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BEFORE THE ARIZONA CORPORATION COMMISSION

WILLIAM A. MUNDELL
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IN THE MATTER OF U S WEST COMMUNICATIONS, INC.'S COMPLIANCE WITH §271 OF THE TELECOMMUNICATIONS ACT OF 1996.	DOCKET NO. T-00000A-97-0238 **NOTICE OF FILING EXHIBITS**

Qwest Corporation ("Qwest") hereby provides notice of filing exhibits. On April 20, 2001, Qwest filed its Revised Qwest Arizona Proposed Performance Assurance Plan ("PAP") as Qwest Exhibit 16. Qwest files the attached revised version of Qwest Exhibit 16. This revision eliminates unnecessary duplication discovered in section 12.0 (second paragraph). Also, in the most recent version, Qwest did not intend to eliminate provisions relative to duplicative recovery. Therefore the attached PAP contains appropriate revised language in paragraph 13.6. In addition, Qwest submits the attached exhibits as Qwest Exhibits 17, 18 and 19.

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Arizona Corporation Commission
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Dated this 9th day of May, 2001.

Respectfully submitted,

Qwest Corporation

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QWEST REVISED EXHIBIT 16

THE QWEST ARIZONA PERFORMANCE ASSURANCE PLAN

1.0 Introduction

In conjunction with its applications to the Arizona Corporation~~State~~ Commissions for recommendation for approval under Section 271 of the Telecommunications Act of 1996 (the "Act") to offer in-region long distance service, Qwest Corporation ("Qwest") proposes the following Performance Assurance Plan ("PAP"). Qwest is committed to continued compliance with its Section 271 obligations. As proof of that commitment, Qwest is prepared to voluntarily enter into this post-271 approval monitoring and enforcement mechanism, as outlined below, as a demonstration of its commitment to continue to satisfy Section 271 of the Act.

The Qwest PAP mirrors the performance assurance plan approved by the Federal Communications Commission ("FCC") for Southwest Bell Telephone Company–Texas.[1] Qwest believes that controversy can be avoided and the resources of the ~~State~~ Commissions and the Company c~~ould be~~ best be utilized by avoiding a drawn out process of creating a performance assurance plan from scratch. Therefore, Qwest ~~has taken~~look the extraordinary step of duplicating key elements of the approved Texas plan.

The FCC has recognized that performance assurance plans may vary widely from state to state, but that the key elements of any plan should fall within a "zone of reasonableness" such that the plans provide incentives sufficient to foster on-going satisfaction of 271 requirements.[2] Rather than "reinvent" key elements, the Qwest PAP adopts the Texas enforcement plan structure, including its statistical tables and payment schedules. Furthermore, the Qwest PAP puts at risk 36% of the Company's "net revenues" derived from local exchange services.

2.0 Plan Structure

The Qwest PAP is a two-tiered, self-executing remedy plan. The plan is developed to provide individual CLECs with Tier-1 payments if Qwest does not provide parity between the service it provides to the CLEC and that which it provides to its retail customers, or if Qwest fails to meet applicable benchmarks. In addition, the PAP provides Qwest with additional incentives to satisfy parity and benchmark standards by requiring Qwest to make Tier-2 payments--

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[1] *In the Matter of the Application by SBC Communications, Inc.*, CC Docket No. 00-65, Memorandum Opinion and Order, June 30, 2000. Subsequently, the FCC approved similar enforcement plans as part of 271 approvals granted for SBC-Kansas and Oklahoma. See *In the Matter of the Joint Application of SBC Communications, Inc.*, CC Docket No. 00-217, Memorandum Opinion and Order, January 19, 2001.

[2] *Id.*, para. 423.

payments to State Funds established by the State Commissions--if Qwest fails to meet parity and benchmark standards on an aggregate CLEC basis. Tier-2 payments are over and above the Tier-1 payments made to individual CLECs. [3]

In the Qwest PAP, performance measurements are given different weightings to reflect relative importance by the designations of High, Medium, and Low. Payment is generally on a per occurrence basis, i.e., a set dollar payment times the number of non-conforming service events. For the performance measurements which do not lend themselves to per occurrence payment, payment is on a per measurement basis, i.e., a set dollar payment. The level of payment also depends upon the number of consecutive months of non-conforming performance, i.e., an escalating payment the longer the duration of non-conforming performance.

The parity standard is met when the service Qwest provides to CLECs is equivalent to that which it provides to its retail customers. Statistically, parity exists when performance results for the CLEC and for the Qwest retail analogue result in a Z-value that is no greater than the Critical Z-values listed in the Critical Z-Statistical Table in section 5.0.[4] The Qwest PAP relies upon statistical scoring to determine whether any difference between CLEC and Qwest performance results is significant, that is, not attributable to simple random variation.

For performance measurements that have no Qwest retail analogue, agreed upon benchmarks are used. Benchmarks are evaluated using a "stare and compare" method. For example, if the benchmark is 95% or better, Qwest performance results must be at least 95% to meet the benchmark. When sample sizes are less than 100, percentage benchmark values will be adjusted to round the allowable number of misses to the next higher integer. For example, in the event of a 95% benchmark, the number of misses is 5% times the sample size, rounded up to the nearest integer.

3.0 Performance Measurements

The Qwest PAP incorporates performance measurements that will ensure Qwest's service performance to competitors can be measured and monitored so that any degradation of the agreed upon level of service is detected and corrected. CLECs operating in Qwest's region offer services through several modes, including resale, interconnection, and the purchase of unbundled network elements. The performance measurements incorporated into the Qwest PAP are broad based enough to cover all the modes of entry.

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[3] It is anticipated that each state fund will be established concurrently with the FCC's approval of the respective State's 271 application.

[4] The standard Z-test is based on normal statistical theory. If the sample size is large enough, the sample mean will follow a known normal distribution that is dependent on the variance of the data and on the sample size. A sample size of 30 is generally considered sufficient, although the required minimum sample size is dependent on the statistical skewness of the data being sampled. The assumption of a normal distribution is what allows the Z-test. When the sample size becomes too small, the distribution of the sample mean is no longer normal and the Z-test may not be reliable. In that event, other methods, as described below, may be appropriate.

Performance measurements have been developed in the 271 collaborative workshops. Each of the measurements have been given a precise definition, called a Performance Indicator Definition ("PID"), that includes specification of the unit of measure, the data to be utilized in the measurement, and the standard. The standard may be a parity comparison of CLEC service performance with the Qwest retail analogue. When no retail analogue exists, the standard is a benchmark. The PIDs have been agreed to among Qwest, the CLECs, and participating State Commission staff members.

The performance measurements incorporated into the Qwest PAP are shown in Attachment 1. Similar to the approved Texas plan, the measurements are designated as Tier-1, Tier-2, or both Tier-1 and Tier-2. The measurements are also given a High, Medium, or Low designation, reflective of relative importance. Of the 46~~51~~ measurements that the parties have agreed to in the Arizona~~ROC~~ PID workshops, Qwest incorporates 32~~4~~ of the measurements into the PAP.[5]

4.0 Statistical Measurement

Qwest proposes the use of a statistical test, namely the modified "Z-test," for evaluating the difference between two means (i.e., Qwest and CLEC service or repair intervals) or two percentages (e.g., Qwest and CLEC proportions), to determine whether a parity condition exists between the results for Qwest and the CLEC(s). The modified Z-tests are applicable if the number of data points are greater than 30 for a given measurement. For testing measurements for which the number of data points are 30 or less, Qwest may use a permutation test to determine the statistical significance of the difference between Qwest and CLEC(s).

Qwest will be in conformance when the monthly performance results for parity measurements (whether in the form of means, percents, or proportions and at the equivalent level of disaggregation) are such that the calculated Z test statistics are not greater than the Critical Z-values. Critical Z-values are listed in Table 1, section 5.0. Qwest will be in conformance with benchmark measurements when the monthly performance result equals or exceeds the benchmark if a higher value means better performance, and when the monthly performance result equals or is less than the benchmark if a lower value means better performance.

The following is the formula for determining parity using the Z test:

$$z = DIFF / \sigma_{DIFF}$$

Where:

[5] Of the 14~~20~~ PIDs not included in Qwest's PAP, 10~~4~~ are diagnostic or parity by design. As such, it is not appropriate to include them in a performance assurance plan. ~~The remaining 6 measurements are not included because they were not requested by the CLECs in the Arizona 271 performance assurance workshops that are underway or are duplicative of other measurements that are included.~~

$DIFF = M_{Qwest} - M_{CLEC}$

M_{QWEST} = Qwest average or proportion

M_{CLEC} = CLEC average or proportion

$\sigma_{DIFF} = SQRT\ [\sigma^2 Qwest\ (1/n_{CLEC} + 1/n_{Qwest})]$

σ^2_{Qwest} = Calculated variance for Qwest

n_{Qwest} = number of observations or samples used in Qwest measurement

n_{CLEC} = number of observations or samples used in CLEC measurement

The Z tests will be applied to reported parity measurements that contain more than 30 data points.

In calculating the difference between Qwest and CLEC performance, the above formulae apply when a larger Qwest value indicates a better level of performance. In cases where a smaller Qwest value indicates a higher level of performance, the order is reversed, i.e., $M_{CLEC} - M_{QWEST}$.

For parity measurements where the performance delivered to CLEC(s) is compared to Qwest performance and for which the number of data points is 30 or less, Qwest will apply a permutation test to test for statistical significance. Permutation analysis will be applied to calculate the z statistic using the following logic:

Calculate the z statistic for the actual arrangement of the data
Pool and mix the CLEC and Qwest data sets
Perform the following 1000 times:
    Randomly subdivide the pooled data sets into two pools, one the same size as the original CLEC data set (n_{CLEC}) and one reflecting the remaining data points, and one reflecting the remaining data points, (which is equal to the size of the original Qwest data set or n_{QWEST}).
    Compute and store the Z-test score (Z_S) for this sample.
Count the number of times the Z statistic for a permutation of the data is greater than the actual Z statistic
Compute the fraction of permutations for which the statistic for the rearranged data is greater than the statistic for the actual samples

If the fraction is greater than α, the significance level of the test, the hypothesis of no difference is not rejected, and the test is passed.

5.0 Critical Z-value and K value

The Critical Z-value and K value table seeks to account for statistical error arising from the natural variation in the performance results. Together, the Critical Z-value and K value result in an adjustment for these statistical errors. The following table will be used to determine the Critical Z-value and the K value that is referred to in section 6.0. In each instance, they are based on the total number of performance measurements that are applicable to a CLEC in a particular month.

TABLE 1: CRITICAL Z-VALUE AND K VALUE

Total Number of CLEC Performance Measurements	K Values	Critical Z-Value
1	0	1.645
2	0	1.9556
3	0	2.122
4	0	2.235
5	0	2.3219
6	0	2.3879
7	0	2.442
8	1	1.6829
9	1	1.7394
10-19	1	1.7974
20-29	2	1.83273
30-39	3	1.75268
40-49	43	1.69881
50-59	54	1.6675
60-69	5	1.74
70-79	6	1.768
80-89	76	1.66974
90-99	7	1.7224
100-109	8	1.6918
110-119	9	1.6667
120-139	10	1.66472
140-159	112	1.6778
160-179	123	1.6879
180-199	14	1.6537
200-249	157	1.6627
250-299	1920	1.6587
300-399	236	1.6687
400-499	2933	1.6627
500-599	358	1.65672
600-699	414	1.65172
700-799	479	1.64673
800-899	525	1.65375
900-999	5860	1.64877
1000 and above	Calculated for Type-1 Error Probability of 5%	Calculated for Type-1 Error Probability of 5%

6.0 Tier-1 Payments to CLECs

Tier-1 payments to CLECs relate solely to the performance measurements designated as Tier-1 on Attachment 1. For purposes of calculating the amount of payments, the Tier-1 performance measurements are categorized as High, Medium, and Low. The amount of payments for non-conforming service varies depending upon the High, Medium, and Low designations and upon the duration of the non-conforming condition, as described below. "Non-conforming" service is defined in section 4.0.

6.1 Determination of Non-conforming Measurements: The number of performance measurements that are determined to be "non-conforming" and, therefore, eligible for Tier-1 payments, are limited according to the K value and Critical Z-value shown in Table 1, section 5.0. The Critical Z-values becomes the statistical standard that determines for each CLEC performance measurement whether Qwest has met parity. The K value determines the number of measurements that are excluded from the payment calculation described in section 8.0. The K value and Critical Z-value are determined from Table 1 by totaling the number of performance measurements applicable to a CLEC during a month where the sample size is 10 or greater. For instance, if the total number of measurements that capture the service provided by Qwest to a CLEC in a particular month was 100, the K value would be 8 and the Critical Z-value would be 1.68.

6.2 Determination of the Amount of Payment: Tier-1 payments to CLECs, except as provided for in section 10.0, are calculated and paid monthly based on the number of performance measurements exceeding the Critical Z-value and the K value. Payments will be made on either a per occurrence or per measurement basis, depending upon the performance measurement, using the dollar amounts specified in Table 2 below. The dollar amounts vary depending upon whether the performance measurement is designated High, Medium, or Low and escalate depending upon the number of consecutive months for which Qwest has not met the standard for the particular measurement.

For those performance measurements listed on Attachment 2 as "Performance Measurements Subject to Per Occurrence Payments With a Cap," payment to a CLEC in a single month shall not exceed the amount listed in Table 2 below for the "Per Measurement" category. For those performance measurements listed on Attachment 2 as "Performance Measurements Subject to Per Measure Payments," payment to a CLEC will be the amount set forth in Table 2 below under the section labeled "per measure."

6.3 The performance measurements listed below will not be excluded from the CLEC payment calculation in the application of k-values as provided in section 8.0, if Qwest performance results have been non-conforming in the previous two consecutive months. K-values will again apply when Qwest achieves two consecutive months of conformance performance results.

PO-5 (FOCs on time), unbundled loops
OP-3 (Installation Commitments Met), analog unbundled loops, LIS trunks
OP-4 (Installation Interval), ADSL qualified loops
OP-5 (New Service Installation Quality), UNE-P (POTS), analog unbundled loops
MR-7 (Repair Repeat Report Rate), analog unbundled loops

MR-8 (Trouble Rate), analog unbundled loops
NI-1 (Trunk Blocking), LIS trunks
CP-2A-1 (Installation Commitments Met), virtual, physical caged, shared collocation

TABLE 2: TIER-1 PAYMENTS TO CLECs

Per occurrence						
Measurement Group	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6 and each following month
High	$150	$250	$500	$600	$700	$800
Medium	$ 75	$150	$300	$400	$500	$600
Low	$ 25	$ 50	$100	$200	$300	$400

Per Measure/Cap						
Measurement Group	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6 and each following month
High	$25,000	$50,000	$75,000	$100,000	$125,000	$150,000
Medium	$10,000	$20,000	$30,000	$ 40,000	$ 50,000	$ 60,000
Low	$ 5,000	$10,000	$15,000	$ 20,000	$ 25,000	$ 30,000

7.0 Tier-2 Payments to State Funds

Payments to State Funds established by the State Regulatory Commissions under Tier-2 of the Qwest PAP provide additional incentive to correct on-going non-conformance. The payments are limited to the performance measurements designated as Tier-2 on Attachment 1 and which have at least 10 data points each month for the period payments are being calculated. Similar to the Tier-1 structure, Tier-2 measurements are categorized as High, Medium, and Low and the amount of payments for non-conformance varies according to this categorization.

7.1 Determination of Non-conforming Measurements: The determination of non-conformance will be based upon the aggregate of all CLEC data for each Tier-2 performance measurement. "Non-conforming" service is defined in section 4.0. The number of performance measurements determined to be "non-conforming" and, therefore, eligible for Tier-2 payments, is limited according to the Critical Z-value shown in Table 1, section 5.0. The Critical Z-value is determined from Table 1 by totaling the number of performance measurements applicable to any CLEC during a month where the sample size is 10 or greater. The Critical Z-value becomes the statistical standard that determines for each performance measurement whether Qwest has met parity.

7.2 Determination of the Amount of Payment: Tier-2 payments are calculated and paid monthly based on the number of performance measurements exceeding the Critical Z-value for three consecutive months. Payment will be made on either a per occurrence or per measurement basis, whichever is applicable to the performance measurement, using the dollar

amounts specified in Table 3 below. The dollar amounts vary depending upon whether the performance measurement is designated High, Medium, or Low.

For those Tier-2 measurements listed on Attachment 2 as "Performance Measurements Subject to Per Occurrence Payments With a Cap," payment to a State Fund in a single month shall not exceed the amount listed in Table 3 for the "Per Measurement" category.

For those Tier-2 measurements listed in Attachment 2 as "Performance Measurements Subject to Per Measurement Payment," payment to a State Fund will be the amount set forth in Table 3 under the section labeled "per measure".

7.3 Use of the Funds: Qwest payments to the State Funds shall be used to reimburse customers' share of fees to extend telephone service within Qwest's service territory, to extend Qwest telephone service into adjacent, unassigned service territory, and for any other purposes that relates to the Qwest service territory that may be determined by the State Commission.

TABLE 3: TIER-2 PAYMENTS TO STATE FUNDS

Per occurrence

Measurement Group	
High	$500
Medium	$300
Low	$200

Per Measurement/Cap

Measurement Group	
High	$75,000
Medium	$30,000
Low	$20,000

8.0 Step by Step Calculation of Tier-1 Payments to CLECs

The following describes step-by-step the calculation of Tier-1 payments. The calculation will be performed monthly for each CLEC.

8.1 Application of the K Value Exclusions:

For each CLEC, determine the total number of Tier-1 performance measurements[6] that measure the service provided by Qwest for the month in question. From Table 1 in section 5.0, determine for each CLEC the K value and Critical Z-value to be used below.

[6] For the purpose of determining the K value and Critical Z-values, each disaggregated category of a performance measurement with a minimum sample size of 10 counts as "one" measure. For instance, a performance measurement that is disaggregated into 10 products, each further disaggregated into two geographic areas would count as "20" measurements.

For each CLEC, identify the Tier-1 performance measurements with a minimum sample size of 10 that Qwest's service performance is "non-conforming" for the month in question, using the Critical Z-value.

For the performance measurements that are identified as non-conforming, group the measurements according to the High, Medium, and Low categories shown on Attachment 1.

Within each High, Medium, and Low group, sort the performance measurements in ascending order based on the number of data points or transactions used to develop the performance measurement result (e.g., service orders, collocation requests, installations, trouble reports).

Exclude the first "K" measurements designated as Low, starting with the performance measurement that has the fewest number of underlying data points. If the number of performance measurements in the Low category is less than "K," repeat the process next with the Medium category and then the High category until a total of "K" performance measurements have been excluded. If all Low, Medium and High measurements are excluded by this process, then those measurements with sample sizes less than 10 may be excluded until "K" measurements are reached. (For example, if the K value is 6 and there are 7 Low measurements, 1 Medium, and 1 High, the 6 Low measurements with the smallest sample sizes are excluded from the calculation of payments to the CLEC.) The remaining "non-conforming" performance measurements, if any, are used to calculate Tier-1 payments to each CLEC.

The following qualifications apply to the general rule of excluding performance measurements as described above. A performance measurement, for which the payment is on a per measure basis, will not be excluded unless the amount of that measure's payment is less than the payment that would result for each remaining measure. A performance measurement, whose payment is on a per occurrence basis subject to a cap, will be excluded whenever the cap is reached and the payments for the remaining measurements are greater than the amount of the cap.

8.2 Performance Measurements for which Payment is Per Occurrence:

The following describes the calculation of Tier-1 payments to CLECs in which payment is based upon a per occurrence dollar amount.

8.2.1 Performance Measurements that are Averages or Means:

Step 1: For each performance measurement, calculate the average or the mean that would yield the Critical Z-value. Use the same denominator as the one used in calculating the Z-statistic for the measure. (For benchmark measurements, use the benchmark value.)

Step 2: Calculate the percentage differences between the actual averages and the calculated averages. The calculation is % diff = (CLEC result – Calculated Value)/Calculated Value. The percent difference will be capped at a maximum of 100%.[7]

Step 3: For each performance measurement, multiply the total number of data points by the percentage calculated in the previous step and the per occurrence dollar amounts taken from the Tier-1 Payment Table to determine the payment to the CLEC for each non-conforming performance measurement.

8.2.2 Performance Measurements that are Percentages:

Step 1: For each performance measurement, calculate the percentage that would yield the Critical Z-value. Use the same denominator as the one used in calculating the Z statistic for the measure. (For benchmark measurements, use the benchmark value.)

Step 2: Calculate the difference between the actual percentages for the CLEC and the calculated percentages.

Step 3: For each performance measurement, multiply the total number of data points by the difference in percentage calculated in the previous step and the per occurrence dollar amount taken from the Tier-1 Payment Table to determine the payment to the CLEC for each non-conforming performance measurement.

8.2.3 Performance Measurements that are Ratios or Proportions:

Step 1: For each performance measurement, calculate the ratio that would yield the Critical Z-value. Use the same denominator as the one used in calculating the Z-statistic for the measure. (For benchmark measurements, use the benchmark value.)

Step 2: Calculate the absolute difference between the actual rate for the CLEC and the calculated rate.

Step 3: For each performance measurement, multiply the total number of data points by the difference calculated in the previous step and the per occurrence dollar amount taken from the Tier-1 Payment Table to determine the payment to the CLEC for each non-conforming performance measurement.

8.3 Performance Measurements for which Payment is Per Measure: For each performance measurement that Qwest fails to meet the standard, the payment to the CLEC is the dollar amount shown on the "per measure" portion of the Tier-1 Payment Table.

9.0 Step by Step Calculation of Tier-2 Payments

[7] In all calculations of percent differences in sections 8.0 and 9.0, the calculated percent differences is capped at 100%.

The following describes step by step the calculation of Tier-2 payments. The calculation will be performed monthly using the aggregate CLEC performance results. All Tier-2 payments will be made to a designated state fund.

Determine the total number of Tier-2 performance measurements[8] that measure the service provided by Qwest to all CLECs for the month in question. From Table 1 in section 5.0, determine the Critical Z value to be used below.

Identify the Tier-2 performance measurement for which Qwest's service performance is non-conforming for the month in question, using the Critical Z-values.

For each performance measurement that is identified as non-conforming, determine if the non-conformance has continued for three consecutive months and if there are at least 10 data points each month. If it has, a Tier-2 payment will be calculated as described below and will continue in each succeeding month until Qwest's performance meets the applicable standard. For example, Tier-2 payments will continue on a "rolling three month" basis, one payment for the average number of occurrences for months 1-3, one payment for the average number of occurrences for months 2-4, one payment for the average number of occurrences for months 3-5, and so forth, until satisfactory performance is established.

9.1 Performance Measurements for which Payment is Per Occurrence:

The following describes the calculation of Tier-2 payments to the State Fund in which payment is based upon a per occurrence dollar amount.

9.1.1 Performance Measurements that are Averages or Means:

Step 1: Calculate the monthly average or the mean for each performance measurement that would yield the Critical Z-value for each month. Use the same denominator as the one used in calculating the Z-statistic for the measure. (For benchmark measurements, use the benchmark value.)

Step 2: Calculate the percentage difference between the actual averages and the calculated averages for each month. The calculation for parity measurements is % diff = (actual average – calculated average)/calculated average. The percent difference will be capped at a maximum of 100%.

Step 3: For each performance measurement, multiply the total number of data points each month by the percentage calculated in the previous step. Calculate the average for three months (rounded to the nearest integer) and multiply the result by the per occurrence dollar

[8] For the purpose of determining the Critical Z-value, each disaggregated category of a performance measurement with a minimum sample size of 10 counts as "one" measure. For instance, a performance measurement that is disaggregated into 10 products, each further disaggregated into two geographic areas would count as "20" measurements.

amount taken from the Tier-2 Payment Table to determine the payment to the State Fund for each non-conforming performance measurement.

9.1.2 Performance Measurements that are Percentages:

Step 1: For each performance measurement, calculate the monthly percentage that would yield the Critical Z-value for each month. Use the same denominator as the one used in calculating the Z-statistic for the measure. (For benchmark measurements, use the benchmark value.)

Step 2: Calculate the difference between the actual percentages and the calculated percentages for each of the three non-conforming months. The calculation for parity measurement is diff = CLEC result – calculated percentage. This formula is applicable where a high value is indicative of poor performance. The formula is reversed where high performance is indicative of good performance.

Step 3: For each performance measurement, multiply the total number of data points for each month by the difference in percentage calculated in the previous step. Calculate the average for three months (rounded to the nearest integer) and multiply the result by the per occurrence dollar amounts taken from the Tier-2 Payment Table to determine the payment to the State Fund for each non-conforming performance measurement.

9.1.3 Performance Measurements that are Ratios or Proportions:

Step 1: For each performance measurement, calculate the ratio that would yield the Critical Z-value for each month. Use the same denominator as the one used in calculating the Z-statistic for the measure. (For benchmark measurements, use the benchmark value.)

Step 2: Calculate the difference between the actual rate for the CLEC and the calculated rate for each month of the non-conforming three-month period. The calculation is diff = (CLEC rate – calculated rate). This formula is applicable where a high value is indicative of poor performance. The formula is reversed where high performance is indicative of good performance.

Step 3: For each performance measurement, multiply the total number of data points by the difference calculated in the previous step for each month. Calculate the average for three months (rounded to the nearest integer) and multiply the result by the per occurrence dollar amounts taken from the Tier-2 Payment Table to determine the payment to the State Fund for each non-conforming performance measurement.

9.2 Performance Measurements that Payment is Per Measure:

For each performance measurement that Qwest fails to meet the standard, the payment to the State Fund is the dollar amount shown on the "per measure" portion of the Tier-2 Payment Table.

10.0 Low Volume, Developing Markets

In the event aggregate monthly volumes of CLECs participating in the PAP are more than 10, but less than 100, Qwest will make Tier-1 payments to CLECs if during a month Qwest fails to meet the parity or benchmark standard for the qualifying performance sub-measurements listed below. The qualifying sub-measurements are the UNE-P (POTS), megabit resale, and ADSL qualified loop product disaggregation of OP-3, OP-4, OP-5, MR-3, MR-5, MR-7, and MR-8.

The determination of whether Qwest has met the parity or benchmark standards will be made using aggregate volumes of CLECs participating in the PAP. In the event Qwest does not meet the applicable performance standards, a total payment to affected CLECs will be determined in accordance with the high, medium, low designation for each performance measurement (see Attachment 1) and as described in section 8.0, except that CLEC aggregate volumes will be used. In the event the calculated total payment amount to CLECs is less than $5,000, a minimum payment of $5,000 shall be made. The resulting total payment amount to CLECs will be apportioned to the individual affected CLECs based upon each CLEC's relative share of the number of total service misses.

At the 6-month reviews, Qwest will consider adding to the above list of performance sub-measurements new product disaggregation that represents new modes of CLEC entry into developing markets.

K-value exclusions will not be applied to the performance sub-measurements covered by this section. However, the sub-measurements covered by this section will be included in the determination of the k-values and critical Z-values.

If the aggregate monthly CLEC volume is greater than 100, the provisions of this section shall not apply to the qualifying performance sub-measurement.

11.0 Payment

Payments to CLECs or the State Fund shall be made one month following the due date of the performance measurement report for the month for which payment is being made.

Payment to CLECs will be made via bill credits To the extent that a monthly payment owed to a CLEC under this PAP exceeds the amount owed to Qwest by the CLEC on a monthly bill, Qwest will issue a check or wire transfer to the CLEC in the amount of the overage. Payment to the State Fund will be made via check or wire transfer.

12.0 Cap on Tier-1 and Tier-2 Payments

There shall be a cap on the total payments by Qwest during a calendar year ~~for each of the 14 states~~. The cap amount for Arizona shall be ~~s by state are shown on Attachment 3. The cap represent~~ 36% of the "net revenues" as defined in the FCC's order approving the Bell Atlantic-New York 271 application and affirmed in the FCC order approving the Southwest Bell Telephone-Texas 271 application.[9] The cap shall be recalculated each year based upon the prior year's Arizona ARMIS results, adjusted to reflect the most current depreciation rates approved by the Arizona Corporation Commission. Qwest shall submit to the Commission the calculation of each year's cap no later than 30 days after submission of ARMIS results to the FCC. CLEC agrees that this amount constitutes a maximum annual cap which will apply to the aggregate total of Tier –1 liquidated damages (including any such damages paid pursuant to this Agreement, any other Arizona interconnection agreement, or any other payments made for the same or analogous performance under any other contract, order or rule) and Tier-2 assessments or payments made by Qwest for the same or analogous performance under another contract, order or rule.

~~The cap applies to the aggregate of Tier-1 payments to CLECs, including payments made pursuant to any other alternative performance obligations pursuant to an interconnection agreement with a CLEC, Tier-2 payments to State Funds, and any other payments required by State Commissions pursuant to service quality rules, orders or other agreements that relate to the same or analogous service.~~

~~The individual state amounts shown on Attachment 3 were calculated based upon Qwest's 1999 ARMIS results, adjusted to reflect the full annual effect of general rate case orders of the respective state regulatory commissions.~~

A monthly cap will be determined by dividing the amount of the annual cap by twelve. The monthly cap shall be calculated by applying all payments or credits made by Qwest under this PAP as well as all payments made or credits applied for wholesale service performance pursuant to interconnection agreements, state rules or orders. To the extent in any given month the monthly cap (i.e., the annual cap divided by 12) is not reached, the subsequent month's cap will be increased by an amount equal to the unpaid portion of the previous month's cap. ~~At the end of the year, if the aggregate of all payments for which the cap applies equals or exceeds the annual cap, but Qwest has paid less than that amount due to the monthly cap, Qwest shall be required to pay an amount equal to the annual cap. In such an event, Tier-1 payments shall be paid first on a pro rata basis to CLECs, and any remainder within the annual cap, shall be paid as Tier-2 payments. In the event the total of Tier-1 and Tier-2 payments is less than the annual cap, Qwest shall be obligated to pay only the actual calculated amount of Tier-1 and Tier-2 payments.~~

In the event the annual cap is reached within a calendar year and Qwest continues to deliver non-conforming performance during the same year to any CLEC or to all CLECs, the

[9] Federal Communications Commission, CC Docket No. 99-404, Memorandum Opinion and Order, December 22, 1999, Para. 436 and footnote 1332; Federal Communications Commission, CC Docket No. 00-65, Memorandum Opinion and Order, June 30, 2000, Para 424.

Commission may recommend to the FCC that Qwest should cease offering in-region interLATA services to new customers.

13.0 Limitations

13.1 Qwest's PAP shall not become available in a State unless and until the FCC approves Qwest's 271 application for that State.

13.2 Qwest will not be liable for Tier-1 ~~or Tier-2~~ payments to a specific CLEC in an FCC approved state until the Commission has approved an interconnection agreement between the CLEC and Qwest that adopts the provisions of this PAP.

13.3 Qwest shall not be obligated to make Tier-1 or Tier-2 payments for any measurement if and to the extent that non-conformance for that measurement was the result of any of the following: a Force Majeure event, periods of emergency, catastophe, natural disaster, severe storms, or other events beyond Qwest's control; an act or omission by a CLEC that is contrary to any of its obligations under its interconnection agreement with Qwest or under the Act or State law; an act or omission by a CLEC that is in bad faith[10]; or non-Qwest problems associated with third-party systems or equipment, which could not have been avoided by Qwest in the exercise of reasonable diligence, provided, however, that this third party exclusion will not be raised more than three times within a calendar year. Qwest will not be excused from Tier-1 or Tier-2 payments on any other grounds, except as described in paragraphs 13.6, 13.7, and 13.8. Qwest will have the burden to demonstrate that its non-conformance with the performance measurement was excused on one of the grounds described in this PAP.

13.4 Qwest's agreement to implement these enforcement terms, and specifically its agreement to pay any "liquidated damages" or "assessments" hereunder, will not be considered as an admission against interest or an admission of liability in any legal, regulatory, or other proceeding relating to the same performance. QWEST and CLEC agree that CLEC may not use: 1) the existence of this enforcement plan; or 2) Qwest's payment of Tier –1 "liquidated damages" or Tier-2 "assessments" as evidence that Qwest has discriminated in the provision of any facilities or services under Sections 251 or 252, or has violated any state or federal law or regulation. Qwest's conduct underlying its performance measures, however are not made inadmissible by its terms. Any CLEC accepting this performance remedy plan agrees that Qwest's performance with respect to this remedy plan may not be used as an admission of liability or culpability for a violation of any state or federal law or regulation. Further, any liquidated damages payment by Qwest under these provisions is not hereby made inadmissible in any proceeding relating to the same conduct were Qwest seeks to offset the payment against any other damages a CLEC might recover.

[10] Examples of bad faith conduct include, but are not limited to: unreasonably holding service orders and/or applications, "dumping" orders or applications in unreasonable large batches, "dumping" orders or applications at or near the close of a business day, on a Friday evening or prior to a holiday, and failing to provide timely forecasts to Qwest for services or facilities when such forecasts are required to reasonably provide services or facilities.

The terms of this paragraph do not apply to any proceeding before the Commission or the FCC to determine whether Qwest has met or continues to meet the requirements of section 271 of the Act.
~~Any CLEC accepting this PAP agrees that Qwest's performance with respect to this remedy plan may not be used as an admission against Qwest's interest. Nor may it be used as an admission by Qwest of liability in any legal, regulatory, or other proceeding, used as evidence that Qwest has discriminated in the provision of any facilities or services under Section 251 or 252 or has violated any state or federal law or regulation. Any Qwest conduct underlying the performance measurements and the performance data provided under the performance measurements are not made inadmissible by these terms.~~

13.5 By incorporating these liquidated damages terms into the PAP, Qwest and CLECs accepting this PAP agree that proof of damages from any non-conforming performance measurement would be difficult to ascertain and, therefore, liquidated damages are a reasonable approximation of any contractual damages that may result from a non-conforming performance measurement. Qwest and CLEC further agree that payments made pursuant to this PAP are not intended to be a penalty. The application of the assessments and damages provided for herein is not intended to foreclose other noncontractual legal and non-contractual regulatory claims and remedies that may be available to a CLEC.

13.6 CLEC is not entitled to remedies under both the PAP and under rules, orders, or other contracts, including interconnection agreements, arising from the same or analogous wholesale performance. Where alternative remedies for Qwest's wholesale performance are available under rules, orders, or other contracts, including interconnection agreements, CLEC will be limited to either the PAP remedies or the remedies available under rules, orders, or other contracts.

13.~~6~~7 In the event that ~~If~~ a CLEC agreeing to this PAP is awarded ~~receives~~ compensation ~~payments or credits pursuant to a Commission rule, order or any other contract with Qwest~~ for the same or analogous wholesale performance covered by this PAP~~, CLEC agrees to waive any claim to credits or payments under this PAP.~~, Qwest may offset the award with amounts paid under this PAP.

13.~~7~~8 Qwest shall not be liable for both ~~any~~ Tier-2 payments and assessments or sanctions ~~if Qwest has been assessed or made payments~~ made for the same or analogous performance pursuant to any Commission order or service quality rules.

13.~~8~~9 Whenever a Qwest Tier-1 payment to an individual CLEC exceeds $3 million in a month, or when all CLEC Tier-1 payments in any given month exceed the monthly cap (section 11.0), Qwest may commence a show cause proceeding. Upon timely commencement of the show cause proceeding, Qwest must pay the balance of payments owed in excess of the threshold amount into escrow, to be held by a third-party pending the outcome of the show cause proceeding. To invoke these escrow provisions, Qwest must file with the Commission, not later than the due date of the Tier-1 payments, an application to show cause why it should not be required to pay any amount in excess of the procedural threshold. Qwest will have the burden of proof to demonstrate why, under the circumstances, it would be unjust to require it

to make the payments in excess of the applicable threshold amount. If Qwest reports non-conforming performance to a CLEC for three consecutive months on 20% or more of the measurements reported to the CLEC and has incurred no more than $1 million in liability to the CLEC, the CLEC may commence a similar show cause proceeding. In any such proceeding the CLEC will have the burden of proof to demonstrate why, under the circumstances, justice requires Qwest to make payments in excess of the amount calculated pursuant to the terms of the PAP.

14.0 Reporting

Upon FCC 271 approval for a state, Qwest will provide CLECs which have approved interconnection agreements with Qwest a monthly report of Qwest's performance for the measurements identified in the PAP by the last~~25th~~ day of the month following the month for which performance results are being reported. Qwest will collect, analyze, and report performance data for the measurements listed on Attachment 1 in accordance with the most recent version of the Service Performance Indicator Definitions (PID). Upon a CLEC's request, data files of the CLEC's raw data, or any subset thereof, will be transmitted, without charge, to the CLEC in a mutually acceptable format, protocol, and transmission medium.

Qwest will also provide the Commission a monthly report of aggregate CLEC performance results pursuant to the PAP by the last~~25th~~ day of the month following the month for which performance results are being reported. Individual CLEC reports will also be available to the Commission upon request. Upon the Commission's request, data files of the CLEC raw data, or any subject thereof, will be transmitted, without charge, to the Commission in a mutually acceptable format, protocol, and transmission form. By accepting this PAP, each CLEC consents to Qwest providing that CLEC's report and raw data to State Commissions upon the Commission's request.

15.0 Audits/Investigations of Performance Results

15.1: Qwest will create a separate financial system which will take performance results as inputs and calculate payments according to the terms of the PAP. An independent audit of this financial system shall be initiated one year after the effective date of the PAP and a second audit shall be started no later than 18 months thereafter. The auditor will be chosen and paid for by Qwest. Alternatively, the Arizona Commission staff may choose to conduct this audit itself. The necessity of any subsequent audits of the financial system shall be considered in the six-month PAP reviews, based upon the experience of the first two audits.

If as a result of the audit, it is determined that Qwest underpaid, Qwest will add bill credits to CLECs and/or make additional payments to the State to the extent that it underpaid. In the event Qwest overpaid, future bill credits to CLECs and/or future payments to the State will be offset by the amount of the overage. All under and over payments will be credited with interest at the one year U. S. Treasury rate.

15.2: In the event of a disagreement between Qwest and the CLEC participating in this PAP as to any issue regarding the accuracy or integrity of data collected, generated, and reported pursuant to the PAP, Qwest and the CLEC shall first consult with one another and attempt in good faith to resolve the issue. If an issue is not resolved within 45 days after a request for consultation, the CLEC and Qwest may upon a demonstration of good cause (e.g., evidence of material errors or discrepancies) request an independent audit to be conducted, at the initiating party's expense. The scope of the audit will be limited to performance measurement data collection, data reporting processes, and calculation of performance results and payments for a specific performance measurement. An audit may not be commenced more than 12 months following the month in which the alleged inaccurate results were first reported.

If an audit identifies a material deficiency affecting results, the responsible party shall reimburse the other party for the expense of the third party auditor, assuming the responsible party was not the party initiating the audit. In the event the CLEC is found to be responsible for the deficiency, any overpayment made to the CLEC as a result of the deficiency shall be refunded to Qwest with interest and any affected portion of future payments will be suspended until the CLEC corrects the deficiency. In the event that Qwest is found to be responsible for the deficiency, Qwest will pay the CLEC the amount that would have been due under the PAP if not for the deficiency, including interest.

Neither CLEC nor Qwest may request more than two audits per calendar year for the entire Qwest in-region states. Each audit request shall be limited to no more than two performance measurements per audit. For purposes of these provisions, a performance measurement is a Performance Indicator Definition (PID), e.g., OP-3, Installation Commitments Met. CLEC agrees that Qwest shall not be required to conduct more than 3 audits at one time for its 14 in-region states, nothwithstanding who has initiated the audit, and notwithstanding the provisions in this paragraph. This provision shall exclusively govern audits regarding performance measurements. Qwest agrees to inform Commission Staff and all CLECs of the results of an audit.

15.3: Qwest will investigate any second consecutive Tier-2 miss to determine the cause of the miss and to identify the action needed in order to meet the standard set forth in the performance measurements. To the extent an investigation determines that a CLEC was responsible in whole or in part for the Tier-2 misses, Qwest shall receive credit against future Tier-2 payments in an amount equal to the Tier-2 payments that should not have been made. The relevant portion of subsequent Tier-2 payments will not be owed until any responsible CLEC problems are corrected. For the purposes of this sub-section, Tier-1 performance measurements that have not been designated as Tier-2 will be aggregated and the aggregate results will be investigated pursuant to the terms of this Agreement.

16~~5~~.0 Reviews

Every six (6) months, Qwest, CLECs, and the Commission shall review the performance measurements to determine whether measurements should be added, deleted, or modified; whether the applicable benchmark standards should be modified or replaced by parity standards; and whether to move a classification of a measure to High, Medium, or Low or Tier-1 to Tier-2. The criterion for reclassification of a measure shall be whether the actual volume of data points was less or greater than anticipated. Criteria for review of performance measurements, other than for possible reclassification, shall be whether there exists an omission or failure to capture intended performance, and whether there is duplication of another measurement. The first six-month period will begin upon the FCC's approval of Qwest's 271 application for that particular state. Any changes to existing performance measurements and this PAP shall be by mutual agreement of the parties.

Qwest will make the PAP available for CLEC interconnection agreements until such time as Qwest eliminates its Section 272 affiliate. At that time, the Commission and Qwest shall review the appropriateness of the PAP and whether its continuation is necessary. However, in the event Qwest exits the interLATA market, that State PAP shall be rescinded immediately.

176.0 Voluntary Performance Assurance Plan

This plan represents Qwest's voluntary offer to provide performance assurance. Nothing in this plan or in any conclusion of non-conformance of Qwest's service performance with the standards defined in this plan shall be construed to be, of itself, non-conformance with the Act.

Attachment 1: Tier-1 and Tier-2 Performance Measurements

Performance Measurement		Tier-1 Payments			Tier-2 Payments			
		Low	Med	High	Low	Med	High	
GATEWAY AVAILABILITY								
Availability of IMA – IMA GUI	GA-1						X	
Gateway Availability – IMA-EDI	GA-2						X	
PRE-ORDER/ORDERS								
Pre-Order/Order Response Time	PO-1					X		
LSR Rejection Notice Interval	PO-3	X						
Firm Order Confirmations On Time	PO-5	X				X*		
Billing Completion Notification Timeliness	PO-7	X						
Jeopardy Notice Interval	PO-8	X						
ORDERING AND PROVISIONING								
Calls Answered within Twenty Seconds	OP-2						X	
Installation Commitments Met	OP-3			X			X	
Installation Intervals	OP-4			X			X	
New Service Installation Quality Only	OP-5a			X			X	
Number Portability Timeliness	OP-8		X			X		
Coordinated Cuts On Time – Unbundled Loops	OP-13a		X			X		
MAINTENANCE AND REPAIR								
Calls Answered within 20 seconds Interconnect	MR-2						X	
Out of Service Cleared within 24 hours	MR-3		X					
All Troubles Cleared within 4 hours	MR-5		X					
Repair Repeat Report Rate	MR-7			X			X	
Trouble Rate	MR-8			X			X	
Repair Appointments Met	MR-9			X			X	
BILLING								
Time to Provide Recorded Usage Records	BI-1	X						
Invoices Delivered within 10 Days	BI-2						X	
Billing Accuracy Adjustments for Errors	BI-3	X						
Billing Completeness	BI-4	X				X		
NETWORK PERFORMANCE								
Trunk Blocking	NI-1			X			X	
NXX Code Activation	NP-1			X			X	
COLLOCATION								
Installation Interval	CP-1	X						
Installation Commitments Met	CP-2			X			X	
Feasibility Study Interval	CP-3	X						
Feasibility Study Commitments Met	CP-4	X						
Quote Interval	CP-5	X						
Quote Commitment Met	CP-6	X						

* Some PID Sub-Measurements are Tier1 only.

GATEWAY AVAILABILITY								
Availability of IMA – IMA-GUI	GA-1				X			
Gateway Availability – IMA-EDI	GA-2				X			
Gateway Availability – EB-TA	GA-3				X			
Gateway Availability – EXACT	GA-4				X			
Gateway Availability – GUI-Repair	GA-6				X			
PRE-ORDER/ORDERS								

Pre-Order/Order Response Time	PO-1					X		
LSR Rejection Notice Interval	PO-3	X						
Firm Order Confirmations On Time	PO-5	X				X		
Billing Completion Notification Timeliness	PO-7	X						
Jeopardy Notice Interval	PO-8	X						
ORDERING AND PROVISIONING								
Calls Answered within Twenty Seconds	OP-2						X	
Installation Commitments Met	OP-3[a]			X			X	
Installation Intervals	OP-4[b]			X			X	
New Service Installation Quality	OP-5			X			X	
Delayed Days	OP-6[c]			X			X	
Number Portability Timeliness	OP-8		X			X		
Coordinated Cuts On Time – Unbundled Loops	OP-13a		X			X		
MAINTENANCE AND REPAIR								
Calls Answered within 20 seconds-Interconnect	MR-2						X	
Out of Service Cleared within 24 hours	MR-3		X					
All Troubles Cleared within 4 hours	MR-5		X					
Mean time to Restore	MR-6a,b,c		X					
Repair Repeat Report Rate	MR-7			X			X	
Trouble Rate	MR-8			X			X	
BILLING								
Time to Provide Recorded Usage Records	BI-1	X					X	
Billing Accuracy-Adjustments for Errors	BI-3	X						
Billing Completeness	BI-4	X				X		
NETWORK PERFORMANCE								
Trunk Blocking	NI-1			X			X	
NXX Code Activation	NP-1			X			X	
COLLOCATION								
Installation Interval	CP-1	X						
Installation Commitments Met	CP-2			X			X	
Feasibility Study Interval	CP-3	X						
Feasibility Study Commitments Met	CP-4	X						

a. OP-3 is included as three "families:" OP-3a/3b, OP-3c, and OP-3d/e. Measurements within each family share a single payment opportunity with only the measurement with the highest payment being paid.

b. OP-4 is included with OP-6 as five "families:" OP-4a/OP-6-1, OP-4b/OP-6-2, OP-4c/OP-6-3, OP-4d/OP-6-4, and OP-4e/OP-6-5. Measurements within each family share a single payment opportunity with only the measurement with the highest payment being paid.

c. For purposes of the PAP, OP-6a and OP-6b will be combined and treated as one. The combined OP-6 breaks down to OP-6-1 (within MSA), OP-6-2 (outside MSA), OP-6-3 (no dispatch), OP-6-4 (zone 1), and OP-6-5 (zone 2).

Attachment 2

Performance Measurements Subject to Per Occurrence Payments With a Cap

Pre-Order/Orders

Pre-Order/Order Response Time – PO-1 (~~Tier-1/~~Tier-2)
LSR Rejection Notice Interval – PO-3 (Tier-1)
~~Firm Order Confirmation on Time – PO-5 (some sub-measurements do not have caps) (Tier-1/Tier-2)~~
Billing Completion Notification Timeliness – PO-7 (Tier-1)

Billing

Time to Provide Recorded Usage Records – BI-1 (Tier-1/Tier-2)
~~Invoices Delivered within 10 Days – BI-2 (Tier-1/Tier-2)~~
Billing Accuracy – Adjustments for Errors – BI-3 (Tier-1)
Billing Completeness – BI-4 (Tier-1/Tier-2)

Network Performance

Trunk Blocking – NI-1 (Tier-1/Tier-2)

Performance Measurements Subject to Per Measure Payments

Gateway Availability

Availability of IMA – IMA-GUI – GA-1 (Tier-2)
Gateway Availability – IMA-EDI – GA-2 (Tier-2)
Gateway Availability – EB-TA – GA-3 (Tier-2)
Gateway Availability – EXACT – GA-4 (Tier-2)
Gateway Availability –GUI-Repair – GA-6 (Tier-2)

Ordering & Provisioning

Calls Answered within Twenty Seconds – OP-2 (Tier-2)

Maintenance & Repair

Calls Answered within Twenty Seconds – MR-2 (Tier-2)

~~Attachment 3~~

~~Annual Cap on Qwest Payments~~

~~State ($ Millions)~~	~~1999 ARMIS Net Return~~	~~Adjustment for Commission Rate Orders~~	~~Annual Cap~~
~~Arizona*~~	~~260~~	~~(59)*~~	~~72~~
~~Colorado~~	~~288~~	~~(10)~~	~~100~~
~~Idaho~~	~~68~~		~~24~~
~~Iowa~~	~~85~~		~~31~~
~~Minnesota~~	~~246~~	~~(18)~~	~~82~~
~~Montana~~	~~44~~		~~16~~
~~Nebraska~~	~~84~~		~~30~~
~~New Mexico~~	~~89~~	~~(10)**~~	~~28~~
~~North Dakota~~	~~35~~		~~13~~
~~Oregon~~	~~132~~	~~(32)~~	~~36~~
~~South Dakota~~	~~42~~		~~15~~
~~Utah~~	~~138~~		~~46~~
~~Washington~~	~~225~~		~~81~~
~~Wyoming~~	~~34~~		~~12~~
~~Total Qwest~~			~~588~~

~~* The Arizona adjustment reflects Commission's represcription Decision No. 62507, Docket No. T-01051B-97-0689. Docket No. T-01051B-99-105 is the general rate case in which revenue recover of the increased depreciation expense is at issue. Upon final order in the rate case, the annual cap will be revised to reflect the offsetting revenues.~~

~~** The New Mexico adjustment reflects the New Mexico Commission's interim rate order in Docket No. 3007. Permanent rates will be set in Docket No. 3008 and will be reflected in this adjustment when rates are final.~~

QWEST EXHIBIT 17

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Performance Measurements and	)	
Reporting Requirements	)	CC Docket No. 98-56
for Operations Support Systems,	)	RM 9101
Interconnection, and Operator	)	
Services and Directory	)	
Assistance	)	

Affidavit of Dr. Colin L. Mallows

Colin L. Mallows, being duly sworn, deposes and says:

1. I am a Technology Consultant at AT&T Laboratories. I make this affidavit in support of AT&T's comments regarding the use of statistical methods to determine whether incumbent local exchange carriers ("ILECs") are providing nondiscriminatory, i.e., parity, service to competing carriers ("CLECs"). I understand this is a requirement of law under Section 251 of the Telecommunications Act of 1996 ("Act").

Qualifications

2. I have been a professional statistician for nearly 45 years. I obtained a B.Sc. in Mathematics in 1951 and a Ph.D. in Statistics in 1953, both from University College, London. After two years in the British Army I became a lecturer at University College in the area of statistics. Since 1960, I have been employed at AT&T (formerly Bell)

Laboratories, becoming Head of the Statistical Models and Methods Research Department in 1969. I relinquished that title in 1986. From 1960 through 1964, I was also an adjunct associate professor at Columbia University, teaching courses in statistical analysis.

3. I am a Fellow of the American Statistical Association ("ASA"), and I served as an associate editor of Journal of the American Statistical Association from 1966 to 1971, and again from 1986-1989. I am also a Fellow of the Institute of Mathematical Statistics ("IMS"), and an elected member of the International Statistical Institute. I was twice elected to the Council of IMS, and have served on various committees of the IMS and ASA. In 1997 I was honored by being named Fisher Lecturer at the Joint Statistical Meetings held by the ASA, IMS, the International Biometric Society and the Statistical Society of Canada.

4. I have published over 100 papers, with a large number of co-authors, in a variety of journals. My name is attached to several well-known statistical techniques, including the Cp-plot for selecting regression variables, the phi-model for analysis of ranking data, and a weighting scheme for robust linear regression. My professional interests include foundations, data analysis, statistical graphics, time series, robustness, software reliability,

moment-problems and Chebychev inequalities, combinatorics and coding theory.

Introduction

5. I have reviewed the Commission's Notice of Proposed Rulemaking ("Notice") in this proceeding, focusing on its discussion of the use of statistical analysis as a means of determining whether ILECs are providing parity service to new competitors. The Notice (¶ 34) is clearly correct that "reporting averages of performance measurements alone, without further analysis, may not reveal whether there are underlying differences in the way incumbent LECs treat their own retail operations in relation to the way they treat competing carriers." Thus, it properly proposes to require the use of statistical tests to determine whether measured differences in average ILEC performance for themselves and competitors "represent true differences in behavior rather than random chance."

6. As the Commission is aware, AT&T has supported the use of statistical tests to determine whether an ILEC has met its statutory obligations. Earlier this year, AT&T provided the Commission with a concept for applying statistical analysis to ILEC performance measurements.[1] The AT&T Statistical Ex Parte provided a methodology, given the

[1] Ex parte letter from Frank S. Simone, AT&T to Magalie Roman Salas, FCC, CC Docket No. 96-98, RM9101, dated February 3, 1998 ("AT&T Statistical Ex Parte").

presence of random error, to determine if an ILEC has complied with its statutory obligations when it reports results of numerous individual parity measurements, some of which show "worse" results for CLECs than for the ILEC.[2]

7. AT&T's Statistical Ex Parte correctly recognized that each of the individual tests of ILEC performance contained statistical Type I error. Thus, it is appropriate to use a Type I error concept when reviewing the ILEC's parity tests in the aggregate to determine whether the ILEC has met its nondiscrimination obligations. AT&T's Statistical Ex Parte thus described the use of a three-part analysis to determine whether ILEC measurements and reported results, when viewed in the aggregate, represent nondiscriminatory performance.[3]

8. Since that time, I have been asked to review and comment upon AT&T's Statistical Ex Parte and provide additional insight on the use of statistical tests in this context. As described in Section I below, the more detailed

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[2] Since most of the measurements for these purposes are measurements of time, a "worse" result for a CLEC is usually a larger value, e.g., a 5-day installation interval for a CLEC is worse than a 3-day interval for the ILEC.

[3] AT&T's proposal recommended establishment of separate thresholds for: (1) the maximum number of "failures" on a monthly report that could reasonably represent mere randomness resulting from the measurement process rather than disparity of performance; (2) repeated failures on specific performance measurements in consecutive months; and (3) measurements showing extreme differences in average performance for the ILEC and CLECs. Id., p. 3.

statistical methodology that is proposed here requires only a two-part analysis and provides the ILECs with more leeway than the original AT&T proposal. Nevertheless, I believe that it provides a valid statistical comparison of the ILECs' actual performance for itself and CLECs.

Summary of Testimony

9: Specifically, my testimony below shows that AT&T's proposed methodology satisfies the Commission's desire to assure that reported differences in ILEC performance are statistically meaningful. With respect to individual tests of ILEC performance, there are three key components in developing an appropriate statistical methodology. First, the modified z-statistic proposed by LCUG provides an appropriate test statistic to determine whether there are significant differences in the mean and the variance of an ILEC's performance for itself and for CLECs. Second, a one-tailed test with Type I error held at the 5% level strikes a fair balance between the need to account for both Type I and Type II errors. Third, the t-distribution provides a useful basis for calculating the critical value for individual tests of ILEC performance, which is used to determine whether CLECs have been given equal treatment by the ILEC. Moreover, in those cases where the sizes of the ILEC and CLEC samples are small, a permutation distribution can be developed that will provide valid test results.

10. My testimony also demonstrates that it is appropriate to aggregate the results of individual tests to determine whether the ILEC is in compliance with its duty to provide nondiscriminatory treatment to CLECs. This should be done through the use of a two-part analysis that sets limits on the number of individual tests that fail to demonstrate parity in any given month and the number of individual tests that fail in three consecutive months. These limits can be determined so that the overall Type I error is held at 5%.

11. I have also been asked to review the BellSouth statistical proposal referenced in the Notice, which is based on the use of Statistical Process Control principles. As shown in Section II below, such principles were not developed for the purpose of determining parity of performance for two different populations. Thus, BellSouth's proposal is unsuited to the present purposes and should be rejected.

I. AT&T's Proposed Statistical Methodology

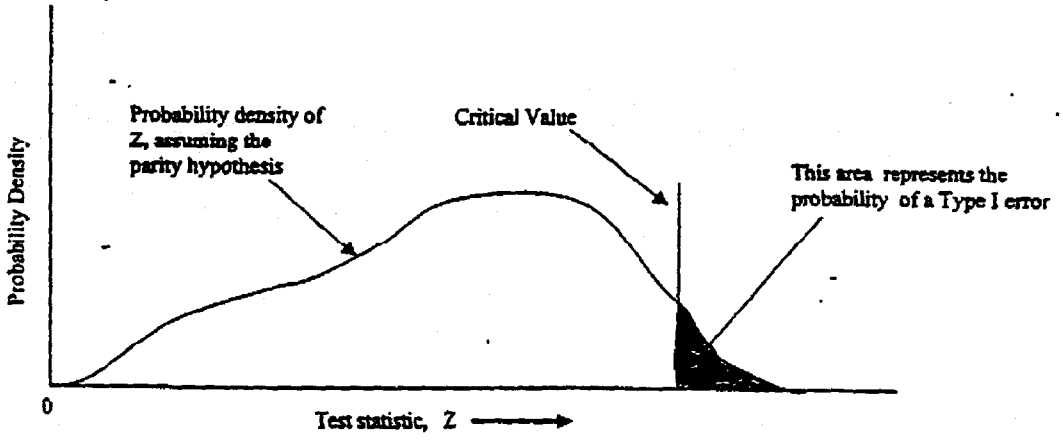
12. The statistical tests described below are designed to test the "null hypothesis," i.e., the assumption that the ILEC's performance is the same for itself and for CLECs. This hypothesis refers to the populations of ILEC and CLEC measurements, from which the observed measurements are assumed to be drawn. We cannot observe these populations,

and must base our test procedures on the observed samples. If the null hypothesis is accepted through the use of the chosen tests, then any differences in the ILEC's performance results for itself and the CLEC are deemed "statistically insignificant," and parity can be assumed.

13. All such statistical tests have three components. First, the test designer must select a test statistic, which is a formula that produces a single number summarizing the observed ILEC and CLEC data. Next, an acceptable Type I error probability must be adopted. The error probability represents the test designer's tolerance for falsely rejecting parity when it exists (Type I error is discussed in Section I.B below). Finally, the test designer must derive, from probability theory or known data, the probability distribution of the test statistic, describing the variability of performance under the null hypothesis.

14. Once these components are established, the test designer can determine (usually from a statistical table) a "critical value" against which to compare the computed value of the test statistic that is based on the actual results. If the test statistic is less than the critical value, it can be inferred that the ILEC's performance has "passed" the test of parity. If, however, the computed test statistic is greater than the critical value, the ILEC's performance is judged to be not at parity, and the ILEC has "failed" the

parity test for that measurement. The relationship between the performance distribution under the null hypothesis and the critical value is demonstrated graphically below.



A. Test Statistic: The Commission Should Use The Modified Z-Statistic Recommended By LCUG.

15. The modified z-statistic recommended by the Local Competition Users Group ("LCUG") is an excellent choice of test statistic in these circumstances. The "z-statistic" is a standard test statistic.[4] It is used to determine if the

[4] The formula for the z-statistic (also called the t-statistic), for the case where the observations are of measurements rather than proportions or rates, is

$$z = (\bar{Y} - \bar{X}) \Big/ \sqrt{\left(\frac{1}{m} + \frac{1}{n}\right) S^2}$$

where $\bar{X}$ (resp. $\bar{Y}$) is the average of the ILEC (resp. CLEC) measurements, m (resp. n) is the number of these measurements, and S is a measure of the scale of variation of these measurements. The usual situation is that the statistical test is designed to detect a difference in the

average results (or means) drawn from two separate performance samples (here the monthly ILEC performance data for itself and CLECs) have population means that are equal.[5] Thus, the standard z-statistic formula can determine whether, based on the reported results, the ILEC's average performance for itself and for CLECs is the same.

16. However, it is not enough to test for a difference in means alone. In order to obtain parity, CLECs are entitled to service from the ILEC that produces both the same mean performance and also the same variance in performance.[6] The z-statistic, in its standard form, is not designed to detect differences in variance between CLEC and ILEC performance.

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population means of the ILEC and CLEC measurements, assuming the population variances to be equal. In this case the standard choice for S^2 is

$$S^2 = S^2_{pooled} = \frac{(m-1)S^2_{ILEC} + (n-1)S^2_{CLEC}}{m+n-2}$$

[5] Similar statistics can also be used to detect differences in proportions and rates.

[6] The Commission also recognizes that it would be discriminatory if the ILEC has the same mean performance time for itself and CLECs but the variability of its performance for CLECs is greater (see Notice, Appx. B, ¶ 4 ("variability of response times . . . may affect the competitiveness of a competing carrier but may not be reflected in a comparison of average response times")). For example, CLECs would be at a commercial disadvantage if ILEC retail customers could always rely on an installation period of 4 days while installation dates for CLECs ranged from 2-6 days or more.

17. In order to create a single test that can account for both of these factors, LCUG proposes a modification that will make the statistical test have the power to detect whether the ILEC's variance in its performance for CLECs is greater than the variance in its performance for itself. Specifically, LCUG proposes to use the ILEC variance, rather than the "pooled" variance, in calculating the z-statistic.[7] This proposal is based on well-supported statistical testing principles and combines the power of tests of means and tests of variance. Thus, if the test proposed by LCUG is used, there would be no need to develop a separate test of the equality of variances.[8]

18. Use of the LCUG modified z-statistic, rather than the more conventional form that uses a "pooled" variance, is appropriate here because the problem here is different from that addressed in the standard texts. In the standard development, it is assumed that if the null hypothesis

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[7] The LCUG proposal is to use $S^2=S^2_{ILEC}$. The resulting test statistic has the same distribution theory as the conventional one (using S^2_{pooled}) except for changing the "degrees of freedom" from m+n-2 to m-1. The effect of this change will be small if the parity hypothesis holds, since as the incumbent monopolist, the ILEC sample is likely to be much larger that the CLEC sample.

[8] See Notice, Appx. B, ¶ 4. It should also be noted that the use of separate tests for differences in averages and differences in variance would reduce the power of each separate test. Thus, it is preferable to use a single test that is sensitive to cases where both the mean and variance can increase.

fails, it is only because the population means are different; the population variances are assumed to stay equal. This assumption is not appropriate here, because an increase in the CLEC variance would be a violation of parity, and the test should be able to detect it.[9]

19. As described above, the denominator of the formula for the z-statistic requires use of a figure for variance. Contrary to the suggestion of some ILECs,[10] the most appropriate variance to use in this case is the variance of the ILEC's performance for itself during the reporting period. This sample variance is the best available estimate of the variance of the ILEC process. Moreover, the entire purpose of the examination is to determine whether the ILEC is providing CLECs at least the same level of service as it provides to itself and its retail customers. Thus, for this purpose, variance in the ILEC's performance is the standard against which the performance for CLECs should be measured.

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[9] Another standard form of the z-statistic is designed for the case where the two population variances may differ even under the null hypothesis. In this case one replaces $\left(\frac{1}{m}+\frac{1}{n}\right)S^2$ by $\frac{S^2_{ILEC}}{m}+\frac{S^2_{CLEC}}{n}$
This form of the statistic ii inappropriate here since under the parity hypothesis the two population variances are equal. Use of this form would reduce the probability of detecting violations of parity.

[10] I am informed that some BOCs have suggested that the variance used in the formula should be based solely on the variance experienced by the CLECs, and others have suggested the use of the pooled variance.

B. The Error Probability Should Be Based On A One-Tailed Test With Type I Error At No More Than The 5% Level.

20. In determining an appropriate Type I error probability for the statistical test, it is important to recognize that any probability rate above 0% means that the statistical test will produce errors.[11] It is also important to understand that there are two distinct types of testing errors. "Type I" errors occur when a statistical test shows that two sets of results (here for the ILEC and CLEC) are inconsistent with the null hypothesis (i.e., are not in parity) when in fact the null hypothesis is true. "Type II" errors are the opposite. They occur when a statistical test indicates that the outcomes are in parity, but parity does not in fact exist. Both types of errors are possible.

21. There are two "tails" to Type I errors, but the Notice (Appx. B, n.3) correctly notes that only one is pertinent here: errors relating to cases in which the ILEC's performance for CLECs is worse than its performance for itself. Under the Commission's rules, CLECs are entitled to performance that is "at least equal" to the performance the ILEC provides to itself. Those rules are not concerned with cases where, unintentionally, the ILEC provides CLECs with a

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[11] AT&T Statistical Ex Parte, p. B-1.

level of performance that is better than the performance it provides to itself.[12] Thus, the Commission's rules themselves argue for a one-tailed test.

22. It should also be recognized that Type II errors are as real as Type I errors. Thus, there may be cases in which the ILEC is not in fact providing equal service to CLECs, but purely by chance the statistical test fails to reject the parity hypothesis. Thus, it is necessary to strike a balance between the two types of errors. If we choose to make the Type I error small, then the Type II error will be large; and conversely. AT&T proposes to set the Type I error at no more than the conventional level of 5%. This controls the frequency of false alarms to be at most 5% while making the probability of Type II errors small for violations that are of substantial size. Using a one-tailed test for Type I error at about the 5% level thus strikes a reasonable balance.[13]

C. Probability Distribution Should Be Based On The T Distribution Or A Permutation Distribution Analysis.

[12] I am also informed that CLECs are not entitled to demand performance better than the ILEC provides to itself. Thus, there is no reason to believe that ILECs would intentionally provide their competitors with a higher grade of service than they provide to themselves and their retail customers.

[13] For general information supporting the 5% level, see AT&T Statistical Ex Parte, pp. B-1-B-2.

23. For moderate or large sample sizes, it is appropriate to use the Student t (or "t") distribution to determine the critical value for the test. Use of this distribution, which is readily available in table form, is simple and straightforward and will produce statistically reliable results.

24. The published tables of critical values, using the t-distribution, are based on the assumption that the two populations (of ILEC and CLEC measurements) are exactly Normal. In practice, we will not have Normal distributions, and so these critical values are only approximations. There has been much debate as to the minimum sample sizes for which the tabulated values become acceptable approximations: numbers such as 10 or 30 have been suggested. But this must depend on the shape of the probability density function[14] of the populations, because there exist populations for which the approximation will never be adequate, even for very large sample sizes. In advance of reviewing the actual data, it is impossible to say for what size samples the tabulated values will be acceptable. Nevertheless, assuming that very large values of the observations do not occur and the populations have approximately symmetrical probability density functions, I would guess that the tabulated values

[14] See the graph in ¶14 of these comments for an example of a probability density function.

would be acceptable, provided that both the ILEC and CLEC samples have at least 10 members. Thus, the issue of sample size should not generally be a problem.

25. There is an alternative method for developing the probability distribution of the test statistic that can be used with smaller sample sizes.[15] Under this method, called the permutation distribution, the probability distribution is generated through use of the actual sample results, rather than a preexisting table. Given two samples, X's and Y's from ILEC and CLEC respectively, we combine these into one pool and then divide this into two sets X* and Y* in all possible ways. For each way, we calculate the corresponding z-score, say z*. This gives us a distribution of z* values, each of which is equally likely under the null hypothesis that the ILEC is treating customers impartially. Given the desired Type I error rate, we can read off the appropriate critical value and compare this with the observed value.

26. For example, if the data are

3 ILEC observations: X=1, X=2, X=4
2 CLEC observations: Y=3 and Y=5

then the pooled set is (1,2,3,4,5) and there are 10 ways we can assign these five observations to the ILEC and CLEC samples. We get 10 values of z:

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[15] This method will provide reliable results for any sample size, but the use of the t-distribution and the associated table is simpler for all but very small sample sizes.

-2.74 -1.20 -0.60 -0.44 0.00 0.00 0.44 0.60 1.20 2.74

and the 5% critical value is 2.74. The actual observed value is 1.20, and so is judged to be not significant (i.e., we accept the null hypothesis).

27. This test procedure is valid irrespective of the form of the population distribution, since it depends only on the assumption that each possible permutation is equally likely under the null hypothesis.[16] The method can be used whenever the sample sizes are large enough to make the test statistic well defined, in the present case even for m=2, n=1.

28. The permutation distribution would be developed through the use of a computer program that would enumerate the samples necessary to generate the distribution. I wrote a program to perform this function in a commercially available program language called S Plus in one-half hour. Thus, I believe that a suitable program could be developed promptly for use by the entire ILEC industry at minimal cost[17].

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[16] See, e.g., Cox and Hinkley, Theoretical Statistics (1974) (paperback edition Chapman and Hall, 1979), pp. 182-184; H. Scheffe, The Analysis of Variance (1959) John Wiley & Sons, Section 9.3; P. Good, Permutation Tests (1994) Springer.

[17] The Cytel Software Corporation of 675 Massachusetts Avenue, Cambridge, MA, markets a product called StatXact which has the capability of performing permutation tests.

29. A resource issue relating to the use of the permutation distribution is the time needed to generate results. Unless the sample sizes are very small, the number of permutations to be generated is extremely large.[18] In order to deal with this problem, it would be reasonable to use a random sample of possible permutations to approximate the distribution. For example, if the number of possible permutations in a particular case exceeds 1000, the program could be designed to approximate the permutation probability distribution by randomly selecting 1000 permutations and constructing the distribution from those data. Because computers can perform calculations such as this with remarkable speed, the distribution for any measurement category could be ascertained within a few seconds.[19]

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[18] If m=10, n=5, there are 3003 permutations; if m=20, n=10, there are over 30 million.

[19] The Notice (Appx. B, n.5) raises another interesting possibility for a statistical analysis of individual performance measurements, i.e., comparing the proportions of two samples that exceed some fixed value. AT&T is studying a variation of this concept, in which the fixed value is not specified in advance, but is determined from the ILEC sample itself. We use the upper 90% quantile of the ILEC sample to determine the level of service that the ILEC is providing for 90% of its customers and then measure what percentage of CLEC customers receive at least that level of service. The "parity" hypothesis is rejected if the fraction of CLEC customers receiving that level of service is much smaller than the percentage of ILEC customers receiving such service. (For example, if the ILEC completes repairs on a specific service for 90% of its customers within 48 hours, parity is not achieved if the ILEC complete repairs for much less than 90% of CLEC customers within that amount of time.) This test procedure is non-parametric, i.e., it does not

D. ILECs' Compliance With Their Nondiscrimination Obligations Should Be Based On An Aggregate Assessment Of Parity.

30. One of the key concepts in the AT&T Statistical Ex Parte is that it is also appropriate to use statistical analysis to review the aggregate results of an ILEC's performance to determine whether it is in compliance with its nondiscrimination obligations. If we apply a large number, several hundred perhaps, of tests of individual performance measurement comparisons, each test having a Type I error rate of 5%, then we would expect, on average, about 5% of these tests to indicate non-compliance even when the ILEC is actually fully in compliance. Thus the fact that this many tests indicate non-compliance does not give conclusive evidence that the ILEC is not in compliance with its Section 251 nondiscrimination obligations. The number of tests that erroneously indicate non-parity will vary randomly about this average number. We need to derive some threshold number of failed parity tests such that if more than this number are observed to fail, then non-compliance can be deduced. This threshold number of tests must be determined in such a way as to control the probability of an

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require any assumptions beyond the basic one that under the null hypothesis CLECs receive equal treatment to the ILEC. This methodology only applies, however, to the review of individual performance tests. It does not address the need to develop a method to review ILEC performance in the aggregate.

overall, or aggregate, Type I error at 5%. Furthermore, I also recommend that any review of an ILEC's compliance with its nondiscrimination obligation should be based on two dimensions of statistical comparisons, both of which must be satisfied.[20] The two dimensions of statistical comparisons are

(a) the number of tests that fail in any monthly period must not be too large, and

(b) the number of tests that fail for three consecutive months must not be too large.

Here, "too large" must be determined by consideration of the total number of individual tests and the desired overall Type I error rate.

31. For the first dimension, we must determine how many of the individual measurements subjected to the above comparison tests need to demonstrate non-parity before an ILEC may be found to be in overall violation of its statutory duty. Suppose we have made N individual tests, each having a 5% Type I error rate, and have found that K_1 of them indicate non-compliance. If K_1 is approximately .05 times N, we have no conclusive evidence of overall non-

[20] The AT&T Statistical Ex Parte suggested that a third dimension also be considered, namely imposing a bound on the number of individual tests that exhibit extreme violations. I now judge that imposing this additional constraint does not provide much additional power for detecting extreme violations, and in fact reduces the chance of detecting some more moderate violations.

compliance. Under the assumption that the ILEC is in compliance, we can determine a number k_1 such that the probability that K_1 exceeds k_1 is 5%.[21]

32. The second dimension, i.e., the number of measurements failing the test repeatedly, is necessary to assure that the ILEC failures are indeed random. Without this dimension, the ILEC might be able to "game" the process and produce repeatedly discriminatory results on measures that are critical to one or more competitors. Thus, for this dimension, we must determine how many individual measurements in an ILEC report may be allowed to fail the parity test in three successive months before finding that the ILEC has failed to provide parity.

33. Suppose we have made N individual tests for each of three months, each test having a Type I error of 5%. Let K_2 be the number of tests that have failed in all three months. The probability that any individual test fails in all three months, assuming that the ILEC is in compliance with its nondiscrimination obligation, is $(.05)^3$, or 1/8000. Thus the expected number that fail in all three months,

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[21] This computation assumes that under the null hypothesis, the number K_1 has a binomial distribution with exponent N, i.e., it is as though we had tossed N coins, each with a probability of coming down "heads", and have counted how many "heads" appear. Then we claim non-compliance if K_1 exceeds k_1.

assuming compliance, is N/8000. Given that the number of monthly tests will be well below 8000, noncompliance should be found if K_2 is not zero. In other words, the allowed number of three-time-failing tests is $k_2=0$.

34. If we apply both of these overall procedures simultaneously, the actual overall Type I error rate is a function of three things: the Type I error rates of the individual tests, which I call α_1, the number k_1 of allowed individual failures, and the number k_2 of allowed three-time failures. These three numbers can be determined so that the Type I error rate of the overall procedure is exactly 5% (or whatever other value is required). Details of this computation are given in Exhibit 1.

II. BellSouth's Proposed Methodology Is Unsuited To Measure Parity And Should Be Rejected.

35. The Notice (Appx. B, ¶ 7) also solicits comments on the methodology proposed by BellSouth, which is based on the use of statistical process control. This approach is not suitable to measure parity between ILECs and CLECs and should be rejected.

36. BellSouth has proposed three kinds of control charts. In the first, described in the Notice (Appx. B, ¶ 6), BellSouth maintains its own monthly results (presumably for each type of measurement) on a control chart. Three-sigma limits are established by reference to BellSouth's historical record. Then, each month, results

for the CLEC are plotted on the same chart, and parity is claimed if these values do not fall outside the limits.

37. A second proposal appears in BellSouth's Tennessee Section 271 proceeding (see memo from David Laney to William Stacy, attached to the rebuttal testimony of William N. Stacy, TRA Docket 97-00309, Exhibit WNSPM-2). Here the proposal is to plot values of the variable DIFF=(CLEC value - ILEC value) on a control chart, with limits set at +/- 2.66 times the average moving range of size two.

38. A third proposal also appears in the same document from BellSouth's Tennessee Section 271 proceeding. Here it is proposed to compute z-scores, but using the process standard deviation in the denominator rather than the within-month ILEC sample variance as AT&T recommends. This process standard deviation is the average moving range (presumably of size two) divided by 1.128.

39. Each of these proposals has serious deficiencies, the most serious being that statistical process control is not designed to measure differences in parity. Rather, this technique is used to measure stability in performance. Stability of ILEC processes is of course an important concept, because the overall reliability of the systems used to serve CLECs is essential to determining whether an ILEC has met its duties under Section 251 of the Act. However, it is irrelevant in determining whether an ILEC's

performance for itself is at parity with the performance it provides to others, i.e., CLECs. The ILEC's performance could be stable, with parity not provided, or unstable with parity being provided. Stability and parity are distinctly different concepts.

40. Another shortcoming of each of the three BellSouth proposals is that no allowance is made for the fact that the number of observations that contribute to each average may change from month to month. This makes the use of moving ranges invalid measurements of variability. Also, the number of observations in the CLEC sample is very unlikely to equal the number in the ILEC sample. Thus the ILEC and CLEC averages will not have the same variances, even assuming parity, and so should not be compared to the same control limits, as the first proposal suggests.

41. If control limits for the quantity DIFF were to be set using the process variability of this quantity, as in the second and third proposals, some consistent violations of parity could completely avoid detection. Namely, if for any reason the CLEC measurements were consistently more variable than the ILEC measurements (which would imply that many CLEC customers were getting poorer service), then this variability would be included in setting the control limits, and lack of parity would not be detected.

42. Further, use of separate control charts for each of the many types of measurement leaves open the question of how an overall judgement of compliance should be arrived at. BellSouth has not addressed this issue.

Conclusion

43. In summary, my testimony shows that AT&T's proposed methodology satisfies the Commission's desire to assure that reported differences in ILEC performance are statistically meaningful.

44. With respect to individual tests of ILEC performance, there are three key components in developing an appropriate statistical methodology. First, the modified z-statistic proposed by LCUG provides an appropriate test statistic to determine whether there are significant differences in the mean and the variance of an ILEC's performance for itself and for CLECs. Second, a one-tailed test with Type I error at about the 5% level strikes a fair balance between the need to account for both Type I and Type II errors. Third, the t-distribution provides a useful basis for calculating the critical value for individual tests of ILEC performance. Moreover, in those few cases

where the size of the ILEC sample is small, use of the permutation distribution will provide valid results.

45. It is also appropriate to aggregate the results of individual tests to determine whether the ILEC is in overall compliance with its duty to provide nondiscriminatory treatment to CLECs. This should be done through the use of a two-part analysis that sets limits on the number of individual tests that fail to demonstrate parity in any given month and on the number of individual tests that fail in three consecutive months. These limits can be determined in such a way that the overall Type I error is held at 5%.

46. Finally, the methodology suggested by BellSouth is not designed to measure parity of performance between two different populations. Thus, it should not be used to determine whether ILECs have met their legal duty to provide CLECs with parity service.

Colin L. Mallows

Sworn to before me this
29th day of May, 1998

Notary Public

My Commission expires

Exhibit 1

Statistical Definition of the Compliance Rule for ILEC Parity

The number k_1 of allowed individual violations, and the Type I error of each of the individual tests[22], α_1, are determined so that the probability of falsely claiming overall violation is controlled at a known level[23], which we call α.

Suppose we are aggregating N individual tests. Let K_1 be the number of these tests that indicate violations this month, and let K_2 be the number of tests that have shown violations in each of the past three months. Our proposed procedure is to claim overall violation if either (i) K_1 exceeds some number k_1, or (ii) K_2 exceeds zero. We show how k_1 and the type I error α_1 of each individual test can be determined so that the Type I error of the overall procedure is held at some desired level α.

To determine k_1 and α_1 when we know N, (the number of tests to be aggregated), and α, we proceed as follows. Throughout this calculation, we are assuming that the ILEC is fully in compliance, so that for each individual test the probability of (falsely) indicating non-parity is α_1.

a) Choose a tentative value for α_1. We start with $\alpha_1 = \alpha$. This value of α_1 will be adjusted (downwards) later.

b) Determine k_1 to be the largest number such that the probability that the overall procedure indicates violation[24] (is greater than α.

c) Decrease α_1 until the probability of overall violation using the value of k_1 that was determined in step b), is exactly α.

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22 Also referred to as the size of the individual test.

23 Also referred to as the size of the overall aggregated test.

24 This probability is: $1 - (1 - \alpha_1^3)^N * P(k, N, p)$ where $P(,,)$ is the cumulative probability of the binomial distribution. That is, $P(k, N, p)$ is the probability that the number of false parity test failures is <= k when the probability of an individual false parity test failure is p, and where $p = (\alpha_1 - \alpha_1^3)/(1 - \alpha_1^3)$.

The resulting value of α_1 (and the corresponding critical value on the z-score scale) is to be used in each of the individual tests. Then non-compliance is indicated if any series fails the test in three successive months, or if more than k_1 fail in any single month.

The following table provides an example of how k_1 is determined for the values N = 100 and α = 5%. As shown, the value of k_1 = 8 is the largest value of k that corresponds to a probability of no less than 5% of being exceeded. In this case, the probability of claiming an overall violation is 7.40%.

Table 1

Determination of k_1 for N=100, α= 5%

k	Prob{K_1>k, K_2>0} =1 - (1 - α_1^3)^N * P(k, N, p)	
5	38.95%	
6	24.17%	
7	13.76%	
8	7.40%	← select this k for k_1
9	3.99%	
10	2.36%	

The next step is to iteratively decrease α_1 and recompute the overall probability of violation, with k_1 held at 8, until we arrive at a value for α_1 for which this probability is .05. In this case, that value of α_1 is .04601.

Now we can use the t-tables (or permutation distribution calculations) to determine the appropriate critical values for each individual test. The following Table 2 provides k_1, α_1, and critical values (assuming large sample sizes for each test) for α = .05 and a number of values of N.

Table 2

Determination of k_1 and α_1 for a range of N
where k_1 satisfies $1 - (1 - \alpha_1^3)^N * P(k_1, N, p) = .05$

N	k_1	k_1 as a % of N	α_1	Critical Value (c)
70	6	8.57%	.0465	1.6803
80	6	7.50%	.0408	1.7411
90	7	7.78%	.0437	1.7096
100	8	8.00%	.0460	1.6849
120	9	7.50%	.0442	1.7038
140	10	7.14%	.0430	1.7170
160	12	7.50%	.0462	1.6825
180	13	7.22%	.0452	1.6937
200	14	7.00%	.0443	1.7026
250	17	6.80%	.0441	1.7046
300	20	6.67%	.0440	1.7060
400	26	6.50%	.0437	1.7095
500	32	6.40%	.0431	1.7155
600	38	6.33%	.0423	1.7247
700	44	6.29%	.0412	1.7374
800	49	6.13%	.0397	1.7543
900	55	6.11%	.0384	1.7696
1000	60	6.00%	.0371	1.7851

QWEST EXHIBIT 18

MCI Telecommunications, WorldCom Communications

Local Service Non-Discrimination Compliance and Compliance Enforcement

August 4, 1998

Version 1.0

Executive Summary

The Local Competition Users Group has drafted Service Quality Measurements (SQMs) that are intended to measure parity of service provided by incumbent local exchange carriers (ILECs) to competitive local exchange carriers (CLECs). In addition, the Local Competition Users Group has also identified statistical tests applicable to the SQM results. These statistical tests calculate test parameters that allow for the overall probability of declaring the ILEC out of parity purely by chance. The present document proposes a method for using the test parameters calculated for individual SQM results to determine ILEC compliance with nondiscrimination obligations. Finally, this document proposes corrective actions and remedies that should apply when an ILEC is judged not to be in compliance with its non-discrimination obligations.

MCI and WCom recognize that there can be random variability in results. The procedure allows a small number of SQMs to be out of parity in any given month, and will not declare the ILEC to be out of compliance unless the number of SQMs out of parity exceeds this critical number. When the ILEC is found to be out of compliance, the ILEC must initiate appropriate corrective actions. MCI and WCom also recommend that regulators should establish deterrents for failure to provide non-discriminatory support to CLECs. When conduct emerges that is indicative of discriminatory treatment, sanctions must be both swift and severe. Otherwise, the market effects of the improper conduct will be a fait accompli and the ILEC may choose to absorb any monetary penalties as a cost of maintaining their local monopoly. In the initial stages of competition, degraded service provided to CLECs can place an indelible mark against the CLEC in the eye of local customers and saddle the CLEC with a reputation of poor service that would be difficult to overcome. In addition to financial penalties, other deterrents such as suspension of privileges must be applied to ILECs that are determined to be out of compliance.

Introduction

Purpose

The Local Competition Users Group (LCUG) is a cooperative effort of AT&T, MCI, Sprint, LCI and WorldCom for addressing fundamental issues of new companies (competitive local exchange carriers, or CLECs) into the local telecommunications market. A key initiative of the LCUG is to establish a performance measurement approach for monitoring ILEC compliance with its nondiscrimination requirements of the Telecommunications Act of 1996. Nondiscrimination, or parity, means that the support ILECs provide on behalf of the CLECs is no lesser in quality than the service provided by the ILECs to their own customers.

Previously, the LCUG issued a document listing service quality measurements (SQMs) appropriate to monitor that ILECs provide parity of support. The SQM document has been submitted to the FCC and made available to PUCs in all 50 states and is being reviewed by many of these regulatory agencies. A second LCUG document, "Statistical Tests for Local Service Parity", describes statistical methodology for determining if parity exists for measured results for individual measurements defined in the SQM document. This paper, a joint effort of MCI and WCom, describes 1) the statistical methodology for assessing an ILEC's compliance with the Act's nondiscrimination obligations, 2) corrective actions when an ILEC is not in compliance and 3) possible methods for deterring ILEC non-compliance.

Statistical Procedure for Determining Compliance

Selecting the Critical Values for Z-Scores

In the Local Competition Users Group "Statistical Tests for Local Service Parity", LCUG identified statistical tests for determining if parity exists between individual CLEC SQM results and the ILEC's equivalent results. For each performance result, the difference between the ILEC and CLEC results is converted to a *z*-score. [1] This *z*-score is then compared with a pre-selected critical value, and non-parity is declared if the *z*-score exceeds this critical value. The selection of the critical value is made to reflect the predetermined acceptable probability of erroneously declaring a parity violation (i.e., the probability of a type one error, as discussed below).

In the "Statistical Test for Local Service Parity" paper, LCUG recognized that there are two types of errors that are possible in statistical hypothesis testing. In this application, a type I (alpha) error is declaring a parity violation when in fact none exists, while a type 2 (beta) error is not identifying a parity violation when one truly exists. The probabilities of these events are

[1] The *z*-score is an index that statisticians use to compare results for different samples. It compares two samples on a standard scale, making the proper allowances for the sample sizes. *Z*-score methodology is explained in more detail on pages 8-9 of the "Statistical Test For Local Service Parity" paper.

alpha and beta, respectively. In order to select a critical value for a z-score, the acceptable alpha must be established: that is, what probability of erroneously declaring a parity violation is permissible?

An important consideration is that alpha and beta errors are related: "a low probability of committing a type 1 or alpha error generates a higher probability of committing a type 2 or beta error, and vice versa. for any given sample size."[2] Setting the acceptable alpha at a very low level, meaning a low risk of false non-parity accusations, conversely established a high risk of falsely declaring parity.[3]

MCI & WCom propose that the critical value used in the comparison for the individual SQM z-scores should depend on the number of z-scores being examined, but should be at least 1.645 so that the probability of type one error for each test does not exceed 0.05, or 5%. This means that for each SQM z-score there is at most a 5% chance of indicating that the ILEC is not delivering parity when, in fact, parity exists.

Any measurement for which the ILEC fails to submit a report and z-score will be assumed to have a z-score that is greater than the critical value.

Procedure for Determination of Monthly Compliance

The individual SQM z-scores permit a determination whether an ILEC has provided parity support to the CLEC for that particular SQM and reporting dimension. Because individual scores may indicate both parity and non-parity situations, an overall assessment of the ILEC's support is required. This determination requires an additional statistical procedure, referred to as the "procedure for determination of compliance".

The compliance procedure, like the previously described z-score procedure, recognizes that there can be random variability in results. The compliance procedure is based on two dimensions of statistical comparisons and requires that both dimensions be satisfied. The two dimensions of statistical comparisons are these:

1. A specified maximum number of individual SQM z-scores may exceed the individual critical value each month. We will call this number k_1. The value for k_1 is dependent on the number of individual z-scores reported for the month (N). Based on this criteria dimension, nondiscrimination is achieved if no more than k_1 of the individual measurement and reporting dimension combinations comparisons "failed" the test. That is, compliance for this dimension would be subject to a k_1 compliance threshold.
2. A specified maximum number of individual SQM z-scores may exceed the critical value for three consecutive months. Based on a specified confidence level used in determining the maximum number of comparisons failing the parity test in a given month, one would expect that no more than k_2 of the performance measurement and reporting dimension

[2] John E. Hanke and Arthur G. Reitsch, Understanding Business Statistics (Boston: Richard D. Irwin, Inc., 1994), 300.

[3] John E. Hanke and Arthur G. Reitsch, Understanding Business Statistics (Boston: Richard D. Irwin, Inc., 1994), 328.

combinations would fail the test in three consecutive months when, in fact, the results are not different. Compliance for this dimension would be subject to a k_2 compliance threshold.

The critical number of violations (i.e, the maximum number of SQM z-scores that are permitted to exceed the individual critical value for one month) is determined by the acceptable level of alpha (probability of a type one error). MCI and WCom propose to determine the individual critical values so that the overall probability of type one error is exactly 0.05. This calculation depends on the number of z-scores that are being examined. We take the individual critical value to be the smallest number greater than 1.645 such that the overall procedure has a type one error rate of exactly 0.05.

The probability that a given parity test would fail in three consecutive months when parity is provided is $(\alpha_1)^3$, where α_1 is the probability of falsely failing parity in a given month. The value for α_1 will be no greater than .05 when the overall confidence level is set at 95%. At this overall confidence level, the probability of falsely failing parity for three consecutive months is less that .0001. This means that for 1000 parity tests (i.e., N=1000), one would expect that on average no more than 1/10 measurement (i.e., much less than 1 measurement) would falsely fail parity. We therefore set k_2 to be 0.

The details of these calculations are given below.

Monthly Compliance Decision Rule

The decision rule is that non-compliance exists in any given month when either:

i. more than k_1 of the individual parity tests fail for that month

OR

ii. any individual parity test fails in three consecutive months ending with the given month

The number k_1 of allowed individual violations, and the probability of falsely failing each of the individual comparison tests[4], α_1, are determined so that the probability of falsely claiming overall violation is controlled at a known level[5], which we call α. To determine k_1 and α_1 when we know N, (the number of tests to be aggregated), and α, we proceed as follows. Throughout this calculation, we are assuming that the ILEC is fully in compliance, so that for each individual test the probability of (falsely) indicating non-compliance is α_1.

a) Choose a tentative value for α_1. We start with $\alpha_1 = \alpha$. This value of α_1 will be adjusted (downwards) later.

b) Determine k_1 to be the largest number such that the probability[6] that (i) and (ii) holds is

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4 Also referred to as the size of the individual test.

5 Also referred to as the size of the overall aggregated test.

6 This probability is: $1 - (1 - \alpha_1)^{N-3} P(k, N, p)$ where $P(.,.)$ is the cumulative probability of the binomial distribution. That is, $P(k, N, p)$ is the probability that the number of false parity

greater than α.

e) Decrease α_1 until the probability that (i) and (ii) holds, using the value of k_1 that was determined in step b), is exactly α.

The resulting value of α_1 (and the corresponding critical value on the z-score scale) is to be used in each of the individual tests. Then non-compliance is indicated if any series fails the test in three successive months, or if more than k_1 fail in any one month.

The following table provides an example of how k_1 is determined for a specified N and α_1. As shown, the value of $k = 8$ is the largest value of k that corresponds to a probability of no less than 5% of being exceeded. In this case, the probability that (i) and (ii) holds when there are more than 8 failed comparisons for a given month is 7.40%.

Table 10
Determination of k_1 for N=100, α= 5%

k	Prob{either (i) or (ii)} = $1 - (1 - \alpha_1)^N * P(k, N, p)$	
5	38.95%	
6	24.17%	
7	13.76%	
8	7.40%	← select this k for k_1
9	3.99%	
10	2.36%	

The next step is to iteratively decrease α_1 and recompute Prob{either (i) or (ii)}, with k held at 8, until we arrive at a value for α_1 for which Prob{either (i) or (ii)}, with k held at 8, =.05. That value of α_1 is .04601 which corresponds to a critical value of 1.6849

Similarly, k_1, α_1 and critical value, c, can be determined for any value of N and α. The following table provides k_1, α_1 and critical value, c, for α = .05 and a number of values of N.

Table 11
Determination of k_1 and α_1 for a range of N
where k_1 satisfies $1 - (1 - \alpha_1)^N \Sigma P(k_1, N, p) = .05$

N	k_1	k_1 as a % of N	α_1	Critical Value (c)
70	6	8.57%	.0465	1.6803
80	6	7.50%	.0408	1.7411
90	7	7.78%	.0437	1.7096
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160	12	7.50%	.0462	1.6825
180	13	7.22%	.0452	1.6937
200	14	7.00%	.0443	1.7026
250	17	6.80%	.0441	1.7046
300	20	6.67%	.0440	1.7060

test failures is <= k_1 when the probability of an individual false parity test failure is p, and where $p = (\alpha_1 - \alpha_1^3)/(1 - \alpha_1^3)$].

400	26	6.50%	.0437	1.7095
500	32	6.40%	.0431	1.7155
600	38	6.33%	.0423	1.7247
700	44	6.29%	.0412	1.7374
800	49	6.13%	.0397	1.7543
900	55	6.11%	.0384	1.7696
1000	60	6.00%	.0371	1.7851

Corrective Action

When an ILEC fails to deliver parity, either for individual reporting dimensions or compliance, then the ILEC must adjust its processes to ensure that it will promptly conform to this statutory obligation.

Thresholds for Initiating Corrective Action

An ILEC should initiate corrective action whenever the compliance procedure shows its performance to be out of compliance. In this case, the ILEC should be required to prepare a formal documented Corrective Action Plan for each SQM that had a z-score that exceeded the individual SQM critical value.

Regardless of whether the compliance procedure indicates non-compliance, an ILEC should initiate corrective action when there are individual reporting dimensions that repeatedly or seriously exceed the critical value for the z-score. The CLEC and regulators should have the ability to pursue expedited relief mechanisms and additional more severe and promptly invoked corrective actions as required.

Drafting A Corrective Action Plan

The ILEC should be obligated to document and submit a Corrective Action Plan to the CLEC and the state Public Utilities Commission within 15 business days of the end of the reporting period in which the non-compliance occurred. The plan, as a minimum should describe the root cause for each measurement violation, specify the implementation schedule for all corrective actions, and identify when performance will return to a compliant level.

Implementing A Corrective Action Plan

The ILEC should commence implementation of the Corrective Action Plan no later than the sixteenth business day after the end of the reporting period in which the non-compliance occurred.

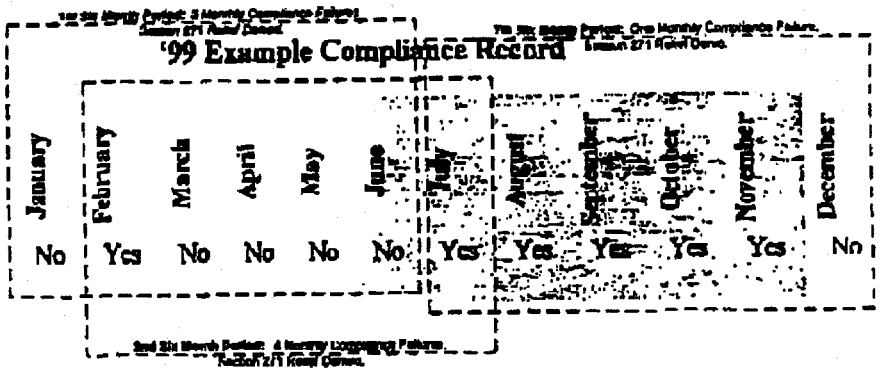
Deterring Non-Compliance

Purpose of Deterrents

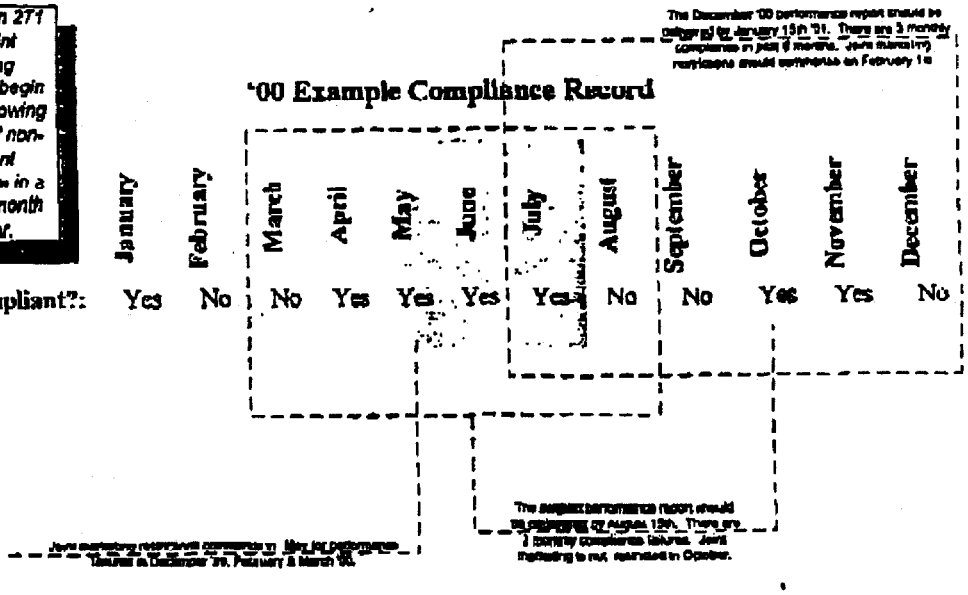
Federal law requires that ILECs provide non-discriminatory support for CLEC operations. Business incentives, absent deterrents, conflict with statutory requirements: competition puts an ILEC's current revenues at risk. Normal market forces cannot be relied upon to insure an ILEC's cooperative behavior.

Incentives are required so that ILECs comply with their legal obligation. MCI and WCom propose certain consequences for nonconforming ILEC behavior. These consequences serve to deter ILEC non-compliance. In order to be effective, deterrents must be severe enough that the ILEC will have a meaningful business incentive to avoid them. In general, MCI & WCom propose that the severity of consequences increases as the severity of the offenses increases. Severity, in this instance, has two dimensions: (1) magnitude of departure from acceptable performance and (2) extent of recurrence of the same violation.

Prior to Section 271 relief, the ILEC must sustain 6 consecutive months of compliant performance in a rolling six month calendar.



After Section 271 relief, joint marketing restrictions begin 30 days following 3 months of non-compliant performance in a rolling six month calendar.



Types of Deterrents

1. Denial or Suspension of Privileges

The Telecommunications Act of 1996 already provides one incentive for compliance with section 251. This incentive, which applies only to RBOCs, is the ability for an RBOC to provide long distance telecommunications services within its operating region, as described in section 271 of the Act.

The RBOC must have in place a fully comprehensive measurements, standards and enforcement program (to prevent backsliding after 271 approval) that generates monthly reporting allowing for meaningful comparisons of the ILEC's retail vs. wholesale performance. Further, an RBOC cannot be granted section 271 relief until its performance reporting demonstrates a track record of sustained, compliant performance. If, within any rolling six month period there exists non-compliant performance results, 271 relief should not be granted as a record of sustained, compliant performance has not been established.

If the compliance criteria described above reveals that an RBOC has not met its nondiscrimination obligations, that RBOC should not be granted relief under section 271 of the Act. Furthermore, once in-region long distance authorization is granted to any ILEC, and that ILEC fails to comply with nondiscrimination obligations, that ILEC should be required to halt all joint local and LD marketing efforts until compliance has been re-established.

When an ILEC's performance develops a track record of non-compliance, joint local and LD marketing should cease and the ILEC cannot onboard new local/LD customers. Joint marketing restrictions lasting one calendar month are triggered when, within any rolling six month period there are three or more months of non-compliant performance.

2. Fines

Fines are another form of deterrent that can be established by federal or state regulatory commissions. Fines, payable to a public fund (e.g., Universal Service Fund) or to the state treasury, can be levied whenever ILEC fails to meet compliance criteria. Such fines need to be self-enacting and based on the results that the ILEC submits for the month. The application of fines should not preclude CLECs from seeking other appropriate remedies through other legal or regulatory recourse.

The amount of the fine should directly relate to the nature of the violation. Fines for repeated failures and/or wide departures from acceptable performance should be much larger than the fines for one-time limited departure from conforming performance. The amount charged for fines should also represent a meaningful incentive for the ILEC to comply in a prompt manner, and not simply become a cost of doing business (i.e., the cost of correction is greater than the fine). They must be sufficient to protect the public interest and to provide the necessary incentive for the ILEC to perform.

3. Damages

Damages payable to the CLEC should be available through an expedited complaint process with the governing PUC, though a civil law suit, or as self executing penalties as part of a contractual damages provision. Damages are intended to remedy the specific and quantifiable harm caused to the CLEC resulting from the ILEC's failure to perform. The damages estimates, however, should not be limited just to the price of the service but should also take into consideration the cost of customer inconvenience or loss, as well as any necessary credits, rebates, gifts, or other apologetic gesture that the CLEC must provide to keep the customer's good will.

MCI and WCom propose that damages be attached to failures to provide compliant (parity) performance and failures to perform to applicable benchmarks.

4. Anti-Trust Suits

As a last resort and based on repeated and pervasive discrimination, CLECs may file an anti-trust suit against the ILEC.

Consequences for Failure to Satisfy Non-Discrimination Obligations

When the ILEC fails to meet the compliance criteria, MCI and WCom propose the following consequences:

- Suspension or denial of in-region long distance authorization until a sustained track record of compliant performance is re-established.
- A fine for each individual z-score that exceeds the critical value.
- An additive fine if ILEC is out of compliance for 3 consecutive months.
- Damages payable to the CLEC available through an expedited complaint process with the governing PUC, though a civil law suit, or through a contractual liquidated damages provision.

Consequences for Failure to Submit Corrective Action Plan Within Required Timeframe

When the ILEC fails to submit a Corrective Action Plan within the required timeframe, MCI and WCom propose the following consequences:

- Fine per day past due.

Consequences for Failure to Implement Corrective Action Plan Within Required Timeframe

When the ILEC fails to commence implementation of the Corrective Action Plan within the required timeframe, MCI and WCom propose the following consequences:

- Fine per day past due.

Consequences for Failure to Supply Performance Reports

If the ILEC fails to submit performance reports by the 15th day of the month, MCI and WCom propose the following consequences:

- (If no reports are filed) Fine per day past due
- (If incomplete reports are filed) Fine per day for each missing performance result (SQM and reporting dimension combination)

QWEST EXHIBIT 19

Local Competition Users Group

Statistical Tests for Local Service Parity

February 6, 1998
Membership: AT&T, Sprint, MCI, LCI, WorldCom

Version 1.0

Executive Summary

The Local Competition Users Group has drafted 27 Service Quality Measurements (SQMs) that will be used to measure parity of service provided by incumbent local exchange carriers (ILECs) to competitive local exchange carriers (CLECs). This set of measures includes means, proportions, and rates of various indicators of service quality. This document proposes statistical tests that are appropriate for determining if parity is being provided with respect to these measurements.

Each month, a specified report of the 27 SQMs will be provided by the ILEC, broken down by the requested reporting dimensions. The SQMs are to be systematically developed and provided by the ILECs as specified. Test parameters will be calculated so that the overall probability of declaring the ILEC to be out of parity purely by chance is very small. For each SQM and reporting dimension reported, the difference between the ILEC and CLEC results is converted to a z-value. Non-parity is determined if a z-value exceeds a selected critical value.

Introduction

Purpose

The Local Competition Users Group (LCUG) is a cooperative effort of AT&T, MCI, Sprint, LCI and WorldCom for establishing standards for the entry of new companies (competitive local exchange carriers, or CLECs) into the local telecommunications market. A key initiative of the LCUG is to establish measures of parity for services provided by incumbent local exchange carriers (ILECs). In short, parity means that the support ILECs provide on behalf of the CLECs is no lesser in quality than the service provided by the ILECs to their own customers.

The LCUG has drafted a document listing service quality measurements (SQMs) that must be reported by the ILECs to insure that CLECs are given parity of suppport. The SQM document has been submitted to the FCC and made available to PUCs in all 50 states and is pending approval by many of these regulatory agencies. This document has been drafted to describe statistical methodology for determining if parity exists based on the measurements defined in the SQM document.

Service Quality Measurements

The LCUG has identified 27 service quality measurements for testing parity of service. These are:

Category	ID	Description
Pre-Ordering	PO-1	Average Response Interval for Pre-Ordering Information
Ordering and Provisioning	OP-1	Average Completion Interval
	OP-2	Percent Orders Completed on Time
	OP-3	Percent Order Accuracy
	OP-4	Mean Reject Interval
	OP-5	Mean FOC Interval
	OP-6	Mean Jeopardy Interval
	OP-7	Mean Completion Interval
	OP-8	Percent Jeopardies Returned
	OP-9	Mean Held Order Interval
	OP-10	Percent Orders Held >= 90 Days
	OP-11	Percent Orders Held >= 15 Days
Maintenance and Repair	MR-1	Mean Time to Restore
	MR-2	Repeat Trouble Rate
	MR-3	Trouble Rate
	MR-4	Percentage of Customer Troubles Resolved Within Estimate
General	GE-1	Percent System Availability
	GE-2	Mean Time to Anser Calls
	GE-3	Call Abandonment Rate
Billing	BI-1	Mean Time to Provide Recorded Usage Records

	BI-2	Mean Time to Deliver Invoices
	BI-3	Percent Invoice Accuracy
	BI-4	Percent Usage Accuracy
Operator Services and Directory Assistance	OSDA-1	Mean Time to Answer
Network Performance	NP-1	Network Performance Parity
Interconnect / Unbundled Elements and Combos	IUE-1	Function Availability
	IUE-2	Timeliness of Element Performance

The Service Quality Measurements document describes the importance of each measure as an indicator of service parity. The SQM document also describes reporting dimensions that will be used to break each measure out by like factors (*e.g.*, major service group).

Why We Need to Use Statistical Tests

The Telecommunications Act of 1996 requires that ILECs provide nondiscriminatory support regardless of whether the CLEC elects to employ interconnection, services resale, or unbundled network elements as the market entry method. It is essential that CLECs and regulators be able to determine whether ILECs are meeting these parity and nondiscriminatory obligations. In order to make such a determination, the ILEC's performance for itself must be compared to the ILEC's performance in support of CLEC operations; and the results of this comparison must demonstrate that the CLEC receives no less than equal treatment compared to that the ILEC provides to its own operations. Where a direct comparison to analogous ILEC performance is not possible, the comparative standard is the level of performance that offers an efficient CLEC a meaningful opportunity to compete.

When making the comparison of ILEC results to CLEC results, it is necessary to employ comparative procedures that are based upon generally accepted statistical procedures. It is important to use statistical procedures because all of the ILEC-CLEC processes that will be measured are processes that contain some degree of randomness. Statistical procedures recognize that there is measurement variability, and assist in translating results data into useful decision-making information. A statistical approach allows for measurement variability while controlling the risk of drawing an inappropriate conclusion (*i.e*, a "type 1" or "type 2" error, discussed in the next section).

Basic Concepts and Terms

Populations and Samples

Statistical procedures will permit a determination whether the support that the ILECs provide to CLECs is indistinguishable from the support provided by the ILECs to their own

customers. In statistical terms, we will determine whether two "samples", the ILEC sample and the CLEC sample, come from the same "population" of measurements.

The procedures described in this paper are based on the following assumption: *When parity is provided, the ILEC data and CLEC data can both be regarded as samples from a common population of possible outcomes.* In other words, if parity exists, the measured results for a CLEC should not be distinguishable from the measured results for the ILEC, once random variability is taken into account. Figure 1 illustrates this concept. On the right side of the figure are histograms of two samples. In this illustration, the ILEC sample contains 200 observations (data values) and the CLEC sample contains 50. Note that the two histograms are not exactly alike. This is due to sampling variation. The assumption that parity exists implies that both samples were drawn from the same population of values. If it were possible to observe this population completely, the population histogram might appear as shown on the left of the Figure. If the samples were indeed taken from this population, histograms drawn for larger and larger samples would look more and more like the population histogram. Figure 1 shows that even when parity is being provided, there will be differences between the samples due to sampling variability. Statistical tests quantify the differences between the two samples and make proper allowance for sampling variability. They assess the chance that the differences that

are observed are due simply to sampling variability, if parity is being provided.

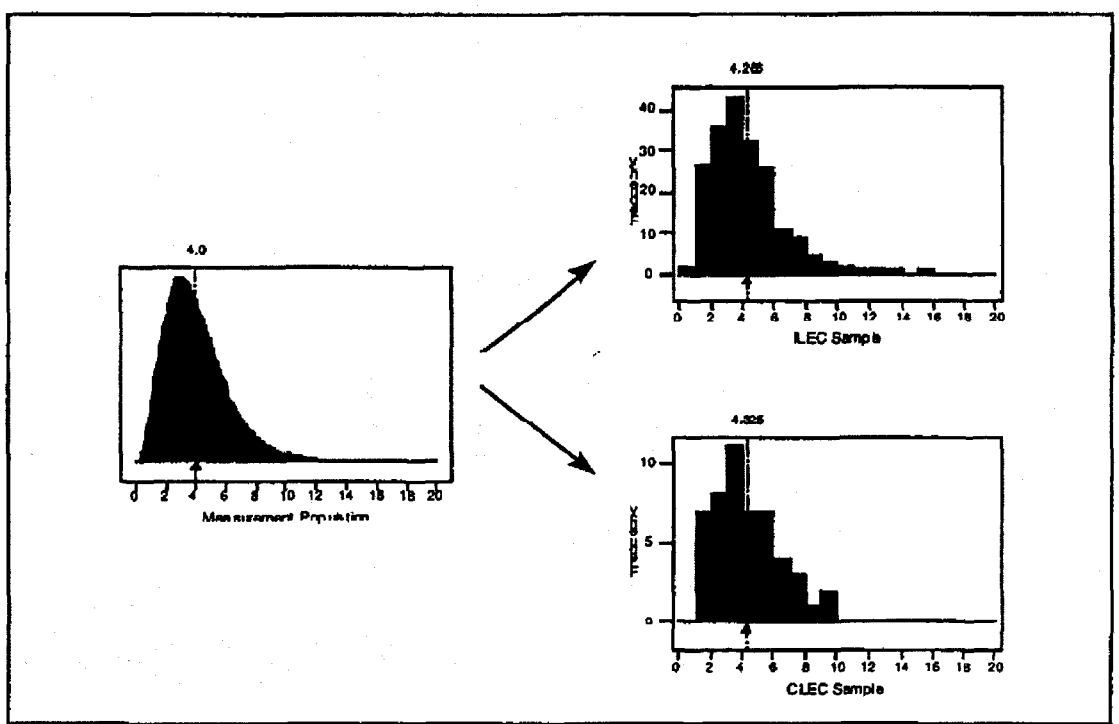


Figure 1.

Measures of Central Tendency and Spread

Often, distributions are summarized using "statistics." For the purpose of this paper, a "statistic" is simply a calculation performed on a sample set of data. Two common types of statistics are known as measures of "central tendency" and "spread."

A measure of central tendency is a summary calculation that describes the middle of the distribution in some way. The most common measure of central tendency is called the "mean" or "average" of the distribution. The mean of a sample is simply the sum of the data values divided by the sample size (number of observations). Algebraically, this calculation is expressed as

$$\bar{x} = \frac{\Sigma x}{n},$$

where x denotes a value in the sample and n denotes the sample size. The mean describes the center of the distribution in the following way: *If the histogram for a sample were a set of weights stacked on top of a flat board placed on top of a fulcrum (a "see-saw"), the mean would be the position along the board at which the board would balance.* (See Figure 1.) The mean in Figure 1 is indicated by the small triangle at approximately the value "4" on the horizontal axis.

A measure of spread is a summary calculation that describes the amount of variation in a sample. A common measure of spread is a called the "standard deviation" of the sample. The standard deviation is the typical size of a deviation of the observations in the sample from their mean value. The standard deviation is calculated by subtracting the mean value from each observation in the sample, squaring the resulting differences (so that negative and positive differences don't offset), summing the squared differences, dividing the sum by one less than the sample size, then taking the square root of the result. Algebraically, this calculation is expressed as

$$\sigma = \sqrt{\frac{\Sigma(x - \bar{x})^2}{n - 1}}.$$

While the notion of mean and standard deviation exists for populations as well as samples, the mathematical definition for the mean and standard deviation for populations is beyond the scope of this paper. However, their interpretation is generally the same as for samples. In fact, for very large samples, the sample mean and sample standard deviation will be very close to the mean and standard deviation of the population from which the sample was taken.

Sampling Distribution of the Sample Mean

In Figure 1 we showed the positions of the means of the population and the two samples with triangular symbols beneath the distributions. If we sample over successive months, we will get

new ILEC samples and new CLEC samples each and every month. These samples will not be exactly like the one for the first month; each will be influenced by sampling variability in a different way. In Figure 2, we show how sets of 100 successive ILEC means and 100 successive CLEC means might appear. The ILEC means can be thought of as being drawn from a population of sample means; this population is called the "sampling distribution" of these ILEC means. This sampling distribution is completely determined by the basic population of measurements that we start with, and the number of observations in each sample. The sampling distribution has the same mean as the population.

Figure 2 illustrates two important statistical concepts:

1. The histogram of successive sample means resembles a bell-shaped curve known as the Normal Distribution. This is true even though the individual observations came from a skewed distribution.
2. The standard deviation of the distribution of sample means is much smaller than the standard deviation of the observations themselves. In fact, statistical theory establishes the fact that the standard deviation on the population of means is smaller by a factor $\sqrt{n}$, where n is the sample size. This effect can be seen in our example: the distribution of the CLEC means is twice as broad as the distribution of the ILEC means, since the ILEC sample size (200) is four times as large as the CLEC sample size (50).

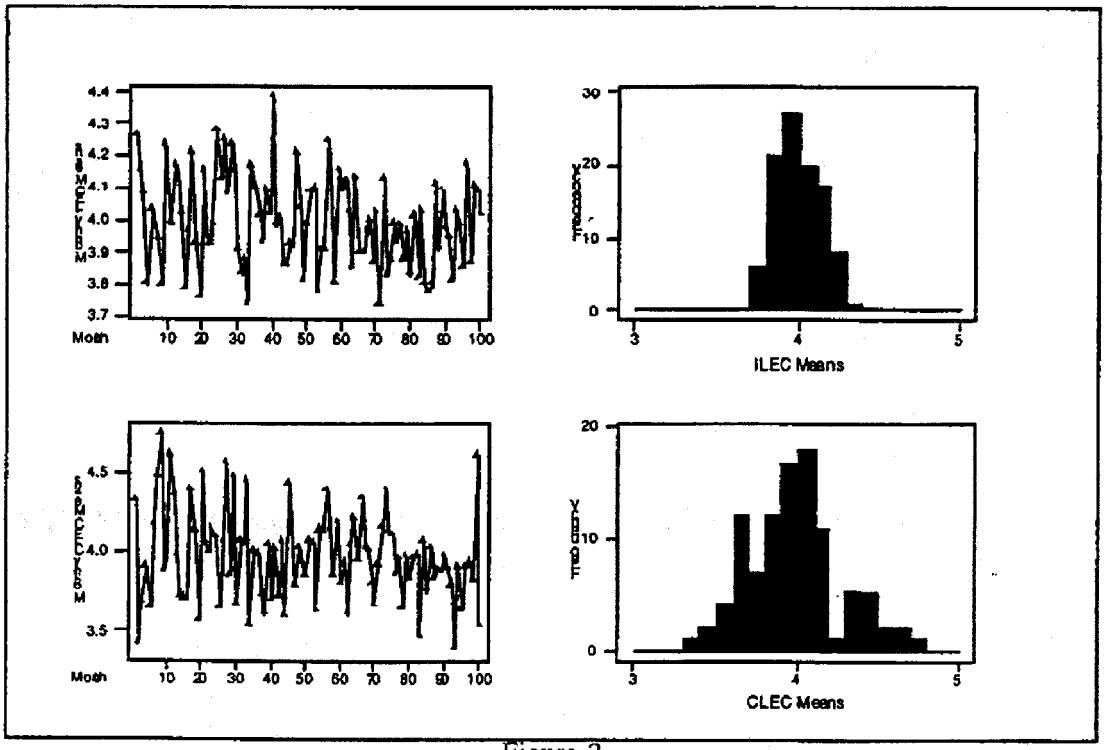


Figure 2.

It is common to call the standard deviation of the sampling distribution of a statistic the "standard error" for the statistic. We shall adopt this convention to avoid confusion between

the standard deviation of the individual observations and the standard deviation (standard error) of the statistic. The latter is generally much smaller than the former. In the case of sample means, the standard error of the mean is smaller than the standard deviation of the individual observations by a factor of $\sqrt{n}$.

The Z-test

Our objective is to compare the mean of a sample of ILEC measurements with the mean of a sample of CLEC measurements. Suppose both samples were drawn from the same population; then the difference between these two sample means (*i.e.*, $DIFF = \bar{x}_{CLEC} - \bar{x}_{ILEC}$) will have a sampling distribution which will

(i) have a mean of zero; and
(ii) have a standard error that depends on the population standard deviation and the sizes of the two samples.

Statisticians utilize an index for comparing measurement results for different samples. The index employed is a ratio of the difference in the two sample means (being compared) and the standard deviation estimated for the overall population. This ratio is known as a z-score. The z-score compares the two samples on a standard scale, making proper allowance for the sample sizes.

The computation of the difference in the two sample means is straightforward.

$$DIFF = \bar{x}_{CLEC} - \bar{x}_{ILEC}$$

The standard deviation is less intuitive. Nevertheless, statistical theory establishes the fact that

$$\sigma^2_{DIFF} = \frac{\sigma^2}{n_{CLEC}} + \frac{\sigma^2}{n_{ILEC}},$$

where σ is the standard deviation of the population from which both samples are drawn. That is, the squared standard error of the difference is the sum of the squared standard errors of the two means being compared.[1]

We do not know the true value of the population σ, because the population cannot be fully observed. However, we can estimate σ given the standard deviation of the ILEC sample (σ_{ILEC}).[2] Hence, we may estimate the standard error of the difference with

[1] Winkler and Hays, *Probability, Inference, and Decision.* (Holt, Rinehart and Winston: New York), p. 370.
[2] Winkler and Hays, *Probability, Inference, and Decision.* (Holt, Rinehart and Winston: New York), p. 338.

$$\sigma_{DIFF} = \sqrt{\frac{\sigma^2_{ILEC}}{n_{CLEC}} + \frac{\sigma^2_{ILEC}}{n_{ILEC}}} = \sqrt{\sigma^2_{ILEC}\left[\frac{1}{n_{CLEC}} + \frac{1}{n_{ILEC}}\right]}$$

If we then divide the difference between the two sample means by this estimate of the standard deviation of this difference, we get what is called a "*z*-score".

$$z = \frac{DIFF}{\sigma_{DIFF}}$$

Because we assumed that both samples were in fact drawn from the same population, this *z*-score has a sampling distribution that is very nearly Standard Normal, *i.e.*, having a mean of zero and a standard error of one. Thus, the *z*-score will lie between ± 1 in about 68% of cases, will lie between ± 2 in about 95% of cases, and will lie between ± 3 in about 99.7% of cases, always assuming that both samples come from the same population. Therefore, one possible procedure for checking whether both samples come from the same population is to compare the *z*-score with some cut-off value, perhaps +3. For comparisons where the values of z exceed the cutoff value, you reject the assumption of parity as not proven by the measured results. This is an example of a statistical test procedure. It is a formal rule of procedure, where we start with raw data (here two samples, ILEC measurements and CLEC measurements), and arrive at a decision, either "conformity" or" violation".

Type 1 Errors and Type 2 Errors

Each statistical test has two important properties. The first is the probability that the test will determine that a problem exists when in fact there is none. Such a mistaken conclusion is called a type one error. In the case of testing for parity, a type one error is the mistake of charging the ILEC with a parity violation when they may not be acting in a discriminatory manner. The second property is the probability that the test procedure will not identify a parity violation when one does exist. The mistake of not identifying parity violation when the ILEC is providing discriminatory service is called a type two error. A balanced test is, therefore, required.

From the ILEC perspective, the statistical test procedure will be unacceptable if it has a high probability of type one errors. From the CLEC perspective, the test procedure will be unacceptable if it has a high probability of type two errors.

Very many test procedures are available, all having the same probability of type one error. However the probability of a type two error depends on the particular kind of violation that occurs. For small departures from parity, the probability of detecting the violation will be small. However, different test procedures will have different type two error probabilities. Some test procedures will have small type two error when the CLEC mean is larger than the ILEC mean, even if the CLEC standard deviation is the same as the ILEC standard deviation, while other procedures will be sensitive to differences in standard deviation, even if the means

are equal. Our proposals below are designed to have small type two error when the CLEC mean exceeds the ILEC mean, whether or not the two variances are equal.

Tests of Proportions and Rates

When our measurements are proportions (*e.g.* percent orders completed on time) rather than measurements on a scale, there are some simplifications. We can think of the "population" as being analogous to an urn filled with balls, each labeled either 0(failure) or 1(success). In this population, the fraction of 1's is some "population proportion". Making an observation corresponds to drawing a single ball from this urn. Each month, the ILEC makes some number of observations, and reports the ratio of failures or successes to the total number of observations; the ILEC does the same does the same for the CLEC. The situation is very similar to that discussed above; however, rather than a wide range of possible result values, we simply have 0's (failures) and 1's (successes). The "sample mean" becomes the "observed proportion", and this will have a sampling distribution just as before. The novelty of the situation is that now the population standard deviation is a known function of the population proportion[3]; if the population proportion is p, the population standard deviation is $\sqrt{p(1-p)}$. with similar simplifications in all the other formulas.

There is a similar simplification when the observations are of rates, *e.g.*, number of troubles per 100 lines. The formulas appear below.

Proposed Test Procedures

Applying the Appropriate Test

Three z-tests will be described in this section: the "Test for Parity in Means", the "Test for Parity in Rates", and the "Test for Parity in Proportions". For each LCUG Service Quality Measurement (SQM), one or more of these parity tests will apply. The following chart is a guide that matches each SQM with the appropriate test.

Measurement (Corresponding LCUG Number)	Test
Preordering Response Interval (PO-1)	Mean
Avg. Order Completion Interval (OP-1)	Mean
% Orders Completed On Time (OP-2)	Proportion
Order Provisioning Accuracy (OP-3)	Proportion
Order Reject Interval (OP-4)	Mean
Firm Order Confirmation Interval (OP-5)	Mean
Mean Jeopardy Interval (OP-6)	Mean
Completion Notice Interval (OP-7)	Mean
Percent Jeopardies Returned (OP-8)	Proportion

[3] Winkler and Hays, *Probability, Inference, and Decision*. (Holt, Rinehart and Winston: New York), p. 212.

Held Order Interval (OP-9)	Mean
% Orders Held ≥ 90 Days (OP-10)	Proportion
% Orders Held ≥ 15 Days (OP-11)	Proportion
Time To Restore (MR-1)	Mean
Repeat Trouble Rate (MR-2)	Proportion
Frequency of Troubles (MR-3)	Rate
Estimated Time To Restore (MR-4)	Proportion
System Availability (GE-1)	Proportion
Center Speed of Answer (GE-2)	Mean
Call Abandonment Rate (GE-3)	Proportion
Mean Time to Deliver Daily Records (BI-1)	Mean
Mean Time to Deliver Invoices (BI-2)	Mean
Percent Invoice Accuracy (BI-3)	Proportion
Percent Usage Accuracy (BI-4)	Proportion
OS/DA Speed of Answer (OS/DA-1)	Mean
Network Performance (NP-1)	Mean, Proportion
Availability of Network Elements (UNE-1)	Mean, Proportion
Performance of Network Elements (UNE-2)	Mean, Proportion

Test for Parity in Means

Several of the measurements in the LCUG SQM document are averages (*i.e.*, means) of certain process results. The statistical procedure for testing for parity in ILEC and CLEC means is described below:

1. Calculate for each sample the number of measurements (n_{ILEC} and n_{CLEC}), the sample means ($\bar{x}_{ILEC}$ and $\bar{x}_{CLEC}$), and the sample standard deviations (σ_{ILEC} and σ_{CLEC}).

2. Calculate the difference between the two sample means; if *larger* CLEC mean indicates possible violation of parity, use $DIFF = \bar{x}_{CLEC} - \bar{x}_{ILEC}$, otherwise reverse the order of the CLEC mean and the ILEC mean.

3. To determine a suitable scale on which to measure this difference, we use an estimate of the population variance based on the ILEC sample, adjusted for the sized of the two samples: this gives the standard error of the difference between the means as

$$\sigma_{DIFF} = \sqrt{\sigma^2_{ILEC}\left[\frac{1}{n_{CLEC}} + \frac{1}{n_{ILEC}}\right]}$$

4. Compute the test statistic

$$z = \frac{DIFF}{\sigma_{DIFF}}$$

5. Determine a critical value c so that the type one error is suitably small.

6. Declare the means to be in violation of parity if $z > c$.

Example

Test for Parity in Proportions

Several of the measurements in the LCUG SQM document are proportions derived from certain counts. The statistical procedure for testing for parity in ILEC and CLEC proportions is described below. It is the same as that for means, except that we do not need to estimate the ILEC variance separately.

1. Calculate for each sample sample sizes (n_{ILEC} and n_{CLEC}), and the sample proportions (p_{ILEC} and p_{CLEC}).

2. Calculate the difference between the two sample means; if *larger* CLEC proportion indicates worse performance, use $DIFF = p_{CLEC} - p_{ILEC}$, otherwise reverse the order of the ILEC and CLEC proportions.

3. Calculate an estimate of the *standard error for the difference* in the two proportions according to the formula

$$\sigma_{DIFF} = \sqrt{p_{ILEC}(1 - p_{ILEC})\left[\frac{1}{n_{CLEC}} + \frac{1}{n_{ILEC}}\right]}$$

4. Hence compute the test statistic

$$z = \frac{DIFF}{\sigma_{DIFF}}$$

5. Determine a critical value c so that the type one error is suitably small.

6. Declare the means to be in violation of parity if $z > c$.

Example

c: [redacted] Critical value for the test

ILEC			CLEC			Test	
num	den	p	num	den	p	z	Violation
[redacted]		2.00%	[redacted]		17.50%	6.50	YES!

Test for Parity in Rates

A rate is a ratio of two counts, *num/denom*. An example of this is the trouble rate experience for POTS. The procedure for analyzing measurements results that are rates is very similar to that for proportions.

1. Calculate the numerator and the denominator counts for both ILEC and CLEC, and hence the two rates $r_{ILEC} = num_{ILEC}/denom_{ILEC}$ and $r_{CLEC} = num_{CLEC}/denom_{CLEC}$.

2. Calculate the difference between the two sample rates; if *larger* CLEC rate indicates worse performance, use $DIFF = r_{CLEC} - r_{ILEC}$, otherwise take the negative of this.

3. Calculate an estimate of the *standard error for the difference* in the two rates according to the formula

$$\sigma_{DIFF} = \sqrt{r_{ILEC}\left[\frac{1}{denom_{CLEC}} + \frac{1}{denom_{ILEC}}\right]}$$

4. Compute the test statistic

$$z = \frac{DIFF}{\sigma_{DIFF}}$$

5. Determine a critical value c so that the type one error is suitably small.

6. Declare the means to be in violation of parity if $z > c$.

Example
