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Capacity Analysis Laboratory Testing 2.4 GHz WLAN and Bluetooth Version 3 & 4 using Time Study Method

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Abstract

As the number of production increases (mainly the production of telecommunication equipment), which also influences the increasing demand for WLAN and Bluetooth testing, it is necessary to analyze the adequacy and operational readiness of the resources (in this case, the support machines and labor) that support the implementation of WLAN and Bluetooth testing at the laboratory. The purpose of this study is to determine the default time for Wlan and Bluetooth testing and calculate the laboratory capacity in conducting Wlan and Bluetooth testing based on the number of currents and future testing requests. The method used is to use a time study. By determining the standard time of testing WLAN and Bluetooth in the Laboratory, it was then calculating the capacity in conducting WLAN and Bluetooth testing, based on the number of current and future testing requests, so that a step can be obtained to optimize the WLAN and Bluetooth testing process in the laboratory. The analysis of the results of data processing shows that currently, the new laboratory can meet 53.03% of requests received. To overcome capacity shortages, efforts must be made to increase capacity by increasing the number of operators, followed by adding the number of machines and work tools. Also, from testing requests in 2016 and 2017, there was an increase in requests by 3.39% per year. This data acquisition can be used as a basis for laboratory capacity analysis for the next few years.

Keywords: *WLAN, Bluetooth measurement, and time study method.*

I. INTRODUCTION

Telecommunication products that are part of the radio frequency spectrum so that the benefits are sought for good, human convenience in communicating, radio frequency spectrum that starts from the ELF (Extremely Low Frequency) band which is in the position of 3-30 Hz to THF (Tremendously High Frequency) that is in position 300-3000 GHz, so that telecommunications products traded in the Republic of Indonesia (NKRI) must be products that have been certified and obtained permission from the Indonesian government. The use of radiofrequency spectrum must obtain permission from the government; this is in line with the sound of article 33 of Law No. 36 of 1999 concerning telecommunications.

The increasing number of telecommunication equipment production, such as mobile phones, computers, TV broadcasts, laptops, speakers, and so on, which greatly influence the increasing demand for testing 2.4 GHz WLAN and Bluetooth from vendors, which is very much compared to the request for testing devices that other and as the structure has not been structured, the measurement schedule and the absence of standard time standards for telecommunication equipment testing process in the Laboratory of Telecommunication Equipment Testing Center, the author raised the topic of analysis of laboratory capacity measurement of 2.4 GHz WLAN testing and Bluetooth using the time study method in the hall extensive testing of telecommunications equipment.

II. LITERATURE REVIEW

Every company is demanded every time to be able to provide satisfactory service to its customers. Both in terms of the time to fulfill the requested needs (efficient) and quality under the request [1]. So it takes a measurement of work where the measurement of work time is related to efforts to determine the standard time needed to complete a job [2]. The success of a production system in the industry is usually expressed in terms of the amount of productivity or the amount of output and input produced. In determining productivity, there needs to be a standard work time. Working time is one of the important factors and needs attention in its production system [3]. Time study was preliminarily adopted more widely, especially in an incentive pay system compared with the use of motion study [4]. The standard time sought is not the time of settlement resolved improperly, such as too fast or too slow, nor is it solved by a worker who has special or slow skills and is not done with a system that is not yet working best [5]. A job can be completed efficiently if the completion time is the shortest [6]. Most companies still use human power or are still manual, assisted by semi-automatic machines, so that the production process runs smoothly by a predetermined plan. But in reality, these plans often occur deviations because the production process at the company is often unable to produce all orders so that the company sub-contracts in the form of finished products to fulfill the demand for the order. Productivity is simply defined as the ratio between output per input [7]. In order for productivity to increase, effective production processes need to be pursued and contribute fully to productive activities related to added value. One way is to try to avoid or minimize the steps of unproductive activities such as the amount of idle / delay, set-up, loading-unloading, materials handling. To get the shortest completion time, there is a need for work research and work method analysis. The purpose of this research and analysis of work methods is to apply the principles and techniques of setting the optimal way of working in the work system so that an alternative method of work implementation is obtained, which is considered to provide the most effective and efficient results [8].

The main objective of work time measurement activities is to find out the standard time achieved by a normal worker to complete a job. Measurement of work time is the activity of observing workers and recording the working time of each element or cycle using a tool that has been prepared. Broadly the technique of measuring work time can be divided into two parts, namely: direct measurement techniques, where measurements are made by direct observation of workers (workpieces) [9]. Time study using a stopwatch is the most popular technique for determining standard time. The first task of the analyst is to divide the work/job into smaller work elements in such a way that the time for each element should not be less than 3 seconds because, for such elements, recording time is difficult. The steps of time study are as follows:

Step 1: First, select the job to be studied. Breakdown the work content of the job into the smallest possible elements. Then, inform the worker and define the best method.

Step 2: Observe the time for an appropriate number of cycles (such as 25 to 50).

Step 3: Determine the average cycle time (CT) [10]. The work sampling method is used for:

a. Measure the delay ratio of several machines, employees, or other facilities. An example is determining the percentage of working hours or people involved in work activities, and the percentage where there is absolutely no work activity carried out (idle or idle),

b. Establishing a Performance Level from a person during working time based on the time this person works or does not work, especially for manual work, c. Determine the standard time for a work process or operation, as well as can be done by other work measurements [11].

The steps to perform standard time calculations using the stop clock method are as follows. The first step taken is a preliminary measurement that aims to determine the number of measurements that must be done. The number of visits is determined by a meter, usually not less than 30. After the measurement is carried out, to determine the number of measurements needed, the next step that must be done is the data uniformity test [12]. Next, to get the standard time, one that must be fulfilled is calculating the allowance. Allowance time is given to provide tolerance to operators by paying attention to 3 factors, namely personal needs, fatigue, and unavoidable obstacles. The way to determine the allowance time is to direct observation of the conditions that occur on the production floor for each functional element [13].

Job factor systems are called "Work Factor" as a measure for evaluating and ranking movements differently in terms of the level of difficulty contained in them. In the Ready Work Factor system, it is ensured that the number of work factors is determined based on the characteristics of each movement so that the analysis can be easily identified. In the principle of Ready Work Factor analysis, the most important are: a. Simple table of organized time values so that the time in a production process can be calculated, b. Is a simple guide for good applications to facilitate understanding [14].

Better use of time and energy results in higher effectiveness in achieving productivity. We must explore the sources of knowledge, creativity, and abilities stored in that line of workers. The workforce is the main thing considered in calculating labor productivity, where productivity is influenced by factors that are real or not real, for example, equipment, work environment conditions, process processes of work knowledge, and motivation [15]. The stopwatch method is a direct measurement of working time commonly applied for jobs of short duration and repetitive. In this study, the stopwatch readout method used is Repetitive Timings. For this method, the stopwatch read simultaneously, and the numbers on the stopwatch are returned to zero after each work element is completed; productivity is a value that indicates the ratio between output and input; increase production value can be seen when comparing the numbers getting bigger. While another opinion explains that productivity is a comparison between the results achieved with the participation of labor per unit time [16].

A. Working Time Measurement

Completion of activities that take place effectively if it can be reached in a short time. To get the shortest completion time, there is a need for work research and work method analysis. The purpose of the research and analysis of work methods is to apply the principles and techniques of setting the optimal way of working in the work system to implement work that is considered to provide the most effective and efficient results. The main benefit of working time measurement activities is to know the standard time achieved by an ordinary worker naturally to complete a job. Measurement of work time is the activity of observing workers and recording the working time of each element or cycle using a tool that has been prepared. Standard time can be calculated using direct and indirect methods involving operators who are trained and skilled in their fields. In working time measurement, two ways can be done :

a) Directly

It is a technique of measuring work time carried out directly in the place where a job found, which is the raw time. There are two direct working time measurement techniques, namely :

a. With the stopwatch method and
b. Work sampling method (work)

b) Indirectly

Indirect methods are a way to determine the standard time for which the data is not directly carried out in the place where the activity/work takes place, but it is enough to use past data that has been recorded for similar jobs. The purpose of the research and analysis of work methods is to apply the principles and techniques of setting the optimal way of working in the work system to implement work that is considered to provide the most effective and efficient results.

B. Calculation of Capacity

The capacity calculation can be done using 3 (three) methods, including theoretical capacity (maximum capacity/design capacity), where the maximum possible capacity of the manufacturing system is based on the available time, without considering rest, downtime, and others. The working time is 8 hours. The second method is the Actual Capacity / Effective Capacity method, where the level is the output that can be expected based on experience, which measures actual production from the work center in the past, which is usually calculated by the average number based on normal workload. So that the time used is 7 hours of work and 1 hour to rest. Or by using the Rated Capacity (Nominated Capacity / Nominal Capacity) method, where capacity measurement is based on adjusting theoretical capacity with productivity factors that have been determined by demonstrated capacity. The measurement is calculated through doubling available working time with utilization and efficiency factors. The capacity calculation can be calculated using equations:

Capacity = Working time / Standard time

III. METHODOLOGY

Data collection and processing were carried out to include primary data, including the results of interviews, observations and direct observations and indirect observations, and secondary data, namely company data. Direct observation includes: With the stopwatch method and the work sampling method (work). Many factors need to be considered so that a reasonable time to do work can be obtained, such as those relating to working conditions, methods of measurement, number of measurements, and others. The steps that need to be followed so that the work measurement objectives can be achieved2, among others: determining the measurement objectives, conducting preliminary research, selecting operators, outlining the work on the elements of work, and preparing measurement tools.

a) Determining Measurement Objectives

As with many other activities, the purpose of carrying out activities must be determined in advance. In measuring time, the crucial things that must be known and determined are the use of measurement results, the level of research, and the desired level of confidence from the results of these measurements.

b) Conducting Preliminary Research

The goal to be achieved from the measurement of time is to get the appropriate time to be given to workers in completing a job, so that a working system with conditions that have existed so far can be found an appropriate time to complete a job.

c) Choosing an Operator

The operator does the measured work is not just someone who is taken from the workplace. The operator to be chosen must fulfill certain conditions so that the measurement runs well, and the results are reliable. These conditions are normal abilities and can be invited to work together.

d) Deciphering the Work on the Elements of Work

Here the work is broken down into elements of work, which is a movement of the part of the work in question, breaking down the work since the raw material begins to be processed in the workplace. These elements are to be measured.

e) Preparing equipment

After the above steps are carried out properly, now comes the final step before making measurements, namely preparing the necessary equipment, including:

1. Stop time.
2. Observation sheets.
3. Pen or pencil.
4. Observation board.

The activity of evaluating the speed and performance of the operator at the time the work the measurement takes place as the most vital and challenging part of measuring work.

A. Observation and Decomposition Process

WLAN 2.4 GHz and Bluetooth V3 and 4 tests are carried out every Monday-Friday, from 08.00-16.00 WIB. They are cut every day (1) hour so that the 2.4 GHz and Bluetooth V3 and 4 every day is carried out for 7 working hours and carried out by 4 (four) workers who are in charge of testing WLAN, and every worker or operator uses/operates each one measuring instrument so that there are 4 (four) workers and 4 (four) measuring instruments in the 2.4 GHz WLAN testing laboratory and Bluetooth V3 and V4. To get valid and accountable field observations, it is not enough to do some measurements to implement test measurements using a stopwatch. Many factors need to be considered so that a reasonable time to do work can be obtained, such as those relating to working conditions, methods of measurement, number of measurements, and others.

The steps that need to be followed so that the work measurement objectives can be achieved, one of which is to describe the work on the elements of work and prepare a measurement tool. Besides that, data in the field of WLAN testing process measurements were carried out in the device test laboratory, as shown in the following table:

Table 3.1 Description of Process Testing for 2.4 GHz WLAN and Bluetooth V3 and 4

No	Process Flow
1.	Look at the testing schedule (weekly)
2.	Taking test samples
3.	Determine measurement items and perform testing measurements
4.	Make a measurement report (LHU)
5.	Tidy up the testing site

Based on the table above, it can be seen that there are 5 (five) process streams carried out by workers in the process of testing 2.4 GHz WLAN and Bluetooth V3 and 4. To get an overall picture of the testing process, each of these processes can be broken down into several sub-processes, as shown in the table below:

Table 3.2 Descriptions Complete the process of testing 2.4 GHz WLAN and Bluetooth V3 and V4

No	Process Flow	Sub Process
1.	View testing schedules (weekly)	View testing schedules (weekly) WLAN 2.4 GHz and Bluetooth v3 and 4
2.	Taking test samples	Take samples to be tested in the lab
3.	Determine measurement items and perform test measurements	1. Look at the specifications for determining measurement items. 2. Perform the measurement process 3. save the measurement results
4.	Create a test measurement report (LHU)	1. Open the report file 2. Enter measurement data 3. Perform final evaluation and examination
5.	Tidy up the test site	Clean and re-arrange the lab after completing the test measurements.

Before the researcher performs a standard time measurement, it is necessary to know in advance the data on the number of requests for testing measurements within a specific period. The data can be seen in the request table for Wlan and Bluetooth testing from January 2016 to April 2017 periods, among others, as follows.

Table 3.3 Wlan and Bluetooth Testing Requests for the January-December 2016 Period

Period: January-December 2016							
Week	Demand (File)	week	Demand (File)	week	Demand (File)	week	Demand (File)
1	21	14	8	27	49	40	48
2	28	15	15	28	29	41	50
3	38	16	33	29	9	42	40
4	43	17	23	30	29	43	36
5	13	18	35	31	26	44	10
6	36	19	10	32	6	45	21
7	36	20	20	33	23	46	23
8	19	21	26	34	12	47	11
9	44	22	27	35	35	48	13
10	28	23	45	36	52	49	9
11	35	24	4	37	40	50	26
12	23	25	23	38	50	51	20
13	29	26	57	39	3	52	24

Table 3.4 Requests for WLAN and Bluetooth testing for the period January-April 2017.

Period : January-April 2017			
Week	Demand (File)	Week	Demand (File)
1	9	11	16
2	8	12	24
3	19	13	27
4	28	14	14
5	9	15	10
6	22	16	17
7	14	17	24
8	15	18	32
9	26	19	59
10	17	20	27

B. Time Measurement

Time measurement in the test measurement process uses stopwatches and is carried out by operators or workers who have been trained with work methods that have been determined according to work standards in device testing laboratories, telecommunication equipment testing hall, Researchers take or measure test measurement process time WLAN and Bluetooth by taking a sample of 20 (twenty) times working time measurement using stopwatch during the period of April-July 2017. The results of the measurement of the measurement process for Wlan testing and Bluetooth can be seen in Table 3.5 below:

Table 3.5 Data Measurement Time Process Test Wlan and Bluetooth

WLAN Testing and Bluetooth Testing Duration of Each File			
No	time (minutes)	No	time (minutes)
1.	210	11.	214
2.	200	12.	222
3.	220	13.	200
4.	202	14.	204
5.	216	15.	212
6.	217	16.	219
7.	212	17.	200
8.	204	18.	204
9.	206	19.	206
10.	201	20.	226

IV. RESULT AND DISCUSSION

Processing data from time measurement results is carried out with the following steps:

Group 20 (twenty) data into 2 (two) columns and each subgroup contains 4 data so that there are 5 subgroups.
Calculate the average price of the average sub-group.

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

So that the average price of 1-5 subgroups is:

$$\bar{x} = \frac{208 + 212{,}25 + 210{,}75 + 208{,}75 + 209}{5} = 209{,}75$$

Calculate the actual Standard Deviation from the completion time.

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

So the actual STDV from the time of completion is:

$$\sigma = \frac{143{,}16 + 145{,}97 + 145{,}05 + 143{,}67 + 143{,}84}{19}$$

$\sigma = 37{,}98$

$\text{STDV} = \sqrt{37.98} = 6{,}16$

Calculate the Standard Deviation from the average price distribution of sub-groups.

$\Sigma - \bar{x} = \sigma / (\sqrt{n})$, $\sigma - \bar{x} = 6.16 / (\sqrt{4}) = 3.08$

Determine the upper control limit (BKA) and lower control limit (BKB).

$BKA = \bar{x} + k\sigma$
$BKB = \bar{x} - k\sigma$

So that it is obtained:

$BKA = 209.75 + 2\ (3.08) = 215.91$
$BKB = 209.75 - 2\ (3.08) = 203.59$

Determine the Amount of Measurement with a precision level of 5% and a confidence level of 95% (k = 2, I - α = 95 %).

$$N' = \left[\frac{k/s \sqrt{N\, \Sigma x^2 - (\Sigma x)^2}}{\Sigma x} \right]^2, \text{ Obtained :}$$

$$N' = \left[\frac{2/0{,}05 \sqrt{20.881175 - (17598025)}}{4195} \right]^2$$

$$N' = \left[\frac{40 \sqrt{17623500 - (17598025)}}{4195} \right]^2$$

$$N' = \left[\frac{6384{,}36}{4195} \right]^2$$

$N' = 1{,}52^2 = 2{,}31 \approx 2$

A. Determination of Cycle Time

From the measurement process time table, the cycle time data is obtained as follows :

$$W_S = \frac{\Sigma x}{n}$$

$$W_S = \frac{4195}{20}$$

$W_S = 209{,}75$ minutes

B. Normal Timing

Normal time is obtained by p notation as the time of adjustment in the formula.

Wn = Ws x p

The adjustment method used in calculating the standard time of measuring the WLAN 2.4 GHz and Bluetooth testing process versions 3 and 4 is the Westing House method, which is an adjustment method that takes into account skills, effort, work conditions, and consistency. In the process of measuring WLAN 2.4 GHz and Bluetooth versions 3 and 4, which have been observed in the field, the authors determine the value of worker adjustment as follows :

Table. 4.1. Adjustment Factor for the 2.4 GHz WLAN Testing Measurement

Factor	Class	Emblem	Adjustment
Skills	Good	C1	+0,06
Business	Good	C1	+0,05
Working conditions	Good	C	+0,02
Consistency	Good	C	+0,01
SUM			+0,14

Classification of adjustment factors in the measurement process of WLAN 2.4 GHz and Bluetooth versions 3 and 4, based on observations in the field or in the laboratory where the testing process takes place directly in the work area. From the data adjustment table above, normal time is obtained, as follows :

$W_n = W_s \times p$, Obtained :

$W_n = 209{,}75 \times (1 + 0{,}14)$

$W_n = 239{,}12$ minutes

C. Determination of Standard Time

In determining the standard time, it needs to be taken into account regarding leeway. Determining the standard time uses the following formula :

$W_b = W_n + W_s.i$

Where i is the percentage of allowance given to cycle time. The amount of allowance is determined based on the influential factors, as shown in the following table :

Table. 4.2. The leeway factor for the WLAN 2.4 GHz and Bluetooth version 3 and 4 testing process

No	Factor	Allowance (%)
1	Energy released	4
2	Work attitude	1
3	Work Movement	0
4	Eye fatigue	3
5	Workplace Temperature Conditions	0
6	Good environment	0
7	Individual needs	2
8	Inevitable	4
Sum		14

From the table data above, the standard time for measuring WLAN 2.4 GHz and Bluetooth versions 3 and 4 is standard, taking into account the allowance factor, as follows:

$W_b = W_n + W_s.i$ Obtained:

$W_b = 239{,}12 + 209{,}75\ (0{,}14)$

$W_b = 268{,}49$ minutes

D. Capacity Calculation

The calculation of the testing process capacity of WLAN 2.4 GHz and Bluetooth versions 3 and 4 are done using the Demonstrated Capacity (Effective Capacity) method, where the level of output that can be expected based on actual measurement results from the work center in the past is usually calculated by the average number based on normal workload so that the time spent in one working day is 7 hours of work and one hour for rest.

Based on the results of observations in the field and the results of standard time measurements, the following data are obtained:

Standard time = 268.49 minutes
Working time per week = 4 workers x 35 hours x 60 minutes = 8400 minutes.

From these data, the capacity of the 2.4 GHz WLAN testing process and Bluetooth versions 3 and 4 are obtained, as follows:

Capacity = (Working Time) / (Standard time), obtained :
Capacity = 8400/268.49
Capacity = 31.29 Testing / week.

From the test request data attached to the test request data in a period of several periods, it can be seen that the largest number of requests for testing WLAN 2.4 GHz and Bluetooth versions 3 and 4 during the period of January-April 2017 are as many as 59 test application files/week, while based on capacity calculation (after calculation of standard time), the capacity of laboratory measurements testing WLAN 2.4 GHz. Bluetooth v3 and v4 are currently only capable of testing as many as 30 tests per week.

Requests for measuring WLAN 2.4 GHz and Bluetooth v3 and v4 measurements that can be met by the laboratory at this time are fulfilled requests = (laboratory capacity) / (number of test requests) x 100%
So that the demand is fulfilled = 31.29 / 59 x 100%
= 53.03%

In other words, the laboratory capacity in measuring testing WLAN 2.4 GHz and Bluetooth v3 and v4 currently only reaches 53.03% of total requests/week.

E. Analysis of capacity improvement

Based on the analysis of several factors that can have an impact on increasing the testing capacity of the 2.4 GHz WLAN and Bluetooth v3 and v4, information is obtained that :

The results of the analysis indicate that the work methods performed are standard, under the work instructions of the quality guidelines, work guidelines that are accredited to ISO 17025: 2005 certification, and have been considered useful in their implementation.

The working environment conditions are adequate so that the operator or worker can carry out the testing process properly. By considering the standard time of measuring WLAN 2.4 GHz and Bluetooth v3 and v4 testing, the agency can take steps by increasing the number of operators or workers so that the measurement capacity of the 2.4 GHz WLAN and Bluetooth v3 and v4 testing by the laboratory can compensate the request or requests received or received from vendors. But it needs to be underlined and also noted that the addition of the number of operators or workers would have an impact on the need for additional machines or measuring instruments and work aids to be used, the amount of which is following the increase in the number of operators. This is due to the process of measuring testing, which is running continuously or continuously so that each worker uses a machine or measuring instrument and work aids; of course, they must each.

The following illustrates the number of operators that must be added with the aim that the measurement capacity of testing WLAN 2.4 GHz and Bluetooth v3 and v4 in the laboratory can compensate for the number of requests/requests received. (current number of operators) / (current lab capacity) = (number of operators on request) / (number of requests). So that : The number of operators needed to fulfill the request is = (current number of operators x number of requests) / (current lab capacity) = (4 operators x 59 tests per week) / (31.29 testing per week)
= 7.54 operators ≈ 8 operators

With the addition of 4 (four) operators measuring testing, from the initial number of 4 (four) to 8 (eight) people, a new laboratory capacity obtained for:

Standard Time = 268.49 minutes
Working time per week = 8 workers x 35 hours x 60 minutes = 16800 minutes.
Capacity = (working time) / (standard time)
Capacity = (16800 minutes) / 268.49
Capacity = 62.57 tests per week. Capacity ≈ 63 testings per week. So the percentage of WLAN 2.4 GHz and Bluetooth v3 and v4 test measurement requests that can be fulfilled by the laboratory becomes:
Request fulfilled = (laboratory capacity) / (number of test requests) x 100%.
Request fulfilled = 63/59 x 100%
Request fulfilled = 106.78%

So that with the addition of operators that were originally 4 (four) operators to 8 (eight) operators, the request for the fulfillment of testing measurements could be fulfilled to 100 (one hundred)%, which initially with 4 (four) operators was only able to fulfill 53.03%.
From the calculation, it can also be seen information about the capacity of each operator to measure WLAN 2.4 GHz and Bluetooth versions 3 and 4 every week, namely:
Capacity per operator / week: (Lab testing capacity) / (number of operators)
Capacity per operator / week: (63 tests / week) / (8 operators) Capacity per operator / week: 7,875 tests / week Capacity per operator / week ≈ 8 tests / week.

F. Analysis of Demand in the Future

In 2016 it was known that the largest number of requests was equal to 57 requests for testing, while for 2017 to April, there were 59 requests for testing, so the percentage increase in requests for testing each year amounted to:

Increase in demand per year = (59-57) / 59 x 100%
Annual increase in demand = 3.39%

Based on the data acquisition, the company can analyze the increase in demand for the short term with the next 5 (five) years, the middle term with the next 10 (ten) years, and the long term with the next 15 (fifteen) years. Analysis of the number of requests is based on the assumption of a constant increase in demand per year of 3.39%.

Short term = 3.39% x 5 x 59 = 10 requests per week.
Medium = 3.39% x 10 x 59 = 20 requests per week.
Long term = 3.39% x 15 x 59 = 30 requests per week

In addition to the increasing number of requests, information can also be obtained on the number of operators needed to anticipate the increase in the number of requests.

Short term (next 5 years)
Capacity = (Working time) / (Standard time)
Working time = Standard x time capacity
Working time = (59 + 10) x 268.49
Working time = 18525.81 minutes
Working time = Number of workers x 35 hours x 60 minutes.
Number of workers = (Working time) / (35 hours x 60 minutes).
Number of workers = 18525.81 / 2100 = 8.82 ≈ 9 operators.

Medium term (next 10 years)
Working time = Standard x time capacity.
Working time = (59 + 20) x 268.49.
Working time = 21210.71 minutes.
Working time = Number of workers x 35 hours x 60 minutes.
Number of workers = (Working time) / (35 hours x 60 minutes)
Number of workers = 21210.71 /2100 = 10.10 = 10 operators.

Long term (next 15 years).
Working time = Standard x time capacity.
Working time = (59 + 30) x 268.49.
Working time = 23895.61 minutes
Working time = Number of workers x 35 hours x 60 minutes.
Number of workers = (Working time) / (35 hours x 60 minutes).
Number of workers = 23895.61 / 2100 = 11.38 = 11 operators .

From the results of the analysis of capacity calculations in the future, we obtain a description of demand, the number of operators, machines and tools needed by the laboratory for the next few years, as follows:

Table 5.1. Table of the fulfilment of requests in the future

Period	Number of requests/week	Number of Operators	Number of Machines	Number of Tools
Short-term	69	9 People	9 Machines	9 Set
Medium-term	79	10 People	10 Machines	10 Set
Long-term	89	11 People	11 Machines	11 Set

V. CONCLUSION

Based on the results of data processing and analysis, conclusions can be drawn as follows:

1. Measurements of testing 2.4 GHz and Bluetooth versions 3 and 4, currently carried out by 4 operators working every Monday-Friday for 7 (seven) working hours plus one hour to rest, with a standard time of testing 268, 49 minutes.
2. The current laboratory capacity in measuring testing at 2.4 GHz and Bluetooth versions 3 and 4 has not been able to compensate for the requests received. At present, a new laboratory can fulfill 53.03% of requests received; out of 59 applications submitted for testing, from 59 requests, only 31.29 tests can be carried out by the laboratory every week.
3. To overcome the lack of laboratory capacity in meeting the number of testing requests for WLAN 2.4 GHz and Bluetooth versions 3 and 4, and after analyzing the factors that affect capacity, capacity building efforts need to be carried out by increasing the number of operators. The number of operators that need to be added is 4 people, so that the total number of operators needed today is 8 (Eight) operators.

After analyzing the results of data processing, there were 4 (four) additional operators, so the consequence that would be faced was the addition of the number of measuring instruments for 4 operators and four work aids, besides the consequence was the addition of expenses for employee payroll, because of the addition 4 (four) operators.

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