Investigation into Defects in Microwave Links

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ABSTRACT

This research aimed to minimize the defects in microwave links. In as much as a microwave link is a circuit between terminals separated by a sizable distance, it can be considered as a type of transmission line; but unlike copper or fiber optic cables, terrestrial microwave signals are propagated through the lower atmosphere because of that microwave transmission is highly essential for long distance transmission.

Most of the telecommunication service providers in Sri Lanka use microwave networks to enhance their network coverage. This microwave connection is very important to the entire network because fault of the link may cause the sites out of control and if that happens, site in a ring type connection communication through ring may be stopped and for other type tower can't properly be operated. Because of that investigation of the defects is highly **essential to provide better service.**

Also according to the traffic transmit different kind of configurations technologies be used. According to the modulation type they use mainly two types of configurations.

1. **SDH- Synchronous Digital Hierarchy.**
2. **PDH- Plesiochronous Digital Hierarchy.**

According to the ODU connection it also vary as

1. **1+1 configuration.**
2. **1+0 configuration.**

For the research it was investigated microwave links constructed by a company in during five month of time period and the phases during its design and operation was considered to find the root causes of the defects. Analysis was done according to the types of the defects and solutions carried out by the results obtained for each cause.

KEYWORDS: Defects, Microwave Propagation, Plesiochronous Digital Hierarchy, Synchronous Digital Hierarchy

INTRODUCTION

Telecommunications transmission facilities are the physical means of communicating large amounts of information over distance. Without exception, communication signals (speech, images, video, or computer data) are electromagnetic waves traveling along transmission lines. For a given route, the type of transmission line selected depends on the topography, the amount of information to carry, and the cost. Even though fiber optic cable carries more information with higher reliability than does any other transmission medium, for a long distance over remote or rugged terrain, a microwave relay system is sometimes the better economic alternative.

There is a company facilitate mobile service providers to do such a project and that is one of the largest general engineering and construction company in Sri Lanka with a diverse portfolio such as Telecommunication Engineering, Civil Engineering, Power, Water supply & Drainage and Road, Pilling with a impressive track record for last two decades they have handled large scale projects for both government and private sector in various parts of the Island.

Their works,

- Design and Construction of outside plant networks.
- Installation of wired and wireless subscriber networks.
- Maintenance and rehabilitation of telecommunication networks.
- Installation of optical fiber transmission networks.
- Installation of transmission systems and towers.
- Supplying and Installation of switching systems.

In the past they highly involved in fiber transmission, BTS installation and Microwave installation.

Normally there is a probability that may have defect(s) in micro links. Some of the links can install without any defects and some projects became success more than the range that expected in the planning. Because of that there

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should be some reasons behind the successful projects and on the other hand, same reasons may interpret as the defect for the failure project. When it becomes to a defects it may occur problems at the beginning of the project or at the end of the project or may occur during processing of the project. Also projects were established with the involvement of people, electronic components and the computer technology. Because of that there were reasons for the defects which may relate with the one or more parties above mentioned. So it's necessary to identify the cause and the effect of the defects to classify the solutions which may able to use to minimized defects. According to that following factors were considered as the problems of the research.

1. What are the phase defects that can occur?
2. What is the background of the occurrences?
3. What is the priority defect(s)?
4. What are the actions can be proposed according to types of the defect(s)?
5. Will those solutions be successful?

Problems generated due to defects, were mainly affected to the accuracy of the installation, cost effectiveness of the project, and for the time plane of the project. Also those things were finally reasons for the profit loss of the project and problems occurrence rapidly will badly affect to goodwill of the company. So classification of the defects, their priorities and solutions from the construction phase to maintenance phase is very important to minimize those problems and optimize installation progress of microwave links. Also according to the priorities they can make some plan to handle the same kind of problems from the beginning of the new projects.

LITERATURE

Basic principles of microwave propagation

Microwave refers to wavelengths of the electromagnetic spectrum in between one meter and one centimeter. For unbounded propagation through vacuum, far from material objects, engineering design can approach exact results based on the laws of electrodynamics. The free space loss for a signal is due to spreading of the electromagnetic wave with increasing distance from the transmitting antenna. As microwave energy spreads over an ever expanding spherical surface, its power flow per unit area decreases. The signal attenuation over distance from the source also depends on the frequency; the higher the frequency, the greater the attenuation. Therefore, given the frequency, the free space loss between two fixed points is constant regardless of other details of the path. Transmission formulas add in the gains and losses of radios, transmission lines, antennas, and path details of a hop. The transmitter power minus waveguide losses plus its antenna gain sets the baseline for the free space loss and additional propagation losses along the path. Absorption of electromagnetic energy by atmospheric gases is also significant in certain parts of the spectrum.

Microwave path engineering

A microwave network's size and setup depend on numbers of users, their geographic distribution, and their calling behavior, either through direct surveys or reliable statistical data. This information is necessary to provision, or size and configure, the switch, multiplexer, and transmission equipment for a specified performance level, or grade of service. Without an accurate estimate of the traffic of a service area, it would be difficult to design a transmission system that maintains a required grade of service economically. The network topology, or layout, is the product of an analysis to determine the optimal connections between switching centers and locations where traffic would be added or dropped from the aggregate streams of the transmission system. An optimal topology has sufficient direct and alternate routes to carry the offered traffic at all times. From the microwave engineer's standpoint, a network layout shows where microwave repeater stations might be needed; thus he begins to define the line-of-sight paths of the network. To keep the BER to an acceptable level most of the time, the ambient noise and interference levels at each end of a path must not exceed certain values. Once the major nodes of the network are known, maps, imagery, and the region's topography are studied to identify possible microwave terminal and relay locations.

Path Profiles and Calculations

The basic method is to check whether a choice of antenna size and height, for given values of transmitter power and receiver sensitivity, results in a sufficient fade margin for a received signal to remain above a threshold level after losses due to the distance, terrain, obstructions, reflections, and other atmospheric effects. In general, there is not a unique solution to the path design problem, and cost is usually the deciding factor. The end result of the design is a microwave installation drawing set and bill of materials for radios, towers, transmission lines, antennas, materials, and their arrangement into a system that will satisfy the stated performance objectives.

Outages

An outage event occurs when the BER(Bit Error Ratio) exceeds a specified threshold for less than ten consecutive seconds; longer than that, the link is said to be unavailable. The distinction arises from the fact that digital trunks lose framing when high BER persists longer than the defined outage duration. Outage

time is the accumulated time for all outage events in a given period.

Field Survey

The propagation variations of each path are determined by its terrain, obstructions, and atmospheric conditions. One purpose of a microwave field survey is to collect accurate data on locations and elevations of critical terrain points along a path, heights of obstructions, and meteorological data in the vicinity of a path. Accuracy is essential in order to meet the performance objectives of a microwave transmission system. Uncertainty in locations and elevations forces the engineer to be conservative about the clearance required for the line-of-sight between antennas.

Equipment and site engineering

The FCC's chapter on frequency assignments for the fixed microwave services lists 41 bands ranging from 928 MHz to 42.5 GHz. Antennas, RF transmission lines, microwave combining and dividing components, and radios are the elements of microwave systems common to all of these bands, but their characteristics vary greatly over this range.

METHODOLOGY

Defects can occur in any stage of the installation process while it processing. It's decided to use observation method to gather factors as primary data which may reasons for the defects. To identify the defects may occur due to human errors was identified as a percentage according to the factors mentioned bellow.

Secondary data were collected by using existing inventory reports and additional reports where applicable. Also data engage with the links performance hope to be measured to make some evidence to the performance failures of the microwave links. Studies of the similar or previous cases can be very important to generate some ideas about some cases. Those cases were used to make some comparison among the links.

Following conditions were observed to measure the percentage of the errors done during installation process. If the person did not achieve following requirements was decided to add 10 marks for the relevant task.

1. Use the appropriate tool.
2. Follow the given guidelines to handle the equipments.
3. Use the cleaning and waterproofing component provided by the manufacture.
4. Assembling correct units, proper connections.
5. Connect the cable connectors properly and safely.
6. Cover all the outdoor connections properly with waterproof materials.
7. Use the provided guidelines to connect ODU (Out Door Unit)
8. Configure the IDU (Indoor Unit) appropriately with given configuration.
9. Label link connections separately for transmit and receive and use the relevant E1's to carry signals.
10. Connect the power to the equipment with safe and accurate.

Furthermore following conditions were used to classify data.

Errors at the designing part were decided to identify with use of the report prepared by the company. Most of the time design errors reflect as a LOS problems and interference problems. Also it was concerned incorrect frequency allocation as a design faulty. Effects of the human error were decided to analyze by using out puts of the observations. Equipments problems were decided to identify with the analysis of reports prepared by the company and the inventory reports where appropriate. Technical problems were decided to analyze with the use of reports prepared by the company and inventory reports generated from the commissioning software.

DATA COLLECTION & ANALYZING

For the research, was used fifth month of time was used to collect data and analyze. For clear understand, total defect ratings encountered from collected data was given in graphical manner as shown in bellow.

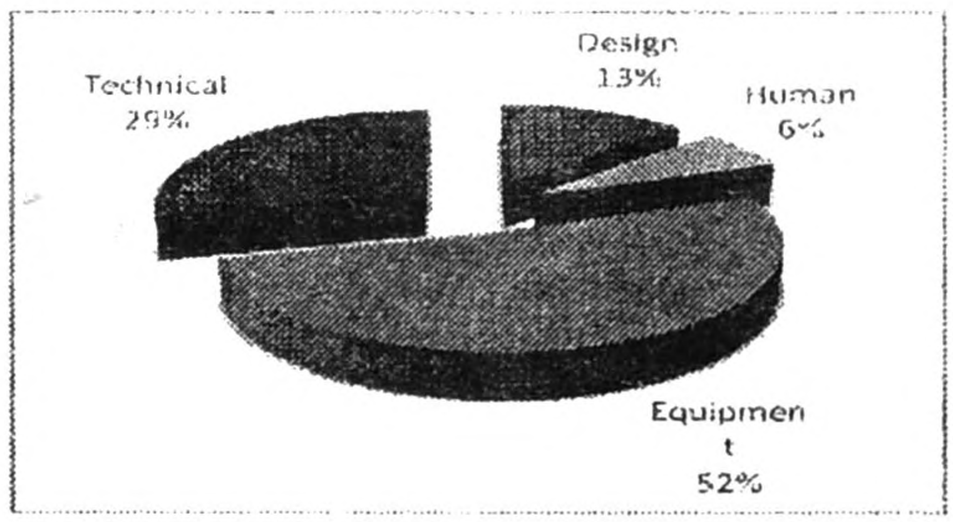

Figure 1 Total error percentages for design, human, equipment and technical errors.

Equipments faults

Figure 1 shows the total involvements of each defect as a percentage of the total defects. It is clearly shows the equipments faults are 52% from the total

deffects which is the highest category of fault occur. The humen errors aer the lowest persentage of the fault occur.

The equipment falier can be further categarized in to three types ther are,

1.ODU faulty.
2.IDU faulty.
3.Cable faulty.

Persentage calculated for equipments faulty can be reflected as follow.

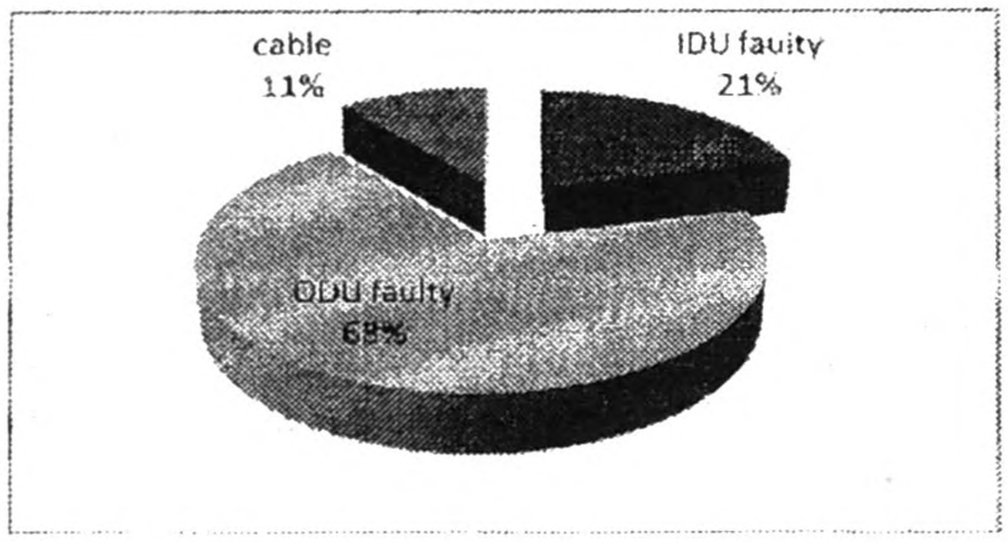

Figure 2. Deffects on equipments faults.

Design phase is one of the most effected phse can genarete deffects in all the other phases.so it is very important to design links with unique data for each sites. According to the environment, traffic to be transmitted can have slide variations among the sites.

Technical faults.

For the technical faults was observe a SDH project done by the company. From the site three out of five sites were effected by the interfearences. Also there may be problem with used subband and frequancy range.

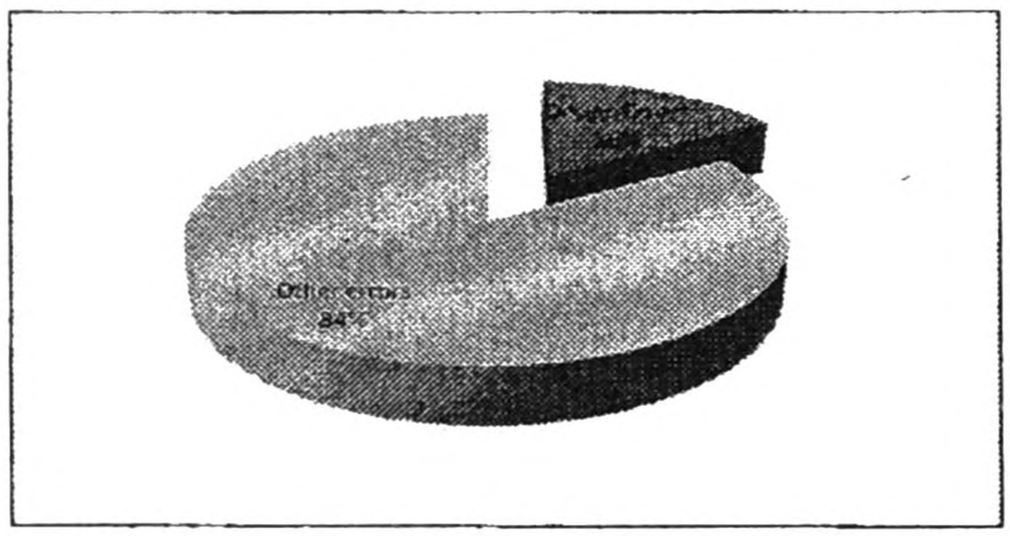

Figure 3 Percentage of the design errors

Details of RX frequency and interference levels for Horizontal and Vertical propagations of a link were given bellow. For the better performance it should have interference level over -90DBm. But figures show the variations from the expected level due to interferences from the other sites.

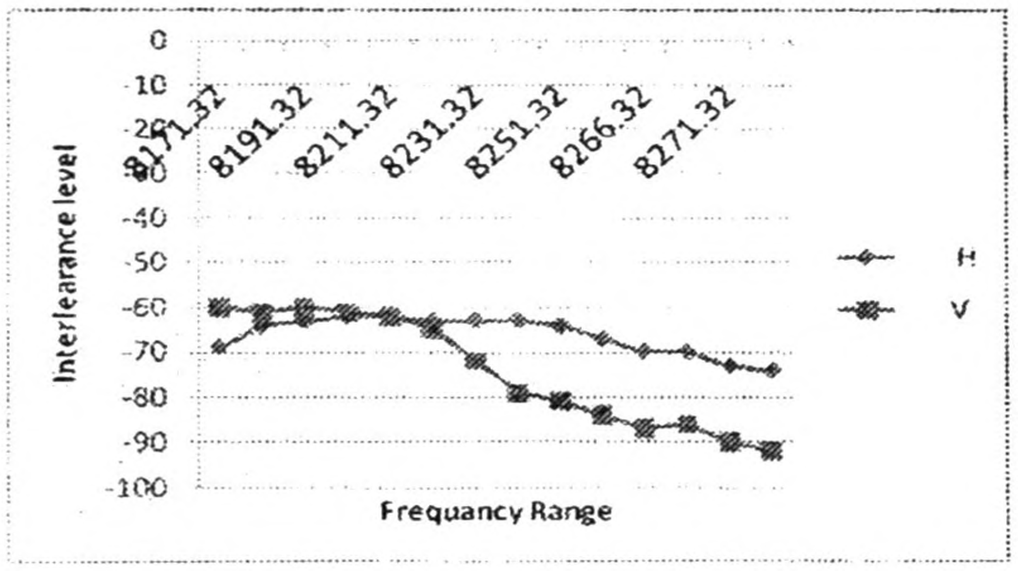

Figure 4 Interference levels at a side when mute other site.

Other site also had interferences when mute this side transmission. This is because of inaccurate frequency allocation and frequency reuse.

Sub band allocation.

Sub band configuration is one of the identical features of ODU. According to the frequency decided to transmit ODU should be selected. When it use same sub band frequently it cause defects. Also in this research it was investigated about the ODU faulty according to the sub band.

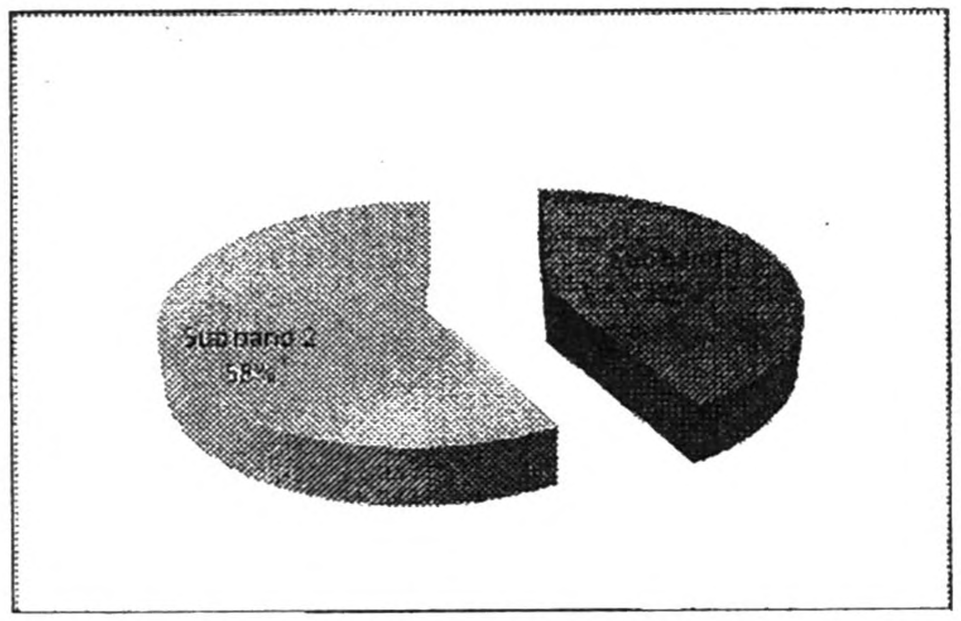

Figure 5 Comparison of sub bands on defects

Effect of frequency range on defects

Transmitting frequancy range should be vary according to the distance it travel For the selected sample faulty of each section can be represented as follows.

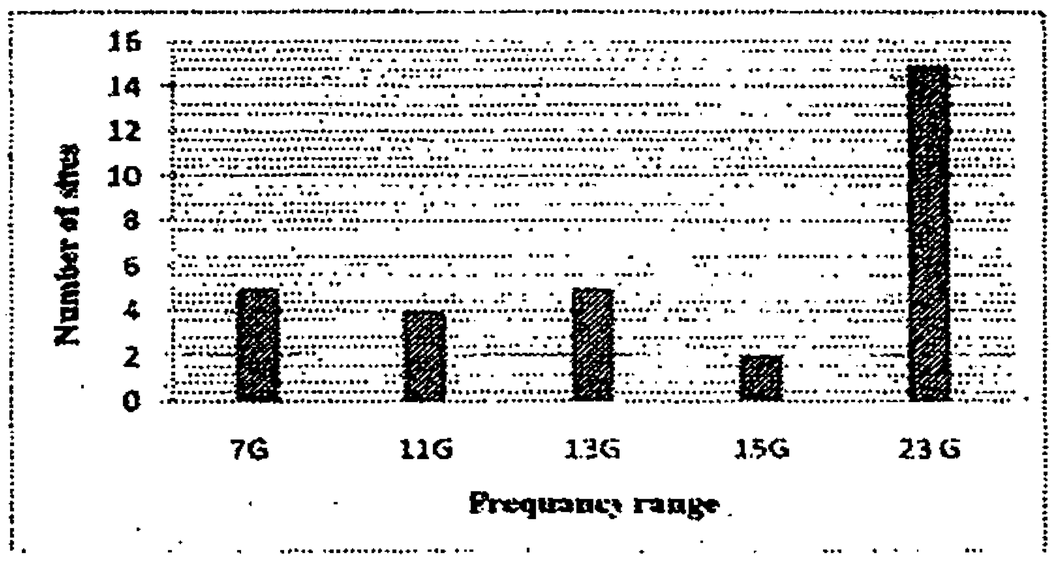

Figure 6; comparison of faulty with decided frequency ranges

RESULTS AND DISCUSSION

Effect of the equipment types on defects.

According to the research, main kind of a defect can have in any micro link is equipment fault. That represents 52% from the total defects. According to the further analyze most of the common fault can be cause defect in a link is ODU fault. Other than that IDU fault and cable fault can be sufficiently affected on microwave link performance.

Results for effect of the technical problem

The other important factor can be generating defects on micro links is technical problems. It shows 29% out of the total. So that factor also to be considerable for make solutions.

In the case of SDH link interference on the selected frequency band is very high. Even though it had reception level in an acceptable range (around -35DBm) it can't be used for transmission. Because of that technical problems for the microwave links is considerable.

	Site Name	Total Errors%
1	Kalladi	40
2	Anamaduwa	30
3	Mahailluppallama	10
4	Galnewa	40
5	Devahoowa	30
6	Andiyagala	40
7	Brawns hill	20
8	Kapugama	40
9	Siwalasakulam	10
10	Tammannawa	30
11	Dvalapola	20
12	Devlapitiya	20
13	Ukgalboda	40
14	Digana	30
15	Mitiyagoda	20

Table 1; Observed human error percentages

And the figure 4 shows sites with sub band 2 willing to fault on the operations than the antennas with sub band 1. But the effect on it can be neglected because both antennas with sub band 1 and 2 shows nearly equal trend to fault. But in the case of frequencies use to transmission 23G range shows highest probability to be fault. It's a considerable factor to be concerned, because higher the frequency means lower the distance among the antennas. So frequency range of the antenna use for short distance transmission can affect on micro link.

Results for effect of the design problem

From the outcomes of the investigation it was found that, percentage of the design error is 16% and other defects may effect on the link performance is 84%.

One of the most important factors of the site construction is design. Because that the phase determine all the things of the link. So defect occurred as results of design errors must highly considerable. Also cost for an installation, link performance and the other effects like environmental effect on the link depend on the design phase. So even though 16% is small value it can be identify as a one of the main reasons for defect.

Results for human errors

For the human errors, mean percentage of the errors for particular site is 28% and expected sites may having defects on human errors is 9.Sites with defects on human errors is 3. Because of that we can identify, variation of theoretical value from the real value is 6. This can be expressed as a percentage of the variation between expected value and real value that is 66.67%.

According to the results of above mentioned there are some probability affect human errors on microwave. But, when it concern with total defects it shows 6% involvement. And according to the figure 1 it shows minimum affect than the other affects. With the calculations, it can be predict, workers in the company are talented to do installation with minimum errors. Also from the variation of the expected faulty from the real faulty shows contribution of the human errors for the link defects is on the lowest level.

Feasible solutions for investigated defects

- As a Solution for most possible equipment fault, necessary to have an additional ODU for installation.
- To minimize technical errors there must do another technical investigation according to the fault type and also to minimize technical

- Problems it must use accurate data in design phase. It also recommended to do accurate survey for

determine site location, height of the antenna, useable frequency range and the interferences from the other sites and from the atmosphere. To increase the accuracy of the LOS it must use accurate geographical details.

CONCLUSION

This research is focused on finding defects in microwave links. With the collected data was identified some root causes may effect on the microwave links. Also this is totally base on the links which are installed with a common brand name which was investigated. From the results of this research can't implement strong recommendation. Because the sample were selected is very small when consider with 1900 about total sites. But it may sufficient to make some assumption to suggest some helpful recommendation to minimize defects. Also was able to identify deferent kinds of defects in a measurable manner. So outcomes of this research can be very useful to generate some ideas about common defects and can use to minimize the defects in microwave links.

Farther developing this research can check the accuracy of this research and with observation with large number of achievements can accurately identify the area which may have probability to occur defects by the human errors. This research also can develop to identify the effects of the microwave communication to the human being.

From the details observed should think twice before install sub band 2 ODU for short distance transmission. Because of that, it is necessary to have an additional research base on the effect of the sub band on short distance microwave propagation.

As a solution for ODU faulty it is necessary to have a feasibility study for use pre-commissioned ODU to minimize the installation time and to minimize the inconsistencies at the site which may generated at the installation.

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