory, significantly lower than the average frequency in the preceding seven years (4.0 per year). 2004 had the most CO Power outages attributed to Standby Generator (3) since 2000; nevertheless, over the last four years, the frequency of CO Power outages attributed to Standby Generator (1.5 per year) has been significantly less than the frequency in its peak years 1998-2000 (4.7 per year).

The major contributors, by failure subcategory, to the CO Power aggregated outage index over the 12 year history are: DC Plant (29%), Standby Generator (27%), DC Distribution (21%), and Other (14%). In 2004, the CO Power aggregated outage index attributed to Standby Generator had its second highest value to date (117); over the last two years, the aggregated outage index for Standby Generator outages has been significantly higher than in the first ten years (137 versus 30 per year).

Commercial and/or Back-Up Power Failure (38%) and Procedural Service Provider (33%) are the primary root cause categories among CO Power outages over the 12 year history. However, when all three Procedural Error root causes are combined over the 12 years, Procedural Errors cause 49% of CO Power outages. In 2004, the number of outages attributed to Procedural Errors matched its lowest level to date (3); over the last three years, the number of Procedural Error outages (3.7 per year) has been significantly less than in the first nine years (8.3 per year). Over the last seven years, the frequency of Commercial and/or Back-Up Power Failure outages has decreased at the statistically significant rate of 15% annually.

With respect to the aggregated outage index, Commercial and/or Back-Up Power Failure is the dominant root cause category (49%) followed by Procedural Service Provider (24%) over the 12 year history. All three Procedural Error root cause categories combined account for 38% of the CO Power aggregated outage index over the 12 years. In 2004 the aggregated outage index for Procedural Error outages reached its highest level since 1995 (84) although it was not significantly greater than its Baseline Level (67). The CO Power aggregated outage index attributed to Commercial and/or Back-Up Power Failure has been significantly higher in the last seven years than in the first five years (138 versus 16 per year).

DIGITAL CROSS-CONNECT SYSTEMS (DCSS)

The percentage of DCS outages attributed to the Hardware subcategory (54%) is significantly greater than those of the other subcategories including Software (29%) and Other (13%). With respect to the aggregated outage index, the three major failure subcategories are Hardware (53%), Other (22%), and Software (21%). In the last four years, the number of DCS outages attributed to Software has been significantly less than in the peak years 1997-2000 (0.5 versus 3.5 outages per year); the difference between these periods is also statistically significant with respect to the aggregated outage index (4 versus 30 per year).

Looking at the root causes of DCS outages, 24% are attributed to Design Software, 23% to Procedural System Vendor, 17% to Procedural Service Provider, and 17% to Hardware Failure. With respect to the aggregated outage index, Design Software accounts for 39% of the DCS aggregated outage index, Procedural Service Provider 21%, Hardware Failure 12%, Design Hardware 10%, and Procedural System Vendor 9%. Over the last four years, the frequency of DCS outages attributed to Design Software has been significantly less than in the peak period 1998 – 2000 (0.5 versus 3.7 per year). 2004 was the first year in which no DCS outages were attributed to a Procedural Error; since reaching its peak of 7 outages in 1997, the frequency of DCS outages attributed to a Procedural Error has decreased at the statistically significant rate of 27% annually. 2004 had the highest number of DCS outages attributed to Hardware Failure in any year to date (3). In the last seven years, Hardware Failure has caused 1.7 DCS outages per year compared to none in the first five years; this is a statistically significant difference. In 2004, the aggregated outage index for Hardware Failure outages reached its highest level to date (43), significantly greater than its Baseline Level (4.5 per year); over the last three years, the aggregated outage index for Hardware Failure outages has been significantly greater than in the first nine years (22 versus 3 per year).

PROCEDURAL ERROR OUTAGES

Three root cause categories can be grouped as Procedural Errors (PE): Procedural Service Provider, Procedural System Vendor, and Procedural Other Vendor. Procedural Error root cause categories account for 39% of the number of outages and 35% of the aggregated outage index. The significantly largest share of the PE outages is attributable to the Procedural Service Provider (81%) as opposed to the Procedural System Vendor (15%) or Procedural Other Vendor (5%); their shares of the aggregated outage index are close to these values as well.

Figure 20 presents the number of Procedural Error outages in each year. In 2004, Procedural Error outage frequency dropped to its lowest annual level to date (22). It was below the Baseline Level (62.4 outages per year); this difference is statistically significant. The frequency of PE outages has demonstrated a statistically significant decline of 28% per year since 2000. The frequency also has a statistically significant seasonality effect. The frequency is high in third quarters (17.6), low in fourth quarters (12.7), and near average in first and second quarters (14.9 and 13.8 respectively). Among the three PE categories, Procedural Service Provider and Procedural System Vendor demonstrate statistically significant declines in outage frequency (28% and 47% annually since 2000 respectively), but Procedural Other Vendor has a statistically significant increase in frequency (17% annually since 1995).

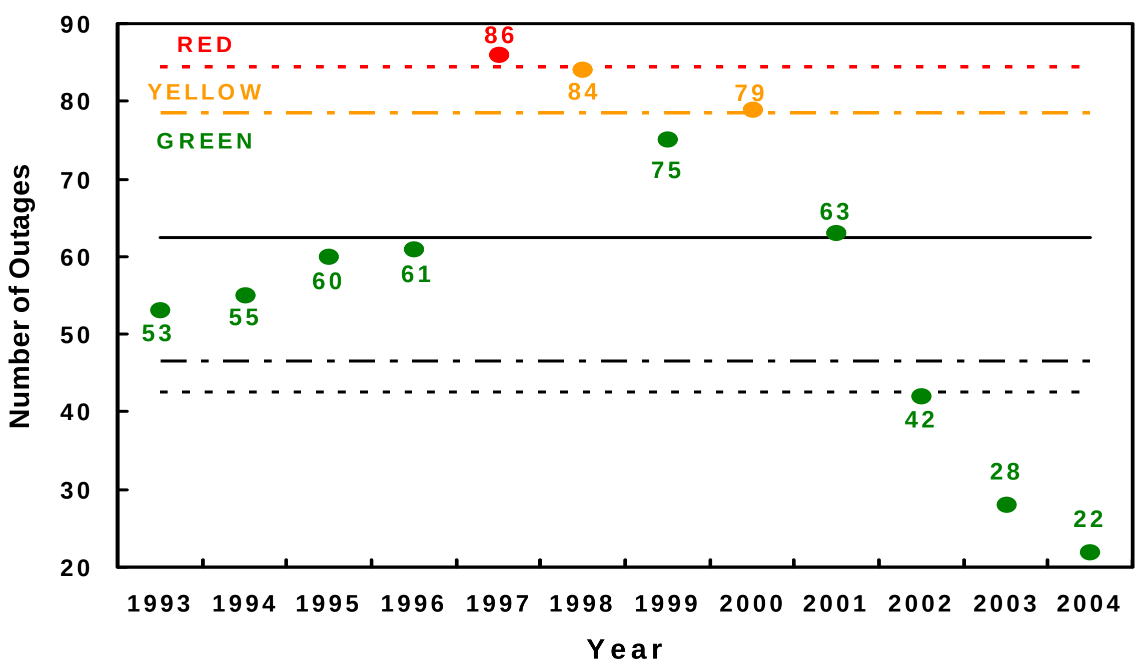

Figure 20: Annual Frequency Control Chart for Procedural Error Outages

[Figure 21](#) shows the frequency of PE outages by root cause subcategory. The three major root cause subcategories are Insufficient Supervision/Control (34%), Documentation/Procedures (unavailable, unclear, incomplete) (22%), Insufficient Training (22%), and Inaccurate Cable Locate (10%). In 2004, the number of PE outages caused by Insufficient Supervision/Control (10) was the lowest number since 1995, significantly lower than the Baseline Level (20.8); since rising to its peak (41) in 1998, this frequency has been decreasing at the statistically significant rate of 19% per year. Documentation/Procedures (unavailable, unclear, incomplete) outage frequency in 2004 matched its lowest level to date (4 in 2002 and 2003), significantly lower than its Baseline Level (13.7 outages per year); this frequency has been declining at the statistically significant rate of 22% per year since reaching its peak (23) in 1997. In 2004, the number of PE outages caused by Insufficient Training declined to its lowest level to date (4), significantly less than its Baseline Level (13.7 per year); this frequency has been declining at the statistically significant rate of 19% per year since reaching its peak (25) in 1997. The number of Inaccurate Cable Locate outages in 2004 dropped to its lowest value to date (1), significantly lower than its Baseline Level (6.5 per year); since 2001, this frequency has decreased at the statistically significant rate of 53% annually. 2004 was the second consecutive year with no PE outages caused by Documentation/Procedures (out-of-date, unusable, or impractical); over this period, this frequency has been significantly lower than in the first ten years (2.8 per year). It was also the fourth consecutive year with no PE outages caused by inadequate routine maintenance/memory back-up, significantly less than its frequency over the first eight years (1.8 per year).

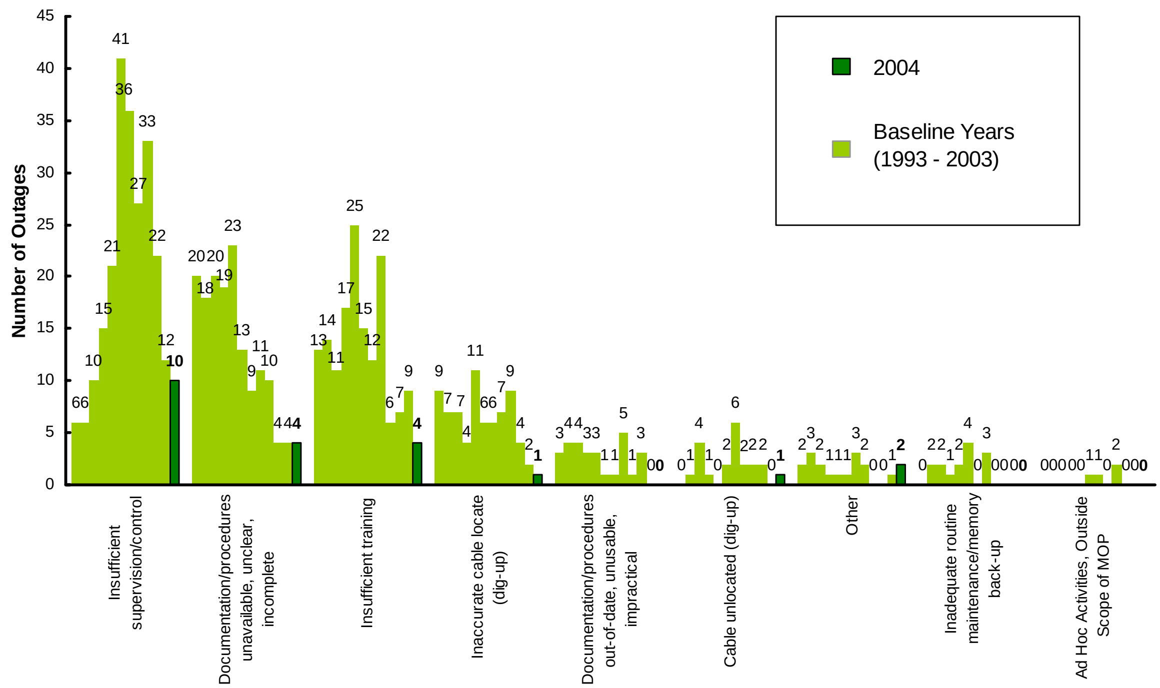

Figure 21: Number of Outages by Procedural Error Root Cause Subcategory[9]

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[9] The Insufficient Staffing root cause subcategory (one outage reported in 1999) is not shown.

In 2004, the aggregated outage index of Procedural Error outages had its second lowest value to date (342). Over the last three years, the annual aggregated outage index of Procedural Error outages (337 per year) has been significantly lower than in the first nine years (581 per year). With respect to aggregated outage index, the major root cause subcategories of Procedural Error outages are Insufficient Supervision/Control (37%), Documentation/Procedures (unavailable, unclear, incomplete) (24%), Insufficient Training (15%), and Inaccurate Cable Locate (12%). Over the last three years, the annual aggregated outage index of Insufficient Supervision/Control outages (183 per year) has been significantly less than its 1998 - 2001 peak (339 per year). Over the last six years, the annual aggregated outage index of Documentation/Procedures (unavailable, unclear, incomplete) outages has been significantly lower than in the first six years (64 versus 189 per year). Over the last four years, the annual aggregated outage index of Insufficient Training has been significantly less than in the first eight years (30 versus 103 per year).

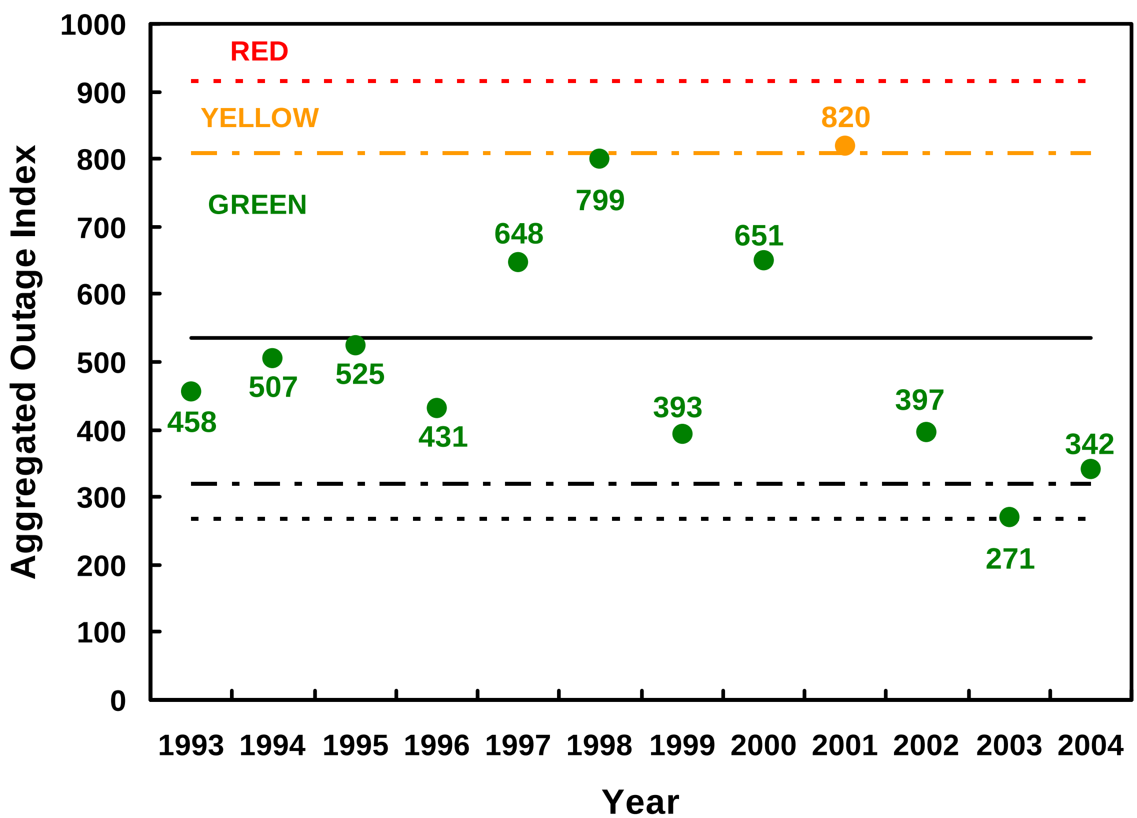

Figure 22: Annual Aggregated Outage Index Control Chart for Procedural Error Outages

“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 2004 there were eight outages reported to the FCC that fell in these categories. Of these, two were reportable because of their impact to 911 services, five were reportable fire-related incidents, and one was reportable because it affected FAA circuits.

Of the two outages which impacted 911 services, one was the result of the 911 access number being inadvertently disconnected because it was not registered in the reporting carrier’s records; this outage impacted 1,742 customers for 90 minutes. In the second incident, customers were isolated from 911 services when wildfires burned a fiber optic cable that served as the umbilical between a host office and two remote offices. The two remote offices had been removed from a fiber ring due to a timing problem, which eliminated diversity. This outage impacted 4,172 customers for 3 hours and 40 minutes.

The incident that was reportable because of the impact to FAA circuits was the result of mice chewing through seven of eight fibers in a repeater hut. The affected air traffic control center advised the carrier that it was not out of service during this incident because its secondary system provided coverage in backup to the primary system. This incident potentially impacted 12,200 customers for 5 hours and 10 minutes.

Of the five outages reportable because of fire, none occurred in or on the premise of a service provider. Three of these outages occurred when a structure fire burned through nearby aerial fiber and/or copper cables; one occurred when a forest fire, believed to have been set by vandals, burned an aerial fiber cable; and, one occurred when a fire which was started to clear brush from the banks of a lake damaged a fiber optic and two copper cables which had become exposed when the water level dropped nine feet. The average duration of these five outages was in excess of 31 hours, and the average number of customers affected was 6,285. In most cases, these outages required the replacement of multiple cables, and in some repairs were impaired when local public safety officials delayed access to the area.

SUMMARY AND CONCLUSION

Table 3 provides a summary of the degree to which all outages, all failure subcategories, and Procedural Error outages in 2004 compared to the Baseline Years with respect to frequency and aggregated outage index. For each such group of outages, "F" indicates whether the frequency of those outages in 2004 was significantly below, below, above, or significantly above its Baseline Level. "I" presents a similar indication for the aggregated outage index.

Overall, outage frequency showed a significant improvement over prior years; aggregated outage index improved as well but not significantly. Local Switch, Tandem Switch, and Procedural Error outages showed a similar pattern of improvement. Facility outages showed significant improvement with respect to frequency and aggregated outage index. "Other" outages had frequency and aggregated outage index above Baseline Levels with aggregated outage index significantly so in the Yellow region. The remaining failure categories showed no significant differences from the Baseline Years; CCS outages declined in frequency and aggregated outage index while DCS and CO Power outages declined in frequency but rose in aggregated outage index.

The statistical results indicate that the reliability of the public switched telephone network is stable and that no special intervention is warranted at this time.

Table 3: Summary of 2004 Relative to the Baseline Years

	GREEN			YELLOW	RED
Relative to Baseline Level	Significantly Below	Below	Above	Significantly Above	
All	F	I			
Facility	F I				
Local Switch	F	I			
Tandem Switch	F	I			
CCS		F I			
CO Power		F	I		
DCS		F	I		
Other			F	I	
Procedural Error	F	I			

The NRSC recognizes that the underlying causes of outage trends are of interest. In the case when a (negative) trend of increasing frequency is observed within a category, the Committee identifies direct and root causes of the individual events and assesses whether existing NRIC Best Practices, if implemented, would have prevented the outages. A special task group may be formed. These analyses continue to confirm the value of existing Best Practices and occasionally yield other insights. On the other hand, when a (positive) trend of decreasing outage frequency is observed, the Committee abstains from interpreting the primary influences. However, the Committee has assembled factors that can contribute to positive trends. The NRSC used the FCC Network Reliability and Interoperability Council (NRIC) communications infrastructure framework to systematically review the network elements and identify possible influences (either a negative or positive) on national network outage trends. Table 4, Systematic Review of Infrastructure Elements, summarizes these factors.

Table 4: Systematic Review of Infrastructure Elements

Elements of Communications Infrastructure	Potential Factors Having Influence
Power (internal systems)	decreasing expertise (per NRIC VI Area for Attention, Dec 2002 FG 1A Report)
Environment (buildings, etc.)	less maintenance, fewer alterations, changes in physical security, construction trends
Software	fewer upgrades; fewer new features; offshore outsourcing (less control over design, development and testing); cyber (software) vulnerabilities, worms, viruses
Hardware	fewer upgrades, outsourcing (less control over design, development and testing)
Payload	trends in traffic, abnormal traffic patterns, rapid growth of specific services
Networks	less growth, evolution (technology), concentration of traffic
Human	less training, less staff, longer hours, more stress, increased mechanization
Policy	increased security, activities at the sub-federal level, dig-ups (one-call legislation, partnering with gas, oil, railroad), less resource investment in Standards Development Organizations (SDOs)

This NRSC Annual Report is the final one in a series started in 1994. The goal of the report was to provide a current view of the reliability of the wireline PSTN based on outage reports submitted by carriers to the FCC. The purpose was to convey this quantitative information to the public and to guide the telecommunications industry (carriers and suppliers) in identifying areas of PSTN reliability that required further study. The NRSC categorized the data contained in the reports (based on the broad experience of the NRSC participants), implemented metrics (the outage index), and employed accepted statistical techniques (control charts) in order to provide thorough, unbiased analysis, results, and recommendations. In later years, the goal of the report was expanded to identify trends in reliability over time. Based on the conclusions from these reports, the NRSC formed focus groups to perform a more in-depth analysis in several areas such as central office (CO) power and procedural errors. One such group for facility outages was instrumental in the passage of One Call legislation. The downward trends in outage reports in recent years are an indication that the industry has absorbed lessons learned from this process.

With the conclusion of this series of reports the Network Reliability Steering Committee would like to take an opportunity to reflect on the past 12 years and to acknowledge the leadership, participants, and companies responsible for production of its quarterly and annual reports and findings.

The NRSC wishes to acknowledge and thank the Chairs and Vice Chairs who have provided leadership and focus for the committee over the years. Their expertise and knowledge of the telecommunications industry was paramount to the NRSC fulfilling its charter.

NRSC Chair	Company	Years Served
Ray Albers	Verizon	1993 – 1999
P.J. Aduskevicz	AT&T	2000 – 2004
Jim Lankford	SBC	2004
Archie McCain	BellSouth	2005 – Present

NRSC Vice Chair	Company	Years Served
P.J. Aduskevicz	AT&T	1993 – 1999
Karl Rauscher	Lucent	2000 – Present

The committee also recognizes the Alliance for Telecommunications Industry Solutions (ATIS) for its support and efforts throughout the years in organizing and producing valuable public information on industry issues. Additionally, the analysis provided by Telcordia Technologies' Jay Bennett, Spilios Makris, and John Healy set the focus for wireline network reliability.

We thank our FCC partners for their guidance; and our consumer representative Kathleen O'Reilly for her efforts and participation in making this public forum successful.

And finally, we acknowledge the participation of current and past companies and organizations that have provided subject matter experts throughout the years:

AT&T*	MCI	SBC*
BellSouth*	NARUC	Sprint*
CTIA	NCS*	Telcordia Technologies*
ICA	Nortel Networks*	USTA
Juniper Networks*	Qwest*	Verizon*
Lucent Technologies*	Siemens	

* Current Members

Starting in 2005, the FCC initiated a new set of outage reporting requirements. The new process for collecting and administering outage reports does not currently allow industry access to these reports. This has halted the industry's joint efforts to improve network reliability based on the outages reported to the FCC. The NRSC has expressed its willingness to continue its statistical analysis of these outage reports, and potential procedures that would provide relevant data based on the outage reports are currently being investigated. Regardless of the success of these investigations, the accomplishments and lessons learned from the NRSC quarterly and annual reports will provide a solid foundation for moving forward in maintaining reliability in telecommunications networks.