Bulletin of TUIT: Management and Communication Technologies

Volume 3 Article 1

11-16-2020

# EVALUATION OF RELIABILITY INDICATORS OF MOBILE COMMUNICATION SYSTEM BASES

Dilmurod Davronbekov
*Bulletin of TUIT: Management and Communication Technologies*, ab.shaxnoza84@gmail.com

Utkir Karimovich Matyokubov
*Urgench branch of Tashkent university of information technologies named after Muhammad Al-khwarizmi. Tashkent university of information technologies named after Muhammad Al-khwarizmi*, otkir_matyokubov89@mail.ru

Malika Ilkhamovna Abdullayeva
*Tashkent University of Information Technologies named after Muhammad al-Khwarizmi*, malika.ilkhamovna@gmail.com

UDK 621.396.44

# EVALUATION OF RELIABILITY INDICATORS OF MOBILE COMMUNICATION SYSTEM BASES

**D.A.Davronbekov, U.К.Matyokubov, M.I.Abdullayeva**

**Abstract.** In this study, the reliability of mobile system base stations (BTS) is assessed by analyzing data obtained on faults in about 200 BTS over a six-month period. Five BTSs with the highest number of failures and duration of failure were selected in these BTSs. Based on the data obtained, reliability parameters were calculated and compared.

The study used Weibull’s dismissal process distribution method. The breakdown times of each BTS were sorted. In all five BTS, it was found that β<1 (where the value of β is the approximate value obtained from the values of the smallest squares of the Weibull graph), thus reducing the failure rate. Defects can be caused by poor quality control, manufacturing defects, poor handling and various malfunctions. Detailed information on the problem was provided and described.

**Keywords**: BTS, GSM, Weibull distribution method, reliability, mobile system, failure time, failure probability.

## Introduction

The growing demand for GSM networking is crucial, as network providers ensure the reliability and quality of the services their customers want. To do this, providers need to expand their network, ie deploy more BTS. They also need to ensure the reliability of these BTSs [1].

In the context of mobile network expansion, additional power infrastructure must also be considered to ensure network reliability and minimize the impact of power outages [2].

In the event of a fault, there is a possibility that the equipment may fail for a period of time before switching to additional power infrastructure or returning to the main power supply in the event of a fault. In the context of lack of technical resources and distribution problems, the process of assessing the nominal capacity and reliability standards of key subsystems is important to determine their effectiveness, adequacy or vice versa [3]. Unfortunately, very little research has been done in these areas.

Based on the reliability of cellular subsystems, we can recognize the following research. Research on network failures due to interruptions in radio frequencies has yielded some good results. Smart agent technology has been proposed as a solution to these problems [4]. Empirical equations can be used to study the reliability, availability, viability, and many other reliability parameters of network elements [5, 6]. A high level of network reliability requires many network elements and more observation periods in the research process [7]. The reliability of a cellular communication system also depends on the type of communication lines. It should be noted that network providers should strive to establish communication lines based on optical cables [8].

In an analysis of network reliability based on power outages, Goel and Gupta evaluated the reliability of power generation capacity using a Monte Carlo simulation. With the help of Monte Carlo simulation or various deterministic approaches and computer programs, it is possible to obtain information about many reasons, such as the rate of forced shutdown of the element, changes in the maximum load of the system, partial failure of the generator [9-13].

Currently, research on the use of renewable energy in the uninterruptible power supply of BTS systems has expanded significantly. Emphasis is placed on research that takes into account the geographical location, climate, and economic development of the study area [14-19].

We performed the following tasks during this study:

1. Sort the breakdown time of the five BTSs under study;
2. Determining the probability of failure of each BTS;
3. Determine the parameter of the Weibull distribution and draw a graph;
4. Determine the average downtime of each BTS;
5. Determine the reliability of each BTS and compare the results;
6. Calculate the overall reliability of BTSs.

This work will lead to more efficient, better monitoring, management and maintenance of BTSs. If the reliability and performance of an existing BTS is evaluated and controlled, this will lead to an improvement in the performance and maintenance of the system. With the 2-parameter Weibull method, the system reliability that ensures a high level of BTS availability is better assessed.

## Main part

EXPERIMENTAL PROJECT

The method adopted in this study is experimental research design. The design approach to this study is based on a data collection method. For this study, six-month statistics from five BTSs in the Khorezm region of Uzbekistan were analyzed and used in modeling. 12,407 fault signals were received from the NMC (Net Worker Management Console) server regarding various error data.

WEYBULL METHOD

One of the most useful probability distributions in terms of reliability is the Weibull distribution. The advantage of Weibull's distribution law is that it can take another form due to changes in parameter values. The Weibull distribution is mainly used to model the growth and decline rates.

$$\lambda(t) = at^b \tag{1}$$

The function $\lambda(t)$ is known to increase the failure rate when a failure rate or risk level a>0, b>0, and decreases the failure rate when a> 0, b <0. Weibull has three different types of distribution.

$$R(t) = e^{-\left(\frac{t}{\theta}\right)*\beta} \tag{2}$$

$R(t)$ – is a reliability function or reliability probability.

It is necessary to evaluate the values of parameters 2 (ϴ va β) of the Weibull distribution. ϴ is a measurement parameter that affects the average and distribution of the distribution. As ϴ increases, so does reliability. As the ϴ increases, the risk level slope decreases. β is called the form parameter. Its effect on distribution varies on different values. If β = 1, then the faults are random and a constant fault level can be assumed where there is a fault level.

$$\lambda(t) = 1/\beta \tag{3}$$

If β>1, then the fault rate increases. Defects can occur due to physical wear, operation with large loads, corrosion, erosion and other causes. If β<1, then the failure rate decreases. The causes of failures can be poor control, manufacturing defects, poor workmanship, and so on. The probability of failure is calculated according to formula (4).

$$F(t_i) = (i - 0{,}3)/(n + 0{,}4) \tag{4}$$

Here, $t_i$ - is the duration of the fault (hours), $n$ - is the total number of faults, $i$ - is the number of faults analyzed.

$$y_i = lnln\left(\frac{1}{1-F(t_i)}\right) \tag{5}$$

$$x_i = lnt_i \tag{6}$$

Where $x_i$ are the values of the coordinates on the vertical axis and $y_i$ are the values of the coordinates on the horizontal axis. Our basic approach to probability plots is to match the linear regression line (smallest squares) of the shape.

$$y = a + bx \tag{7}$$

If the fault times correspond to the estimated distribution, the modified data is plotted as a straight line and the set regression line has a high index.

$$y_i = lnln\left(\frac{1}{1 - F(t_i)}\right), \quad x_i = lnt_i$$

RESULTS AND DISCUSSION.

DATA PRESENTATION.

The following graphs provide information on BTS faults.

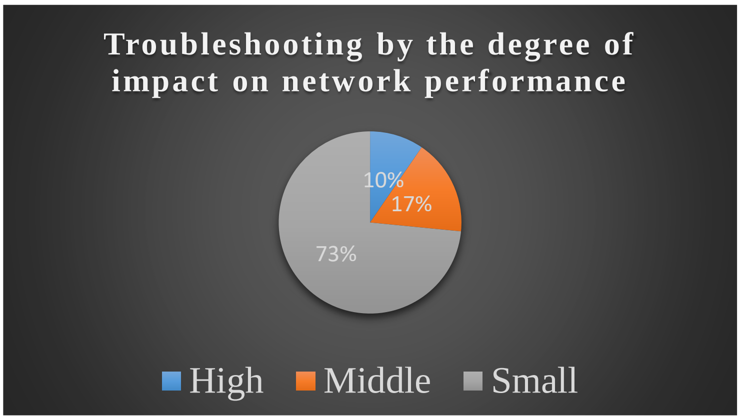


Figure 1. Evaluation of fault signals received from all (200 BTS, for six months) BTS during the study on the level of impact on network performance

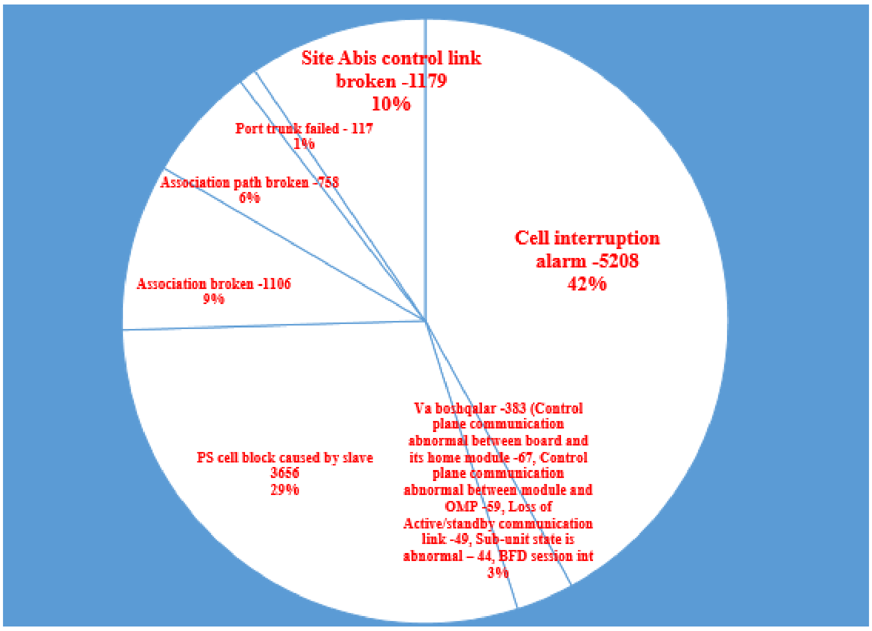


Figure 2. Classification of fault signals received from all (200 BTS, for six months) BTS during the study

Table 1. The main reasons for the occurrence of failures in the observed period

| **№** | **Cause of failure** | **Number of faults** | **Percentage of failures as a percentage (%)** |
|---|---|---|---|
| 1 | Equipment malfunction | 8873 | 71,5 |
| 2 | Communications subsystem failure | 2128 | 17,15 |
| 3 | DTE-DCE (DTE - Data terminal equipment, DCE-Data communication equipment) interface error | 1185 | 9,55 |
| 4 | Performance degraded | 116 | 0,93 |
| 5 | Underlying resource unavailable | 43 | 0,87 |
| 6 | Input/Output device error | 17 | |
| 7 | Local Node transmission error | 17 | |
| 8 | Clock synchronization problem. | 10 | |
| 9 | Threshold crossed | 8 | |
| 10 | Replaceable unit missing | 6 | |
| 11 | Processor problem | 2 | |
| 12 | External equipment failure | 2 | |

Table 2. Information on BTSs selected during the study

| **№** | **Names** | **Conditional designation** | **Number of faults during the study period** | **Total duration of all disturbances (sec)** | **Total duration of all violations (hours)** |
|---|---|---|---|---|---|
| 1 | Besharik Bagat_2G (6074) | BTS1 | 265 | 213463 | 59:17:43 |
| 2 | Durvadik Xanka_2G (5913) | BTS2 | 145 | 335461 | 93:11:01 |
| 3 | Gandimiyon_SEZ_2G (6031) | BTS3 | 85 | 116962 | 32:29:22 |
| 4 | Mirishkor Bagat_3G (6068) | BTS4 | 139 | 338650 | 94:04:10 |
| 5 | Xadra Kushkupir_2G (5927) | BTS5 | 178 | 593083 | 164:44:43 |

Table 3. 10 cases with the longest duration of failure in BTS

| № | Besharik Bagat_2G (6074) | | Durvadik Xanka_2G 5913) | | Gandimiyon_SEZ_2G (6031) | | Mirishkor Bagat_3G (6068) | | Xadra Kushkupir_2G (5927) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Fault duration (t), (hr; mins) | Fault duration (t), hr | Fault duration (t), (hr; mins) | Fault duration (t), hr | Fault duration (t), (hr; mins) | Fault duration (t), hr | Fault duration (t), (hr; mins) | Fault duration (t), hr | Fault duration (t), (hr; mins) | Fault duration (t), hr |
| 1 | 01:23:14 | 1,394 | 01:04:36 | 1,07 | 01:19:41 | 1,357 | 01:18:07 | 1,307 | 02:19:02 | 2,318 |
| 2 | 01:23:16 | 1,396 | 01:05:06 | 1,089 | 01:20:30 | 1,363 | 01:33:48 | 1,598 | 02:19:10 | 2,326 |
| 3 | 01:23:17 | 1,397 | 01:05:29 | 1,112 | 01:20:32 | 1,365 | 01:33:53 | 1,603 | 02:19:13 | 2,330 |
| 4 | 01:27:34 | 1,414 | 01:05:59 | 1,142 | 01:20:36 | 1,368 | 01:33:56 | 1,606 | 02:19:16 | 2,333 |
| 5 | 03:02:04 | 3,037 | 01:42:44 | 1,744 | 01:20:39 | 1,371 | 01:33:59 | 1,609 | 03:24:44 | 2,444 |
| 6 | 03:02:13 | 3,046 | 01:43:14 | 1,75 | 01:20:40 | 1,372 | 01:34:03 | 1,613 | 03:24:46 | 2,450 |
| 7 | 03:56:32 | 3,965 | 01:44:26 | 1,77 | 01:20:41 | 1,373 | 01:34:08 | 1,616 | 03:24:59 | 2,458 |
| 8 | 04:05:24 | 4,107 | 01:44:56 | 1,81 | 01:21:33 | 1,383 | 01:34:27 | 1,619 | 03:25:04 | 2,462 |
| 9 | 04:17:23 | 4,306 | 02:20:00 | 2,333 | 01:21:37 | 1,387 | 01:35:04 | 1,623 | 03:25:05 | 2,469 |
| 10 | 04:39:02 | 4,652 | 02:20:30 | 2,363 | 01:21:39 | 1,389 | 01:35:34 | 1,643 | 03:25:10 | 2,472 |

ANALYSIS OF BTS1, BTS2, BTS3, BTS4, BTS5

The following variables are used in the calculation:

$t_i$ - failure time; $i$ - is the number of cases considered. In our study, we selected 10 cases with the greatest failure time; $n$ – is the total number of faults in the BTS; $F(t_i)$ -Probability of failure.

In BTS1 we perform calculations on the first case. According to formula (4), $F(t_i)$ - is calculated as follows.

$$F(t_1) = \frac{i-0.3}{n+0.4} = \frac{1-0.3}{265+0.4} = 0.00263$$

$$\ln(t_1) = \ln(1.394) = 0.332$$

The following results are obtained by formula (5):

$$y_1 = lnln\left(\frac{1}{1-F(t_1)}\right) = lnln\left(\frac{1}{1-0.00263}\right) = lnln1.0026 = -5.953$$

In the same sequence, we perform the calculations for the following cases and summarize the results in Table 4.

Table 4. Analysis of data from BTS1

| $i$ | $t_i$, hour | $\ln(t_i)$ | $F(t_i) = \frac{i-0.3}{n+0.4}$ | $y_i = lnln\left(\frac{1}{1-F(t_i)}\right)$ |
|---|---|---|---|---|
| 1 | 1.394 | 0,332177312 | 0.00263 | -5,93659285 |
| 2 | 1.396 | 0,333611004 | 0,006405426 | -5,047398577 |
| 3 | 1.397 | 0,33432708 | 0,010173323 | -4,582877993 |
| 4 | 1.414 | 0,346422567 | 0,013941221 | -4,265893859 |
| 5 | 3.037 | 1,110870186 | 0,017709118 | -4,024755015 |
| 6 | 3.046 | 1,113829254 | 0,021477016 | -3,829936086 |
| 7 | 3.965 | 1,377505855 | 0,025244913 | -3,66637332 |
| 8 | 4.107 | 1,412692835 | 0,029012811 | -3,525332909 |
| 9 | 4.306 | 1,460009399 | 0,032780708 | -3,401296366 |
| 10 | 4.652 | 1,537297235 | 0,036548606 | -3,290553379 |

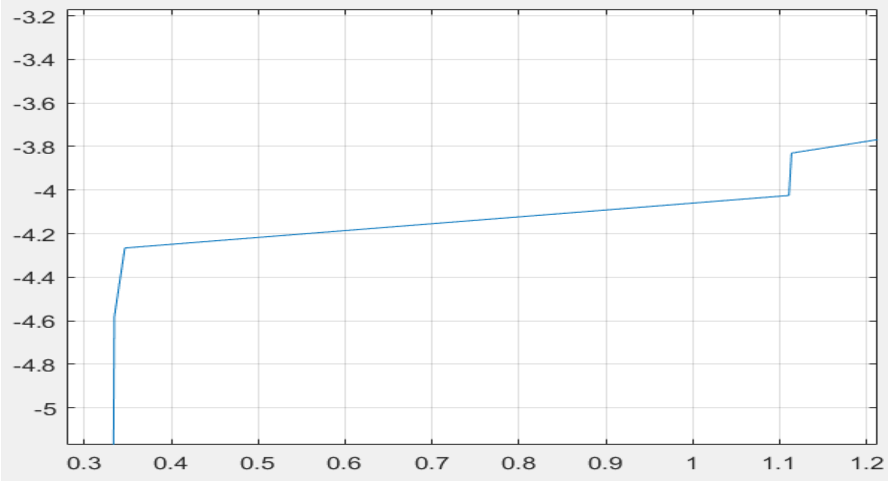


Figure 3. Weibull graph of BTS1 faults

$$(x_i = \ln(t_i)\ and\ y_i = lnln\left(\frac{1}{1-F(t_i)}\right)\ interdependence$$

BTS reliability is calculated using Equation (2);

$$R(t) = e^{-\left(\frac{t}{\theta}\right)*\beta}$$

Here, t = 6 months = 24 * 30 * 6 = 4320 hours for all BTSs;

$\beta = 0{,}991$ for BTS1; $\theta = 213463$ is the total degradation duration in the study period for BTS1.

$$R(t) = e^{-\left(\frac{t}{\theta}\right)*\beta} = e^{-\left(\frac{4320}{213463}\right)*0{,}991} = 0{,}971$$

We perform calculations on BTS2, BTS3, BTS4 and BTS5 on the same parameters and summarize the results in tables.

Table 5. Analysis of data from BTS2

| $i$ | $t_i$, hour | $\ln(t_i)$ | $F(t_i) = \frac{i-0.3}{n+0.4}$ | $y_i = lnln\left(\frac{1}{1-F(t_i)}\right)$ |
|---|---|---|---|---|
| 1 | 1,07 | 0,067658648 | 0,004814305 | -5,333751514 |
| 2 | 1,089 | 0,085259844 | 0,011691884 | -4,442985691 |
| 3 | 1,112 | 0,106160196 | 0,018569464 | -3,976879411 |
| 4 | 1,142 | 0,132781111 | 0,025447043 | -3,65829522 |
| 5 | 1,744 | 0,556181325 | 0,032324622 | -3,415541742 |
| 6 | 1,75 | 0,559615788 | 0,039202201 | -3,219093378 |
| 7 | 1,77 | 0,570979547 | 0,04607978 | -3,053886147 |
| 8 | 1,81 | 0,593326845 | 0,052957359 | -2,911186011 |
| 9 | 2,333 | 0,847154993 | 0,059834938 | -2,785474243 |
| 10 | 2,363 | 0,859931998 | 0,066712517 | -2,673040289 |

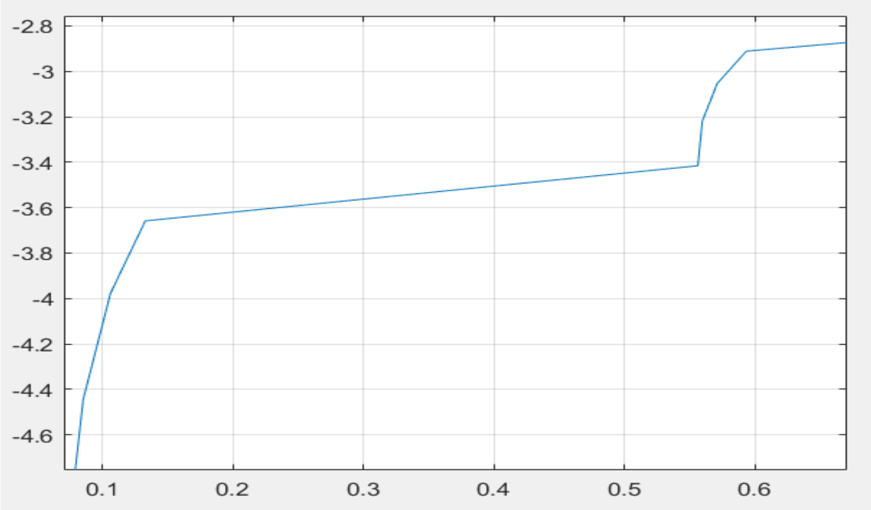


Figure 4. Weibull graph of BTS2 faults
$(x_i = \ln(t_i)$ and $y_i = lnln\left(\frac{1}{1-F(t_i)}\right)$ interdependence)

$\beta = 0{,}961$ and $\theta = 335461$ hours for BTS2 $R(t) = e^{-\left(\frac{t}{\theta}\right)*\beta} = e^{-\left(\frac{4320}{335461}\right)*0{,}961} = 0{,}948$

Table 6. Analysis of data from BTS3

| $i$ | $t_i$, hour | $\ln(t_i)$ | $F(t_i) = \frac{i-0.3}{n+0.4}$ | $y_i = lnln\left(\frac{1}{1-F(t_i)}\right)$ |
|---|---|---|---|---|
| 1 | 1,357 | 0,305276381 | 0,008196721 | -4,799908618 |
| 2 | 1,363 | 0,309688153 | 0,019906323 | -3,906681134 |
| 3 | 1,365 | 0,311154429 | 0,031615925 | -3,438074083 |
| 4 | 1,368 | 0,313349819 | 0,043325527 | -3,116948972 |
| 5 | 1,371 | 0,315540401 | 0,055035129 | -2,871613343 |
| 6 | 1,372 | 0,316269529 | 0,066744731 | -2,672540476 |
| 7 | 1,373 | 0,316998127 | 0,078454333 | -2,504665227 |
| 8 | 1,383 | 0,324255053 | 0,090163934 | -2,359252344 |
| 9 | 1,387 | 0,327143141 | 0,101873536 | -2,230781845 |
| 10 | 1,389 | 0,328584064 | 0,113583138 | -2,115541865 |

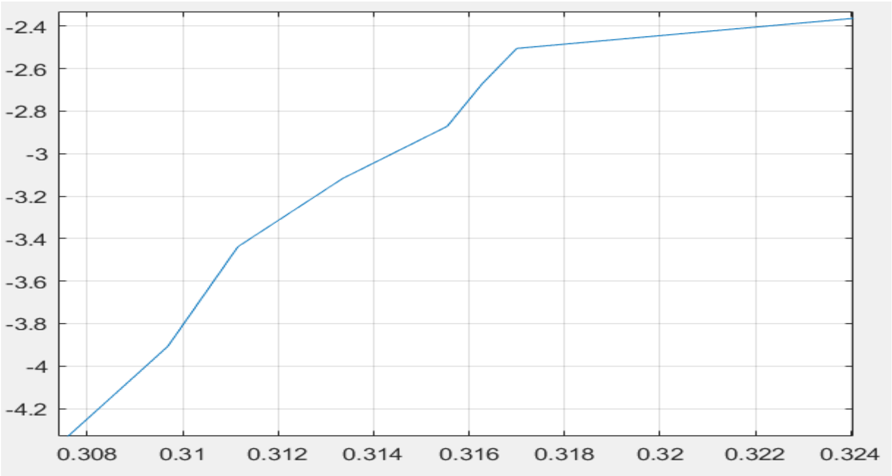


Figure 5. Weibull graph of BTS3 faults
$(x_i = \ln(t_i)$ and $y_i = lnln\left(\frac{1}{1-F(t_i)}\right)$ interdependence)

$\beta = 0{,}97$ and $\theta = 116962$ hours for BTS3

$R(t) = e^{-\left(\frac{t}{\theta}\right)*\beta} = e^{-\left(\frac{4320}{116962}\right)*0{,}97} = 0{,}934$

Table 7. Analysis of data from BTS4

| $i$ | $t_i$, hour | $\ln(t_i)$ | $F(t_i) = \frac{i-0.3}{n+0.4}$ | $y_i = lnln\left(\frac{1}{1-F(t_i)}\right)$ |
|---|---|---|---|---|
| 1 | 1,307 | 0,267734435 | 0,005021521 | -5,291506413 |
| 2 | 1,598 | 0,468752847 | 0,012195122 | -4,400590474 |
| 3 | 1,603 | 0,471876874 | 0,019368723 | -3,934332287 |
| 4 | 1,606 | 0,473746616 | 0,026542324 | -3,615594365 |
| 5 | 1,609 | 0,475612868 | 0,033715925 | -3,372685295 |
| 6 | 1,613 | 0,478095799 | 0,040889527 | -3,176079439 |
| 7 | 1,616 | 0,47995396 | 0,048063128 | -3,010712783 |
| 8 | 1,619 | 0,481808675 | 0,055236729 | -2,867851247 |
| 9 | 1,623 | 0,484276289 | 0,06241033 | -2,741976065 |
| 10 | 1,643 | 0,496523839 | 0,069583931 | -2,629376641 |

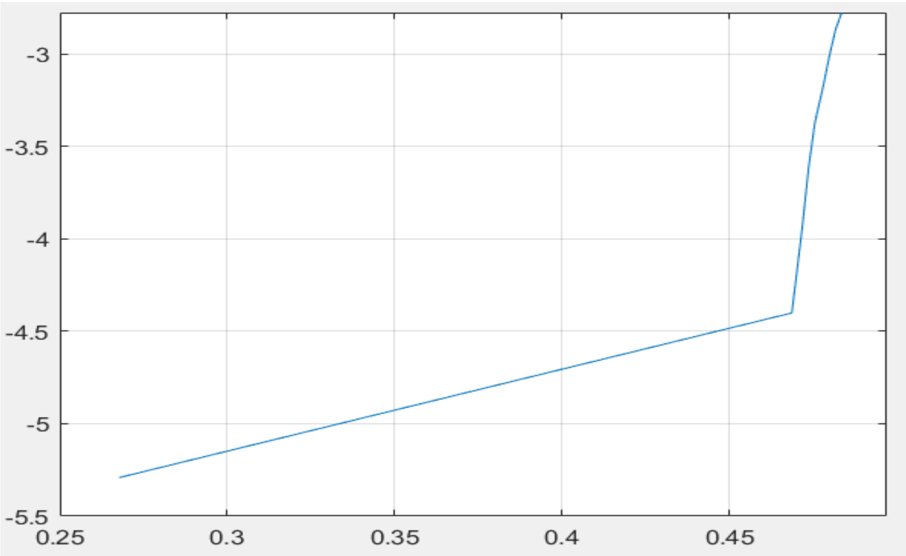


Figure 6. Weibull graph of BTS4 faults

$(x_i = \ln(t_i)\ and\ y_i = lnln\left(\frac{1}{1-F(t_i)}\right)\ interdependence)$

$\beta = 0{,}93$ and $\theta = 338650$ hours for BTS4 $R(t) = e^{-\left(\frac{t}{\theta}\right)*\beta} = e^{-\left(\frac{4320}{338650}\right)*0{,}93} = 0{,}918$

Table 8. Analysis of data from BTS5

| $i$ | $t_i$, hour | $\ln(t_i)$ | $F(t_i) = \frac{i-0.3}{n+0.4}$ | $y_i = lnln\left(\frac{1}{1-F(t_i)}\right)$ |
|---|---|---|---|---|
| 1 | 2,318 | 0,840704745 | 0,003923767 | -5,538738066 |
| 2 | 2,326 | 0,844150054 | 0,009529148 | -4,648616369 |
| 3 | 2,330 | 0,845868268 | 0,015134529 | -4,183161025 |
| 4 | 2,333 | 0,847154993 | 0,02073991 | -3,865234701 |
| 5 | 2,444 | 0,893636041 | 0,026345291 | -3,623146138 |
| 6 | 2,450 | 0,896088025 | 0,031950673 | -3,427369863 |
| 7 | 2,458 | 0,899348011 | 0,037556054 | -3,262842022 |
| 8 | 2,462 | 0,900974028 | 0,043161435 | -3,120828704 |
| 9 | 2,469 | 0,90381321 | 0,048766816 | -2,995811319 |
| 10 | 2,472 | 0,90502754 | 0,054372197 | -2,884079445 |

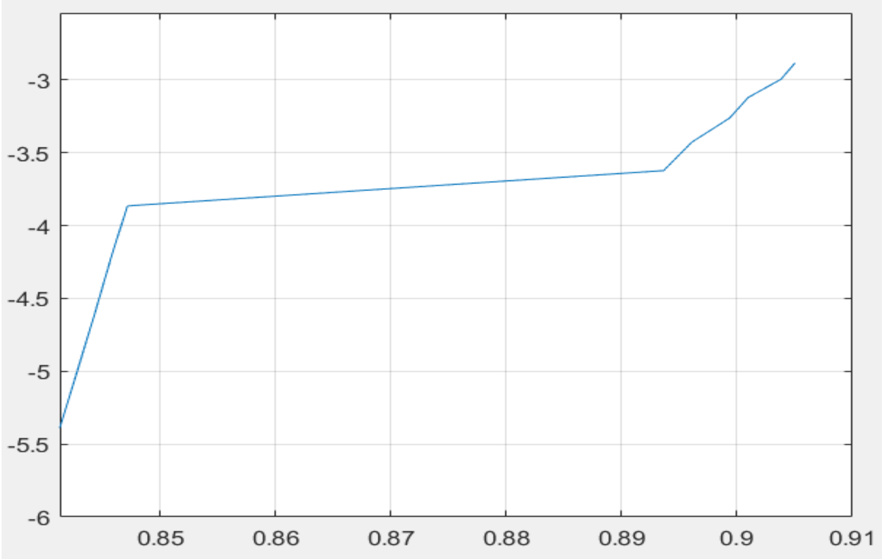


Figure 7. Weibull graph of BTS5 faults

$$\left(x_i = \ln(t_i)\ and\ y_i = ln ln\left(\frac{1}{1-F(t_i)}\right)\ interdependence\right)$$

$\beta = 0{,}917$ and $\theta = 593083$ hours for BTS5

$$R(t) = e^{-\left(\frac{t}{\theta}\right)*\beta} = e^{-\left(\frac{4320}{593083}\right)*0{,}917} = 0{,}910$$

To calculate the total reliability of the network, which can be formed from the studied BTS, the formula of reliability of the parallel system can be used, and it is calculated as follows:

$$R_{um} = [1-(1-R_1)(1-R_2)(1-R_3)(1-R_4)(1-R_5)] =$$
$$= [1-(1-0{,}971)(1-0{,}948)(1-0{,}934)(1-0{,}918)(1-0{,}910) =$$
$$= 1-0{,}029*0{,}052*0.066*0{,}082*0{,}09 = 0.99999926$$

## Conclusion

Analysis of the failure times obtained from each of the five BTSs revealed that BTS had β<1, which reduced the failure rate. Possible causes of failures can be poor quality control, manufacturing defects, poor service, wear of parts. The reliability of all BTSs is given in Table 9. The results show that the probability of reliability was high in BTS1 through a 6-month data analysis.

Table 9. Reliability indicators of BTS

| | BTS1 | BTS2 | BTS3 | BTS4 | BTS5 |
|---|---|---|---|---|---|
| Reliability rate (in percent) | 97,1 | 94,8 | 93,4 | 91,8 | 91 |

In this study, the reliability of BTSs was assessed. This study includes the mathematical expressions for calculating reliability, as well as the Weibull measurement parameter. The reliability of each BTS was calculated successfully. From the results obtained, BTS1 was found to have the highest reliability and BTS5 to have the lowest reliability.

## REFERENCES

[1] D Davronbekov. Sredstva peredachi i priyema informatsii v mobilnix sistemax svyazi: konspekt leksiy, 2011.

[2] Muradova A.A. Khujamatov Kh.E. Results of Calculations of Parameters of Reliability of Restored Devices of the Multiservice Communication Network
// International Conference on Information Science and Communications Technologies ICISCT 2019, Tashkent, Uzbekistan - 2019. (Scopus) DOI: 10.1109/ICISCT47635.2019.9011932

[3] Nazarov A.M., Davronbekov D.A. Controlling and Forecasting the Reliability of Integrated Circuits of Radio Systems Transmitting Information // Chemical Technology, Control and Management: Vol. 2020 : Iss. 1 , Article 3.

[4] Mas'ud A. Fault management in communication networks (A Case Study of the CDMA Intercullar network at Kaduna). MSc Thesis. Ahmadu Bello University, Zaria. Retrieved March 21, 2008 rom Department of Electrical Engineering Theses, Ahmadu Bello University, Zaria; 2006.

[5] Chen Y. Episode perspective of wireless network dependability. MSc Thesis. Ohio University, Ohio; 2006.

[6] Snow A, Varshney U, Malloy A. Reliability and survivability of wireless and mobile networks IEEE Computer Magazine. 2000;49-55.

[7] Albaghdadi M, Razvi K. Efficient transmission of period data that follows a consistent daily pattern. 9th IFIP/IEEE International Symposium on Integrated Network Management, IEEE Operation Center, Piscataway, NY. 2005;511-526.

[8] Fawaz W, Martignon F, Chen K, Pujolle G. A novel protection scheme for quality of service aware WDM Networks; 2005. IEEE, 0-7803-8939-5/2005.

[9] Goel L, Gupta R. A Windows based simulation tool for reliability evaluation of electricity generating capacity. Int. J. Engng Ed. 2007;13(5):347-357.

[10] Paska J. Methodology and tools for electric power system reliability assessment on HL I and HL II Levels. Paper presented at the 9th International Conference, Electrical Power Quality and Utilization, Barcelona; 2007.

[11] Silverstein BL, Porter DM. Contingency ranking for bulk system reliability criteria. Transactions on Power Systems. 2002;7(3).

[12] Burgio A, Menniti D, Pinnarelli A, Sorrentino N. The reliability evaluation of a power system in presence of photovoltaic and wind power generation plants and UPS. Paper presented at the 9th International Conference, Electrical Power Quality and Utilization, Barcelona; 2007.

[13] Chowdhury AA, Glover BP, Herbert S, Stadley K, Turanli H. Bulk transmission equipment outage performance reporting at mid-continent area power pool, Power Engineering Society General Meeting, London; 2004.

[14] Matyokubov U.K., Davronbekov D.A. The impact of mobile communication power supply systems on communication reliability and viability and their solutions // International Journal of Advanced Science and Technology. Vol. 29, No. 5, (2020), pp. 3374 – 3385 (Scopus http://sersc.org/journals/index.php/IJAST/article/view/12023/6302)

[15] Matyokubov U.K., Davronbekov D.A Increasing energy efficiency of base stations in mobile communication systems // Scientific-technical journal Turin polytechnic university in Tashkent. Vol. 1, No. 1, 2020, pp. 22-27.

[16] D.A.Davronbekov, U.T.Aliev, J.D.Isroilov, X.F.Alimdjanov. Power Providing Methods for Wireless Sensors // International Conference on Information Science and Communications Technologies. Applications, Trends and Opportunities, ICISCT 2019 DOI: 10.1109/ICISCT47635.2019.9011850

[17] O‘ Matyokubov and D Davronbekov. Approaches to the organization of disaster resistant mobile network architecture in uzbekistan. Acta of Turin Polytechnic University in Tashkent, 10(2):10, 2020.

[18] Davronbekov D.A., Matyokubov U.K. Reliability of the BTS-BSC System with Different Types of Communication Lines Between Them // International Journal of Advanced Trends in Computer Science and Engineering. Vol. 9, No. 4, (2020), pp. 6684 – 6689. (Scopus) http://www.warse.org/IJATCSE/static/pdf/file/ijatcse362942020.pdf
DOI: 10.30534/ijatcse/2020/362942020

[19] Davronbekov D.A., Matyokubov U.K. The role of network components in improving the reliability and survivability of mobile communication networks // Acta of Turin Polytechnic University in Tashkent, 10(3):2, 2020