REDUCING LOST CALLS DUE TO THE CALLED SUBSCRIBER
AN EXPERIENCE IN BRAZIL

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ABSTRACT

It is well known that high busy line (BY) and don’t answer (DA) rates, lead to lower revenues and higher investment costs for the Telecommunication Companies, and poor quality of service for the users.

The BY and DA rates improvement campaign being carried out by TELEBRAS, the brazilian Telecommunication Holding Company, and its 29 subsidiaries, since 1979, is briefly described. The main causes of the problem, the adopted solutions and the results obtained are presented.

So far, the results achieved show an improvement of about 8% on the DDD traffic completion rate, representing around US$ 40 million increase on the TELEBRAS annual revenue.

1. INTRODUCTION

TELEBRAS, the Government owned Telecommunication Administration, was created in 1972 to manage the Telecommunications services in Brazil. It is the holding company of TELEBRAS System, which consists of 28 Telecommunication Operating Companies, responsible for operating the local and intrastate toll service, and EMBRATEL, the interstate toll and international services Operating Company.

Presently, the brazilian telephone network consists of 155 toll centers and 3100 local exchanges, to which are connected about 10.5 million telephones, spread over an area of 8.5 million Km² of the national territory.

In 1978 the quality of the DDD service was very poor. The call completion rate (OK) was 36.3% and the equipment blockage and failure rate (EBF) was 23.6%.

By that time, TELEBRAS and its subsidiaries were already carrying out an EBF rate improvement campaign. The settled target was 6%. Prospective studies showed that, after this target had been reached (and it was actually met by 1981), the completion rate would be only 45.7%, due to the EBF rate reduction. This value was considered very high in comparison with the accepted international standards (about 25%).

High BY/DA rates are undesirable because they lead to:

1. Lower revenues, as the call abandonment increases;
2. Higher investment costs, as the number of ineffective attempts increases;
3. Poorer quality of service for the subscribers.

2. PROBLEM DEFINITION

The main causes of the high BY/DA rates were:
1) very few high DDD incoming traffic subscribers, with an insufficient number of lines, responded for a large amount of BY/DA calls.
2) lack of automatic hunting facilities for many line groups connected to key systems.
3) Erroneous publishing of telephone number of all individual lines belonging to a hunting group.
4) Insufficient number of operator positions in some PBX's, quite often, in the subscribers' publications.

3. THE SOLUTION

Top management at TELEBRAS and its subsidiaries decided to carry out a BY/DA rates reduction campaign, based on the following actions:

a) Pinpointing the high DDD incoming traffic subscribers with high BY/DA rates and correction of their service deficiency.

b) Implementing hunting facilities as much as possible.

c) Increasing the number of operator positions, which led some subscribers to have an insufficient number of lines.

d) Improving the quality of service for the subscribers.
possible, for all subscribers having more than one line in a same address. This same action should also be applied to lower DDD traffic lines not listed on the monthly report.

c) Publishing the hunting number only.
This action should be applied directly to the Telephone Directories. The subscribers should also be oriented to do the same thing on its advertisements, pamphlets, name-cards, stationery, sales gadgets, etc...

d) Implementing the terminal hunting system, which performs the line hunting even when any individual line in the group is dialed.
This type of hunting makes the performance of the hunting process much less sensitive to erroneous Directory number publishing. In Brazil it is inherent to some switching equipment models but, for others, some circuit additions are required.

e) Improving PBX maintenance and operation procedures.
It was developed and implemented a more effective PBX maintenance service quality control system and intensive training courses were offered to the operators.

The analysis of the BY/DA rates, by itself, did not show the results of the campaign due to the existing correlation between the BY/DA and EBF rates. It was expected an increase in the BY/DA rates as a result of the reduction of the EBF rate. For this reason is was devised a new indicator called "Loss due to the Called Subscriber (LCS)", as follows,

\[
LCS = \frac{BY + DA}{BY + DA + OK} \times 100\%
\]

This indicator measures the loss probability (due to BY/DA), for those calls which have already reached the called line. It depends essentially on the status of the called line, being fairly independent of the public telephone network status (measured by the EBF rate).

The effectiveness of implementing the measures listed on b, c and d was demonstrated by field trials accomplished in three different cities (Montenegro, Cachoeira do Sul and Vitória). The experience was very simple: implementing hunting facilities as much as possible, including individual lines, and publishing the hunting number only.

The results were excellent. Figura 1 shows, as an example, the evolution of the number of hunting lines in Montenegro, a small city with a 2,000 lines exchange. The results obtained are depicted on figure 2. The OK and LCS rates variations observed during the third quarter of 1983 were due to the implementation of the terminal hunting facility.

### 4. CAMPAIGN COORDINATION

The successful accomplishment of those actions listed on part 3 requires the involvement of many people in different technical and operating areas of all 28 Operating Companies. An specific management structure was created, with the following key elements:

(a) An LCS manager in each one of the 28 Operating Companies, responsible for coordinating all the actions related to the campaign;

(b) a general supervisor in EMBRATEL, responsible for collecting the required data and releasing the monthly report to each Operating Company;

(c) a general manager in TELEBRAS, respon-

4.2B-1-2
LCS reduction campaign. The latter represents the evolution of BY/DA and OK rates due only to the reduction of EBF rates from 23.6% (1978) to 6.8% (1984).

The result of the campaign is a reduction of 9.9% on the LCS rate, which led to an estimated increase of about 8% on the OK rate. It is also estimated that this improvement on the OK rate is worth about US$ 40 million/year (about 4.6% of

6. CONCLUSIONS

The improvement of call completion rate is a fundamental concern of all Telephone Operating Companies. Reducing the BY and DA rates, a hard and long lasting task, is an obligatory step and the most effective and rewarding way towards higher call completion rates compatible with international standards.

To identify and solve the originating problems of high BY/DA rates is a feasible task, even for Telecommunication Administrations which operate telephone networks with a high down-payment for the subscriber’s line and with depressed demand (and so, high traffic/line), such as in Brazil. Managing BY/DA rates is better accomplished with the help of the LCS indicator. The reduction on the LCS rate from 48.7% (1978) to 38.8% (1984), as a consequence of the LCS campaign started in 1979, represents an additional revenue of about US$ 4.00/telephone/year for the TELEBRAS System. The tendency of the LCS rate is to go further down. The present target is to reach values below 35%.

Brazil is showing nowadays call completion rates around 55% for the international incoming traffic, measured by AT&T [2]. These figures are better than those shown by several developed countries. The end result of this work is a better service quality for the subscribers, higher revenues and lower capital costs for the Telecommunication Administrations.

REFERENCES

APPENDIX

A.1 INTRODUCTION

The call completion rate status of any telephone network can be defined by the following parameters: OK (completion rate), BY (busy line rate), DA (don't answer rate), EBF (equipment blockage and failure rate) and OT ("others" rate, which includes all unsuccessful calls not considered in the previous parameters). Those parameters are related to mutually exclusive events and their sum should be equal to one. An important additional auxiliary parameter, which was previously defined, is the LCS (loss due to the called subscriber). All those parameters, representing the status of any network, can always be depicted on an abacus as the one shown on figure A.1.

Fig. A.1 - NETWORK CALL COMPLETION STATUS ABACUS

Any network status change is always due to an (EBF+OT) rate variation or to an LCS rate variation, or both.

It is expected that OK rate variations should lead to revenue variations, due to the variation on the probability that a series of attempts (of the same call intent) finally ends in a conversation.

A simplified theoretical model for estimating completion rate and revenue variations, as a result of LCS and (EBF+OT) rates variations, is given. The aim of the model is not to provide precise results but rough estimates, being rather a managerial and a decision support tool than a new scientific development.

A.2 ESTIMATING COMPLETION RATE VARIATIONS DUE TO EBF AND LCS RATES VARIATIONS

A.2.1 General Considerations

Figure A.2 gives an example of a generic network status change (from status A to status B).

Fig. A.2 - EXAMPLE OF A GENERIC NETWORK STATUS CHANGE

This change can be made by following any line connecting points A and B, but the net OK rate variation will be always the same \( \Delta OK \), and

\[
\Delta OK = \Delta OK_E + \Delta OK_L
\]

\( \Delta OK_E \) - OK rate variation due to the (EBF+OT) rate variation.

\( \Delta OK_L \) - OK rate variation due to the LCS rate variation.

The values of \( \Delta OK_E \) and \( \Delta OK_L \) depend on the specific curve chosen to go from A to B. The abacus geometry (and equations (4) and (6) of this Appendix) shows that:

a) \( \Delta OK_E \) is maximum when LCS is minimum and vice versa

b) \( \Delta OK_L \) is maximum when (EBF+OT) is minimum and vice versa.

As a consequence, the maxima and minima values of \( \Delta OK_E \) and \( \Delta OK_L \) occur for curves ACB and ADB (v. figure A.2). The former curve implies always an (EBF+OT) rate variation (over the constant LCS rate line) in first place, followed by an LCS rate variation (performed over the constant EBF+OT rate line). On the other hand, for the ADB curve the LCS rate variation occurs first (over the constant EBF+OT line), followed by the (EBF+OT) rate variation (performed over the constant LCS rate line).

For the specific example shown on figure A.2 it is true that,

\[
\begin{align*}
\text{MIN} [\Delta OK_E] &= EG & \text{MAX} [\Delta OK_E] &= FH \\
\text{MIN} [\Delta OK_L] &= EF & \text{MAX} [\Delta OK_L] &= GH
\end{align*}
\]

The maxima and minima values of \( \Delta OK_E \) and \( \Delta OK_L \) can be calculated as shown in parts A.2.2 and A.2.3, respectively.

A.2.2 OK Rate Variations Due to (EBF+OT) Rate Variations

Let \( OK, BY, DA, EBF, OT \) and LCS, be the new
parameters of a network after an \((EBF+OT)\) rate variation, with no change on the value of the LCS rate (as in sections AC and DB, in figure A.2).

\[
\Delta LCS = LCS - \frac{LCS}{\Delta LCS} \frac{LCS}{\Delta LCS}
\]

\[
(EBF + OT) = (EBF + OT) + \Delta (EBF + OT)
\]

\[
LCS = LCS
\]

\[
\Delta LCS = \frac{LCS}{\Delta LCS} \frac{LCS}{\Delta LCS}
\]

A.3 REVENUE VARIATIONS DUE TO OK RATE VARIATIONS

The calculation of revenue variations due to OK rate variations will be performed with the aid of the parameter called "Success Rate (S)"; given by

\[
S = \frac{N_{OK}}{N_{CI}}
\]

\(N_{OK}\) - number of completed (successful) calls.

\(N_{CI}\) - number of call intents (which equals the number of first attempts).

The number \(N_{CI}\) of call intents is a measure of the potential revenue from charged calls, i.e., it is the maximum number of calls that could be completed and charged. The number of completed calls \(N_{OK}\) is a measure of the effectively achieved revenue. Thus, the success rate measures the effectiveness of the Administration in generating the necessary revenues and is a key indicator for the whole Administration achievements.

To measure the number of call intents is a very difficult and laborious task. Nevertheless, the use of the theoretical model of call repeated attempts developed by Anders Elldin [1], make it easier to measure the success rate with a reasonable precision. This can be better understood with the aid of the simplified model of a telephone network shown on figure A.3.

\[
N_{CI} = p \cdot N_{F}
\]

where \(p\) is the mean probability of renewing a call after the failure of the previous attempt. It is called perseverance.

\[
N_{F} = N_{CI} \cdot (1 - OK)
\]

\[
N = N_{CI} + N_{R}
\]

\[
N_{R} = p \cdot N_{F}
\]

The perseverance is in general a steady function in time. In the last three yearly real traffic measurements performed on the whole brazilian DDD network, the perseverance values varied only from
67.25% to 67.66%. Those measurements used a sample of about 3 million call attempts and took into account all call reattempts made during the whole day.

Thus, the perseverance can be considered as a constant over a certain period of time and measured less frequently. The success rate can be calculated using equation (7), as frequently as the OK rate is measured.

The success rate is a crescent monotonic function of the OK rate. Thus, increasing OK rates should lead to increasing revenues, due to the augment of the success rate (i.e., augment of the probability that a series of call attempts finally ends in a conversation). Quantifying those revenue variations is a task which will be done with the aid of an example of a generic network status change (figure A.4).

For the sake of simplicity, it will be assumed that the OK rate variations won't significantly change the following parameters:

a) mean revenue per completed call. This means that there is no change on call durations and traffic distributions

\[ \frac{R}{S} = \frac{R'}{S'} \]

where \( R \) and \( R' \) are the revenues from charged calls.

b) number of call intents \( (N_{CI} - N_{CI}') \)

c) perseverance \( (\frac{p}{p} = p) \). This assumption was confirmed for the brazilian DDD network by real traffic measurements.

\[ \frac{R - R'}{S} = \frac{\Delta R = R - R'(1 - S)}{S} \]

(9)

By the use of equations (7), (8), (9) and (10), it is now possible to quantify revenue variations due to OK rate variations.

### A.4 COMPLETION RATE AND REVENUE VARIATIONS IN THE BRAZILIAN DDD NETWORK

The brazilian DDD network completion rate status has drastically changed in the period 1978-1984, as shown on Table A.1.

The net reductions on the (EBF+OT) and LCS rates, in that time period, were 18.4% and 9.9%, respectively. The contributions \( \Delta OK_E \) and \( \Delta OK_L \) (corresponding to each one of those reductions) to the net increase of 18.2% on the OK rate, will be calculated as described on part A.2.

The maxima and minima values of \( \Delta OK_E \) and \( \Delta OK_L \) occur when it is assumed that the change from status \( A_i \) to status \( B_i \), corresponding to two consecutive years \( i \) and \( (i+1) \), is done over the curves \( ACB \) and \( ADB \) (v. figure A.2).

In the case of curve \( ACB \), for each pair of points \( A_i \) and \( B_i \), it follows that, \( \Delta OK_i = OK_{Ci} + \Delta OK_{Ei} \)

\[ \Delta OK_{Ci} = R_{Ci} - R_{Ai} + \Delta R_{Ei} \]

\[ OK_{Bi} = OK_{Ci} + \Delta OK_{Li} \]

\[ \Delta OK_{Li} (\Delta R_{Li}) = \Delta OK_{EBF+OT} \]

(\( \Delta OK_{EBF+OT} \)) - OK rate (revenue) variation from year \( i \) to \( (i+1) \), due to the \( \Delta OK_{EBF+OT} \) rate variation.

\[ \Delta OK_{Li} (\Delta R_{Li}) = \Delta OK_{LCS} \]

(\( \Delta OK_{LCS} \)) - OK rate (revenue) variation from year \( i \) to \( (i+1) \), due to the LCS rate variation.

The values of \( OK_{Ai} \) and \( OK_{Bi} \) are known (table A.1) and the values of \( OK_{Ci} \), \( R_{Ai} \), \( R_{Bi} \) and \( R'_{Ai} \) can be calculated by the use of equations (4), (7) and (8). The results are shown on Table A.2, where all revenue values are referred to the 1978 revenue, which was made equal to 1,000.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>OK</th>
<th>BY + DA</th>
<th>EBF + OT</th>
<th>LCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>0.363</td>
<td>0.345</td>
<td>0.293</td>
<td>0.487</td>
</tr>
<tr>
<td>1979</td>
<td>0.425</td>
<td>0.366</td>
<td>0.209</td>
<td>0.463</td>
</tr>
<tr>
<td>1980</td>
<td>0.468</td>
<td>0.389</td>
<td>0.143</td>
<td>0.454</td>
</tr>
<tr>
<td>1981</td>
<td>0.510</td>
<td>0.384</td>
<td>0.106</td>
<td>0.430</td>
</tr>
<tr>
<td>1982</td>
<td>0.523</td>
<td>0.370</td>
<td>0.106</td>
<td>0.415</td>
</tr>
<tr>
<td>1983</td>
<td>0.541</td>
<td>0.355</td>
<td>0.104</td>
<td>0.397</td>
</tr>
<tr>
<td>1984</td>
<td>0.545</td>
<td>0.346</td>
<td>0.109</td>
<td>0.388</td>
</tr>
</tbody>
</table>
TABLE A.2 COMPLETION RATE AND REVENUE VARIATION - 
CURVE ADB

<table>
<thead>
<tr>
<th>YEAR</th>
<th>OK A</th>
<th>OK D</th>
<th>(\Delta OK)</th>
<th>OK L</th>
<th>(\Delta OK)</th>
<th>R</th>
<th>(\Delta R)</th>
<th>(\Delta R_T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>0.363</td>
<td>0.406</td>
<td>-0.043</td>
<td>1.000</td>
<td>0.065</td>
<td>0.0609</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1979</td>
<td>0.425</td>
<td>0.461</td>
<td>-0.036</td>
<td>0.019</td>
<td>0.047</td>
<td>0.027</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>0.468</td>
<td>0.488</td>
<td>-0.020</td>
<td>0.007</td>
<td>0.025</td>
<td>0.009</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981</td>
<td>0.510</td>
<td>0.510</td>
<td>0.000</td>
<td>0.199</td>
<td>0.026</td>
<td>-0.026</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td>0.523</td>
<td>0.524</td>
<td>0.001</td>
<td>0.121</td>
<td>0.001</td>
<td>0.015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1983</td>
<td>0.541</td>
<td>0.558</td>
<td>-0.003</td>
<td>0.173</td>
<td>0.004</td>
<td>-0.019</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1984</td>
<td>0.545</td>
<td>0.556</td>
<td>-0.007</td>
<td>1.238</td>
<td>0.008</td>
<td>0.008</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The same calculations were made for curve ADB, for which it follows

\[\text{OK}_D = \text{OK}_i + \text{OK}_L\]

\[R_i = \text{OK}_D + \text{OK}_L\]

\[R_i = \text{OK}_D + \text{OK}_L\]

\[R_i = \text{OK}_D + \text{OK}_L\]

\[R_i = \text{OK}_D + \text{OK}_L\]

\[R_i = \text{OK}_D + \text{OK}_L\]

The results of those calculations are shown on Table A.3

TABLE A.3 COMPLETION RATE AND REVENUE VARIATION - 
CURVE ADB

<table>
<thead>
<tr>
<th>YEAR</th>
<th>OK A</th>
<th>OK D</th>
<th>(\Delta OK)</th>
<th>OK L</th>
<th>(\Delta OK)</th>
<th>R</th>
<th>(\Delta R)</th>
<th>(\Delta R_T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>0.363</td>
<td>0.380</td>
<td>-0.017</td>
<td>1.000</td>
<td>0.108</td>
<td>0.026</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1979</td>
<td>0.425</td>
<td>0.430</td>
<td>-0.007</td>
<td>0.045</td>
<td>1.092</td>
<td>0.009</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>0.468</td>
<td>0.488</td>
<td>-0.012</td>
<td>0.036</td>
<td>1.148</td>
<td>0.076</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981</td>
<td>0.510</td>
<td>0.523</td>
<td>-0.013</td>
<td>0.021</td>
<td>1.199</td>
<td>0.025</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td>0.523</td>
<td>0.539</td>
<td>-0.016</td>
<td>0.121</td>
<td>1.214</td>
<td>-0.018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1983</td>
<td>0.541</td>
<td>0.560</td>
<td>-0.008</td>
<td>0.002</td>
<td>1.234</td>
<td>0.008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1984</td>
<td>0.545</td>
<td>0.566</td>
<td>-0.004</td>
<td>1.238</td>
<td>0.008</td>
<td>0.004</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tables A.2 and A.3 show the maxima and minima values of \(\Delta OK\) and \(\Delta OK_L\) for each pair of points \((A_i, B_i)\). The net variations \(\Delta OK\) and \(\Delta OK_L\) for the whole period 1978-1984, are restricted to the following limiting values,

\[\text{MIN}[\Delta OK_L] = \text{MIN}[\Delta OK] + 0.043 + 0.036 + 0.020 + 0.001 - 0.004 - 0.096\]

\[\text{MAX}[\Delta OK] = \text{MAX}[\Delta OK] + 0.45 + 0.036 + 0.021 + 0.002 - 0.003 = 0.101\]

\[\text{MIN}[\Delta OK_L] = \text{MIN}[\Delta OK] + 0.017 + 0.007 + 0.021 + 0.013 + 0.001 + 0.007 = 0.081\]

\[\text{MAX}[\Delta OK_L] = \text{MAX}[\Delta OK] + 0.019 + 0.007 + 0.022 + 0.013 + 0.001 + 0.007 = 0.086\]

Thus, as shown on Table A.1, the net OK rate increase was,

\[\Delta OK = \Delta OK + \Delta OK_L = 0.182\]

\[0.096 \leq \Delta OK \leq 0.101\]

\[0.081 \leq \Delta OK_L \leq 0.086\]

The reduction of 18.4% on the (EBF+OT) rate, that occurred between 1978 and 1984, led to an increase of 9.6% to 10.1% on the OK rate. This represents an average increase of 0.32% to 0.55% on the OK rate for each 1% reduction on the (EBF+OT) rate.

In the same period, a reduction of 9.2% on the LCS rate led to an increase of 8.1% to 8.6% on the OK rate. This gives an average increase of 0.82% to 0.87% on the OK rate for each 1% reduction on the LCS rate. In general, LCS rate variations have stronger effects on the OK rate than (EBF+OT) rate variations.

By the use of equation (10), it follows that the increase of 18.2% on the OK rate that occurred from 1978 to 1984 led to a revenue increase

\[\Delta R = \Delta R_E + \Delta R_L = 0.238\]

\[\Delta R_E - \text{net revenue variation due to the (EBF+OT) rate variation.}\]

\[\Delta R_L - \text{net revenue variation due to the LCS variation.}\]

The limiting values for \(\Delta R_E\) and \(\Delta R_L\) can be derived from equations (11), (12) and (13) can be applied.

\[\text{MIN}[\Delta R_E] = \text{MIN}[\Delta R_L] = 0.134\]

\[\text{MAX}[\Delta R_E] = \text{MAX}[\Delta R_L] = 0.136\]

\[\text{MIN}[\Delta R_E] = \text{MIN}[\Delta R_L] = 0.102\]

\[\text{MAX}[\Delta R_E] = \text{MAX}[\Delta R_L] = 0.104\]

\[\Delta R = \Delta R_E + \Delta R_L = 0.238\]

\[0.134 \leq \Delta R_E \leq 0.136\]

\[0.102 \leq \Delta R_L \leq 0.104\]

where \(R\) is the 1978 revenue.

In order to translate the revenue variations into dollars, it is necessary to take into account the network parameters values shown on Table A.1 refer to the test period (9:00 to 11:00 a.m., of working days). It will be assumed that they are also valid for the three afternoon peak hours of working days (2:00 to 5:00 p.m.). Those five hours of working days count for 45% of the monthly revenue from charged DDD calls, to which equations (11), (12) and (13) can be applied.

\[R = 0.45 R_T\]

\[R_T - \text{total revenue from charged DDD calls.}\]

By the use of equations (11), (12) and (13)\n
\[\Delta R = 0.238R = 0.45 \times 0.238 \times R_T = 0.107R_T\]

\[0.060R_E \leq \Delta R_E \leq 0.061 R_T\]

\[0.046R_L \leq \Delta R_L \leq 0.047 R_T\]

In 1984 the TELEBRAS System annual revenue from charged DDD calls was approximately US$ 1 000 million.

\[R_T = R_T + \Delta R = 1.107 R_T = \text{US$ 1.000 million}\]

\[R_T - \text{total revenue from charged DDD calls, in 1984.}\]

\[R_T - \text{total revenue from charged DDD calls, projected back to 1978.}\]

\[R_T = \text{US$ 900 million}\]

Thus, by the use of equations (15) and (16) it follows that the 9.2% LCS rate reduction that occurred from 1978 to 1984, led to an annual revenue increase varying from US$ 41.4 to US$ 42.3 million.