PERFORMANCE ANALYSIS OF GSM NETWORK

[1]Rajesh Kumar Upadhyay, [2]Vijay Kumar Singh, [3]Rajnish Kumar,

[1, 2] Department of Electronics & Communication Engineering,

Mangalayatan University, Aligarh, UP (India)

[3]Reliance Communication, UP West & Uttarakhand Circle, Meerut, UP (India)

ABSTRACT

Global System for Mobile (GSM) is a second generation cellular standard that was developed to solve the fragmentation problems of the first cellular systems and it specifies digital modulation techniques and network level architectures and services. To keep up with the change in the technology, organizations must be a learning organization to keep them in the competitive level. My paper is based on Performance Analysis of GSM Network (Reliance GSM) in Aligarh City, UP, India. Two approaches are used to evaluate the network performance, namely: key performance indicators (KPIs) and drive test. In this paper, according to KPI reports and previous drive test samples, necessary changes are done in network parameters for getting the improved value of TCH resources, hand over success rate, call setup success rate, Rx level and Rx quality in acceptable ranges for better utilization of available resources for providing best quality of service for customers.

Keywords: Global System For Mobile; Gsm; Mobile Network, Mobile Network Optimisation; Drive Test; Key Performance Indicators; Kpis; Tch Drop Rate; Handover Success Rate; Signal Quality; Signal Level; Reliance.

I INTRODUCTION

In today's world communication technology plays a vital role. It has become an important tool for sharing information in a personal life or in any organizations for the transfer of data. The telephone was introduced to the public in 1876. Although the wire bound tele-service was growing at that time, there was a need of wireless communication for army, police etc. In the late 1940's, Frequency Modulation (FM) push to talk on the telephone were used to connect with the public telephone network. This analog system used a single high power transmitter and a large tower to cover the distance of 50 km. It used the 120 KHz of radio frequency bandwidth in a half duplex mode. These systems were unable to support the large number of subscribers because of spectrum shortage.

Around the world different analog cellular systems were developed in later years in 34 different countries. These analog systems soon became inefficient because a mobile telephone developed for one system cannot be used with another so roaming was limited. In order to overcome these problems, the conference of European Posts and

Telecommunications (CEPT) formed. In 1982, a Group Special Mobile (GSM) was developed which was using a digital technology. In 1989, GSM responsibility was transferred to European Telecommunication Standards Institute (ETSI), and phase 1 of the GSM specifications was published in 1990. Commercial service was started in the mid of 1991 with GSM 900 which uses 25MHz and band width 890-9l5 MHz from mobile to base station and 935-960 MHz from base station to mobile). With the development of digital telephony GSM became popular due to these features:

- Superior speech quality Low terminal and service costs
- International roaming under one subscriber directory number.
- ISDN compatibility
- High level of security
- Support new range of services and network facilities

Among the existing cellular networks, global system for mobile (GSM) communications is the most popular cellular communication system all around the world [1, 2]. This system was developed over time to include data communications by packet data transport via general packet radio services (GPRS) and enhanced data rates for GSM evolution (EDGE). Further improvements were made when the 3GPP developed third generation (3G) UMTS standard followed by fourth generation (4G) LTE advanced standard [3]. In recent years, a great deal of attention has been paid to the planning, evaluation and optimisation of mobile cellular networks [4, 5]. There are several research papers in the literature that addressed the evaluation and optimisation of operational GSM networks. Thus, Key performance indicators (KPIs) to evaluate the performance of an operational GSM network. The network performance evaluation is based on four major KPIs, i.e., call setup success rate, call drop rate, handover success rate and traffic congestion. Every KPI is explored and improvement methodologies are suggested [6, 7]. However, these improvement methodologies were not implemented in the network. Evaluation of the handling of traffic and network utilization of an operative GSM network during eight months may a basic time span for a network. They developed a regression-based forecasting model for the traffic [8]. The performance of GSM and GPRS operational network is presented with a review of the most common KPIs that are used to evaluate the performance of GSM and GPRS networks [9]. The relationships between these KPIs are introduced and thresholds for some KPIs are suggested so that the GSM operators should not exceed them. Addressed the optimisation of GSM network, data sorting and analysing, implementing the optimisation and system fine tuning [10]. Network dimensioning such as BSC, MSC and other related parameters are addressed and the top ten wireless parameters are listed which are the most important from the authors' point view. KPIs for quality of service (QoS) evaluation in GSM network are identified. Four assessment parameters network accessibility, service retainability, connection quality, and network coverage) for evaluating the QoS were applied on four GSM networks in Nigeria [11]. The results of that study showed that the QoS of GSM networks in Nigeria is unreliable and the network accessibility and retainability are unsatisfactory. Aim of study for presenting the QoS of network optimisation and evaluation of KPIs provided by GSM operators in terms of the ability to establish and maintain call connections, call retention, handover, inter and intra network call set-up [12]. Proposal of a measurable indicator of quality of experience (QoE) in EDGE networks, called busy hour throughput per user, which can be employed to direct practical network design and optimisation [13]. Semi-automatic tool is developed to perform the network optimisation by tuning the parameters of a live GSM network. The authors select the most common KPIs to evaluate the QoS and they assign thresholds for these KPIs. The developed tool is then used to suggest some recommendations that can be applied to the cell so as to enhance its performance [14]. Evaluation of the call set up success rate as one of the most important KPI in GSM system. Suggestion for calculating this KPI as the ratio of the assigned traffic channels (TCHs) to the channel requests [10].

From the literature survey above, some authors have suggested several approaches to improve the available KPIs. However, most of these approaches were not implemented and evaluated for a live GSM network. Other authors have used the drive tests to evaluate the performance of active GSM networks in terms of QoS. Nevertheless, to the best of our knowledge, there are no comprehensive research works that combine both the KPIs and the drive tests to evaluate and optimise the performance of operational GSM mobile networks.

In this paper, a comprehensive research study is carried-out on the performance evaluation and optimisation of Reliance GSM mobile network in Aligarh City is selected as a case study. Our contribution is twofold: Firstly, both the KPIs and the drive tests are used to evaluate and optimise the performance of the GSM network in Aligarh City. In addition, operation and support subsystem (OSS) optimisation tools are used in the final optimisation process. Secondly, performance of the GSM network should be better as before. Figure 1.1 illustrates the various steps carried-out in this research. Starting from the operational Reliance GSM network, an evaluation step is performed by using the data from network audit, KPIs and drive tests. After the evaluation step, an optimisation step is performed followed by implementation. The optimisation process is cyclic till the best performance for the network is reached. At that point a comparative study is carried-out between the performance of the GSM network before and after introducing the new implementation. This research is conducted from October 2013 to April 2014.

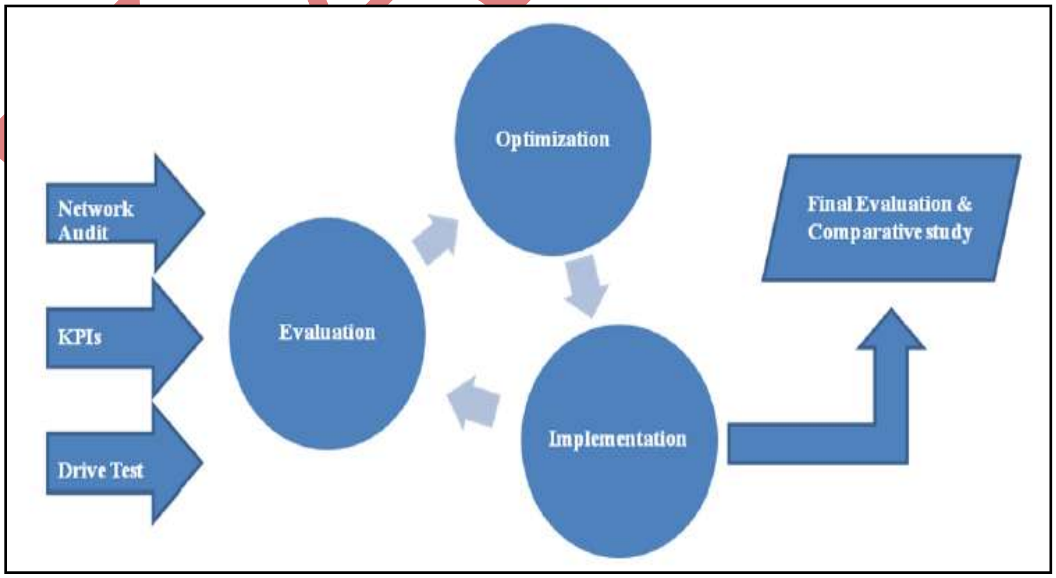

Fig. 1 Various Steps Carried-Out in This Research Paper

II. GSM NETWORK AUDIT IN ALIGARH CITY

2.1 Basic Network Information

The selection of Aligarh City to perform this research for minimizing the TCH drop rate and improving the QoS. Table 1 shows the basic information about Reliance GSM network in Aligarh City of October 2013. This information includes active sites and cells, serving base station controller (BSC), serving Mobile Switching Centre (MSC), broadcast control channel (BCCH) and TCH frequencies and total number of transmitter-receiver units (TRUs). Figure 2 is a map from Map Info Professional software that illustrates all active and planned sites with cell directions in Aligarh City.

Table 1 Basic Information of Reliance GSM, Aligarh

Detail	Specification
Operator	Reliance GSM
Frequency Band	GSM 1800 MHz
Total Sites	66 Sites
Total Cells	198 Cells
TRX	594
Total BCCH & TCH	43
Serving BSC	RC-G-ALGH-BSC-01-HU
Serving MSC	Aligarh MSC

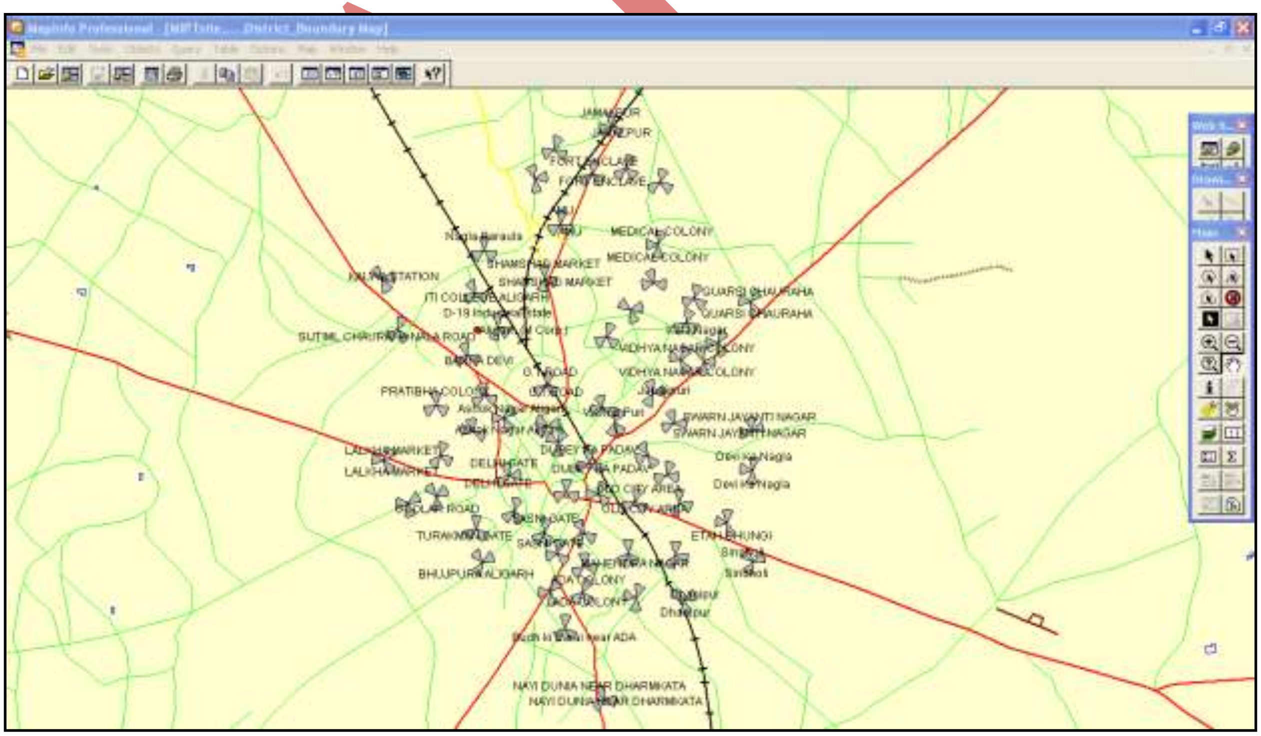

Fig. 2 Reliance GSM sites in Aligarh City, UP displayed on MapInfo Professional

2.2 Frequency Reuse Plan

Although there are 373 channels in the GSM 1800 band, Reliance GSM network in Aligarh has only been allocated 43 channels. These channels are divided into traffic and control channels. More particularly, the available 43 channels can divided into 17 TCHs and 26 BCCHs. The absolute radio frequency channel number (ARFCN) of the BCCH channels and TCH channels are allocated according to frequency planning and requirement to accommodate 198 cells.

III. KEY PERFORMANCE INDICATORS

KPIs are used to evaluate the performance of an operational GSM network. These KPIs come in form of counters from the OSS of GSM network. These counters are then converted into a more readable way. The most common KPIs are listed below:

1. TCH drop rate: this is one of the most critical KPIs in GSM networks since it is annoying to the customer as well as the operator. It is the percentage of lost connections to the total number of connections for a given cell in the active mode (on call). The value of this KPI ranges from 2% in the initial launching for the cell and it must be decreased to 0.5% in normal operating conditions.

2. Standalone dedicated control channel (SDCCH) drop rate: It is the percentage of the lost SDCCH connections to the total SDCCH connection attempts. SDCCH is used during vital roles such as call setup and mobile registration.

3. TCH congestion and congestion perceived by subscriber: There are two different approaches when dealing with TCH congestion. The TCH congestion perceived by subscriber is more realistic since it is from user's point of view rather than the congestion observed by the network and it is given by TCH congestion.

4. TCH assignment success rate: It is a measure of the successful TCH assignments to the total attempts. It is recommended to keep this value as close to 100% (typical value is 98 %).

5. Handover success rate: It is the percentage of successful handovers to the total number of handover attempts.

6. SDCCH congestion: SDCCH is used during call setup, mobile registration and SMS. The SDCCH congestion is the percentage of the time that all SDCCH resources are busy within a given cell. The accepted value is no more than 0.5.

7. Call Setup Success Rate (CSSR): It is a measure of call setup success rate of attempted calls by subscribers in a cell and it should me minimum 98 % in a good network.

IV DRIVE TEST AND KPI RESULTS

Two approaches to evaluate the performance of a live GSM network, namely KPIs and drive tests. On the one hand, KPIs give us detailed statistics for many events in GSM cells. On the other hand, drive tests show the realistic experience of the customer. Customer's point of view is more important since it reflects the real life scenarios.

TEMS investigation data collection Version 10.0.5 is used for drive testing of GSM network all over Aligarh City. This drive test was performed in Oct 2013. TEMS investigation route analysis and MapInfo Professional for analyzing these collected drive test log files. The advantages of the drive test are: Firstly, drive test is a powerful tool for the radio frequency (RF) analysis and problem solving. Secondly, scanner tool used in drive test is a very good tool for detecting interfering signals.

Finally, the drive test gives the exact geographical location for each sample through the connected GPS receiver. There are many parameters that are gathered by the drive test. The most important parameters are the received signal level (RXLEV) and the received signal quality (RXQUAL). RXLEV is the received signal power in units of dBm. The minimum acceptable RXLEV is commonly set to –104 dBm for the cell. While RXLEV value of –60 dBm is considered as excellent value. For a customer to be able to access the GSM network, it is strongly recommended that there will be a sufficient coverage with acceptable quality. RXQUAL is a measure of the QoS and it is given by GSM scale from 0 to 7, where 0 is the best quality and 7 is the worst. TEMS uses RXQUAL to identify the quality of a voice call or data session during the dedicated mode. RXQUAL is used to estimate the quality of GSM network service measured in terms of Bit Error Rate (BER) before channel decoding. Table 2 shows how the RXQUAL is mapped to the BER percentage.

Table 2 RXQUAL with corresponding BER values

RXQUAL	BER
0	<0.2%
1	0.2% to 0.4%
2	0.4% to 0.8%
3	0.8% to 1.6%
4	1.6% to 3.2%
5	3.2% to 6.4%
6	6.4% to 12.8%
7	>12.8%

In October 2013, a drive test was carried-out in the streets of Aligarh City. The distributions of the collected signal samples of RXLEV and RXQUAL are shown in Figure 3 and 4 respectively after optimization of network.

According to Fig 3, most of the samples are within the interval from -85 to 0 dBm with average of –85 dBm. Note that the number of samples with RXLEV less than –85 dBm are negligible. Thus, the signal level in Aligarh City is very good. A sharp spike around the value of –85 dBm comes from the fact that the drive test car stuck in traffic jam close to the RF site in the city centre such that many samples are taken with very good RXLEV. According to Fig. 4, about 68% of the samples have excellent quality corresponding to RXQUAL value of 0. In addition, about 3% of the samples have poor quality corresponding to RXQUAL values of 5 and 7. To analyze the data from drive test, four coverage classes are defined interms of RXLEV and RXQUAL according to Table 3.

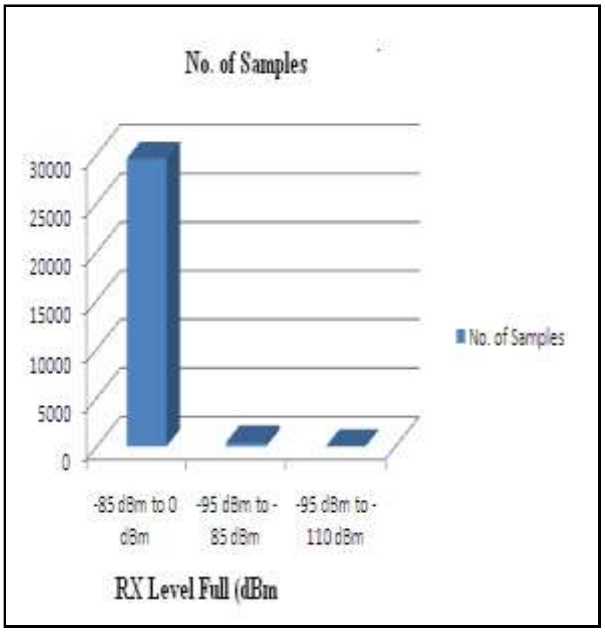

Fig. 3

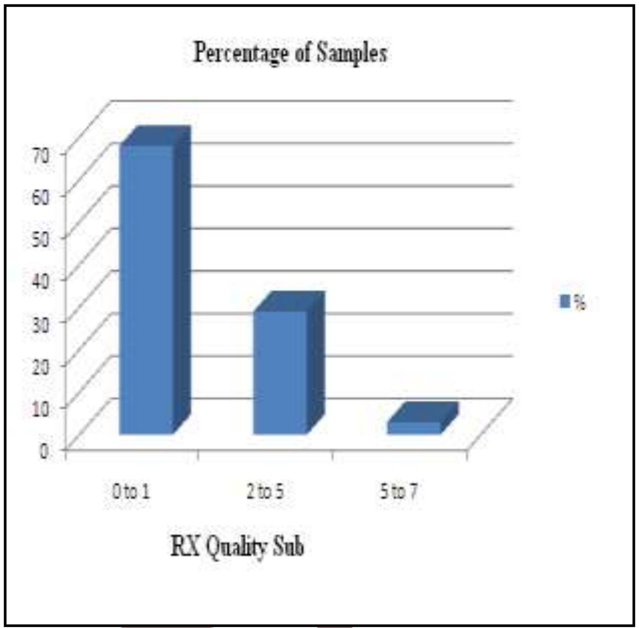

Fig. 4

Fig. 3 RX Level Full (dBm) Distribution of collected samples from drive test

Fig. 4 RX Quality Sub distribution

Table 3 Coverage levels legend in terms of RX LEV and RX QUAL

Coverage class	Condition
Level 1	RX LEV> = –70 and RX QUAL< = 2
Level 2	(RX LEV> = –85 and RX QUAL< = 4) and (RX LEV< –70 or RX QUAL>2)
Level 3	(RX LEV> = –100 and RX QUAL< = 6) and (RX LEV< –85 or RX QUAL>4)
Level 4	RX LEV< –100 or RX QUAL>6

Thus, level 1 is the best level since it guarantees the best of both RXLEV and RXQUAL. Level 2 provides the users with good RXLEV and good RXQUAL. Level 3 provides the user with acceptable RXLEV and RXQUAL. However, level 4 is the worst level since it combines poor RXLEV with poor RXQUAL. Table 4 & 5 shows the percentage distribution of both parameters as obtained from the data collected during the drive test according to operator legends. Figures 5 and 6 show, respectively, the drive test maps of RX LEV and RX QUAL in Aligarh City. This is important since it shows the geographical location for each sample. By inspecting drive tests of each area in Aligarh City, poor performance is negligible after optimization.

Table 4 RX level distribution in drive test in Aligarh City

Table 5 RX Quality distribution in drive test in Aligarh City

Table 4

RX Level Full Value (dBm)	No. of Samples
-85 dBm to 0 dBm	29480
-95 dBm to -85 dBm	437
-95 dBm to -110 dBm	1

Table 5

RX Quality Sub	% of samples
0 to 1	68
2 to 5	29
5 to 7	3

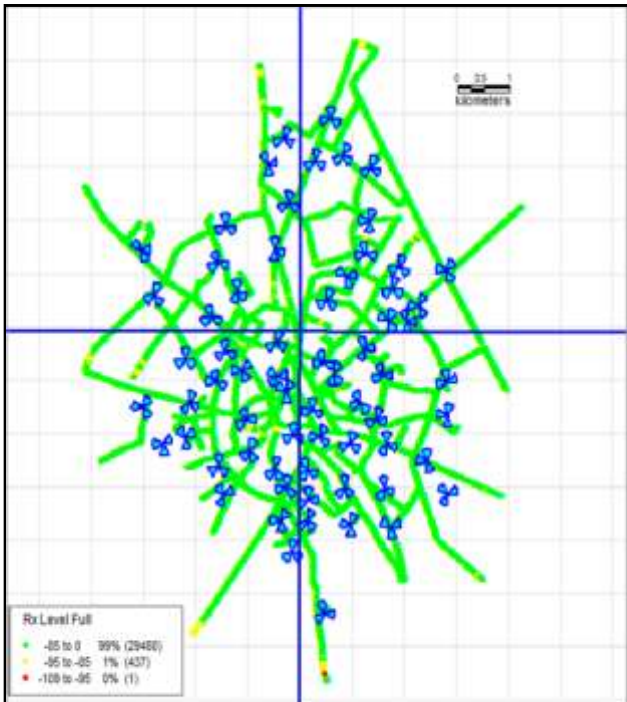

Fig. 5 Rx Level Full dBm Plot of Aligarh City

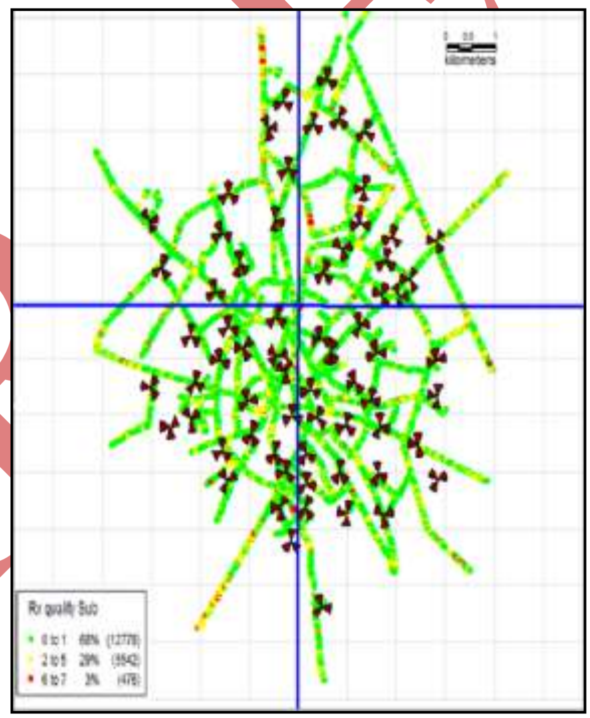

Fig. 6 Rx Quality Plot of Aligarh City

During optimization process, two stages which are the manual optimisation process and the automatic optimisation process using the OSS optimisation tools. The manual optimisation process starts with capacity analysis and neighbour relation plan. It yields two outcomes which are new frequency plan for both BCCH and TCH frequencies, and new neighbour relation plan. The outputs of the manual optimisation process are then fed to the OSS optimisation tools. The main output of the second stage is a frequency plan for BCCH and TCH channels with reduced interference. An enhanced neighbour relation plan with better handover performance is the other outcome of this stage. We also get good KPI results and some of them are shown in Table 6.

Table 6 Drive Test & KPI Reports

Parameter	Target	Achievement (After Optimization)
Technology		GSM
Band of operation (MHz)		1800
Route covered (km)		400
No. of Sites		66
% of route with good outdoor coverage(Rx level/M Tx)	>-85dBm/<0dBm	99%
TCH Drop	< 2 %	0 %
CSSR (%)	>=98%	100%
Call Drop (%)	≤ 1.5%	0%
Rx Quality DL(<=5) %/FER %(<=2)	>=97%	97%
Handover Success Rate (%)	>=96%	99.84%

V CONCLUSION

This paper describes a performance analysis and optimisation of Reliance GSM Mobile Network in Aligarh City, UP, India. Two methods are used to evaluate the performance of the network, namely: drive test and KPIs. Performance of the network before and after optimisation showed significant performance improvement in terms of TCH drop rate, handover success rate, received signal level and received signal quality, call setup success rate. Indeed, the average TCH drop rate is reduced 0 %. In addition, the average handover success rate is increased to 99.94 %. Furthermore, the percentage of samples poor signal strength and poor quality reduced to 1.00 % and 3.00 % respectively that are desirable for proper coverage to the customer's satisfaction in term of signal strength and good quality of service.

VI ACKNOWLEDGEMENTS

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