Minimizing Subscriptions and Financial Losses by Implementing and Improving Quality Process in Radio Base Stations

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Abstract − *There has been an increase in the wireless phone services. It is important for telecommunications companies to manage more efficiently their operations and equipments to be able to maintain a continuous service and prevent losing considerable amounts of customers. Losing customers translate to losing money. It is possible to analyze the operations from Centro de Operaciones de la Red of Claro Puerto Rico to identify areas that cause service failures. Using Lean Six Sigma tools, it is possible to understand better the causes of failures and then create plans to improve and reduce these. After analysis, it is possible to say that the mayor problem is hardware failures. Another observation is that the major causes of this failures are lack of equipment maintenance. This type of analysis could be used by any telecommunication company to identify areas that they could improve.*

Key Terms − *Claro PR, DMAIC, Maintenance, Operations, Radio Base Station, Six Sigma.*

INTRODUCTION

Communication is an essential need in the world that we are living. Many years ago, when our fathers were growing up, there was not telecommunication as we know it today, was not available. Some time ago, you could write a letter and mail it, but it could take a week or more to reach to the right destination. Right now, everything makes it easier to communicate with other people. Today, one has the opportunity to send a picture, a message, mail or browse the internet by just using a single device; being it a cellphone. It is a need right now and that's why it is very important to give the best telecommunications service possible, so that people can communicate with each other and have good memories without complaints.

This project will be focused in *Centro de Operaciones de la Red* (Network Operations Center), which is part of Puerto Rico Telephone Company, and is the biggest telecommunication company in Puerto Rico and Caribbean. Claro Puerto Rico, is current business name, is a wholly owned subsidiary America Movil (AMX). It was founded by 1914. It is dedicated to give telecommunications services, island wide. Some of this services are: cellular wireless, wireline phone and internet services. The company provides telecommunications services to Dominican Republic and other Caribbean Islands.

The *Centro de Operaciones de la Red* (N.O.C.) is responsible for the maintenance and operations of the entire telecommunications network's infrastructure including all equipments, platforms, and nodes throughout the island of Puerto Rico. Any problem that occur anywhere, *Centro de Operaciones de la Red* find the solutions. This center, is in charge of keeping of Claro PR's equipment in the upmost working conditions. This proper maintenance is required to provide a reliable service to all telecommunications customers. *Centro de Operaciones de la Red* along with its paying subscribers, has internal customers including departments of Engineering, Sales, Marketing, and Customer Care. Every department depends on a reliable functional and operationally efficient *Centro de Operaciones de la Red* in order to provide the best services possible.

Frequent problems *Centro de Operaciones de la Red* faces daily, includes: operational failures and long resolution times for customer cases. These result in our service subscribers migrating to other telecommunication companies.

The objective of this investigation is to lower the customer losses by sustaining a superior

telecommunications infrastructure and service by improving its maintenance and applying the necessary process in order to resolve issues in the least amount of time possible.

FINDINGS

Since, Claro PR has operations and maintenance budget to handle the *Centro de Operaciones de la Red* problems and fixes, the design project will help reduce the operational costs by focusing on the mayor cause of problem; radio base station outages. It represents [1] 48.6% of problems at the network.

At the end of this project design, if Claro PR/ PRTC decides to implement it; the impact would be positive which will help retain existing customers. It is by providing the required attention to the telecommunications network infrastructure, by means of preventive maintenance routines, continuous employee trainings and developing procedural documentation for the attention of the network nodes in case of failure.

While performing the investigation as an internal audit, some important factors that accurately helped identify these problems were found. In the *Centro de Operaciones de la Red* the resources are focused on the maintenance of just the equipment, platforms and nodes in their headquarters offices in Caparra. This is a cause to avoid works on maintenance at the field and achieve problems on the equipments that is located outside the central offices.

Regularly, could occur about [1] 1-3 failures by week, as well as [1] 5-7 failures by week. This failures tends to happen not only because the equipment is electrical and had a power problem (typically for a power system), but it is by lack of maintenance. An example of this is: a DSLAM is damaged (equipment that provides internet services to the customer), it makes that some city sectors fail to connect to the internet, so this sectors lack of connectivity and communication. When there is an available technician, he goes to where the equipment is located, verified and find that this equipment is no longer working because it is overheated, therefore it shut down to defend itself. And it is overheated because: there was not verification of working fans, internal fans cleaning, air conditioning power failure, and air conditioning failure, among others.

Sometimes, it is by lack of knowledge from the employees.

The lack of technical knowledge is because the Claro PR/PRTC is contracting personnel that is not fully capable and lack of the "know how" of how to manage these different platforms and nodes of the network. Additionally, Claro PR/PRTC do not provide an introductory level training program that presents the basic tasks of any given technical position. This lack of basic knowledge contributes negatively and does not help find solutions neither to these node failures nor to establish initiatives proactively inspects equipment and identifies solutions to problems.

The technicians are in charge of maintain the network nodes assigned to them. These nodes/ equipment must be in perfect working conditions since the technicians directly monitor the nodes. When a failure occurs, the technicians are in charge of resolving the issues in order to sustain a good service experience for the customers. They are in charge of performing pro-active tasks to maintain the applications and platforms in a good state. They provide professional recommendations, if any equipment needed; e.g. "end of life equipment", "end of support equipment", "out of update equipment", among others. In addition, they upkeep the applications and equipment in order to maintain the highest levels of performance of these nodes and equipment and in optimal working conditions. Usually the technicians are in constant communication with the company's technical support team to make them aware of any news and keep them up to date thus providing better coverage to the equipment.
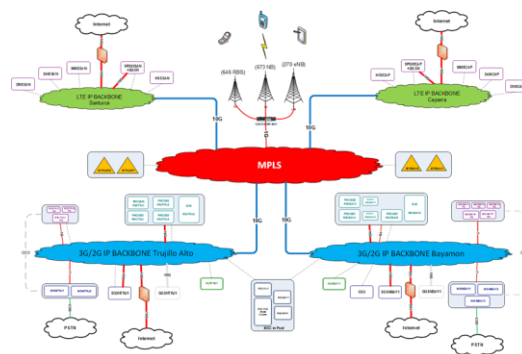

Figure 1
Actual Wireless Telecommunications Network Diagram

It is estimated that the losses are around the [1] 700 customers up to 3,000 customers monthly. It is a data information taken from the losses in the voicemail service. This service is a standard feature of any cellular plan that a customer may choose. The numbers from Customer Service reflects similar statistics.

The quantifiable items due to a network problem or equipment failures are the contribution and operational costs to the company. The need to have technical personnel after hours in the field incurring overtime pay, requiring technical resources not under contract, parts that are not in stock, among other things. In addition, there are no records for monetary loses attributed to each failure or for any annual budgetary request to cover operational or capacitation costs

Losses for no effectivity on service: for the month of [1] September of the year 2014, there was around 892,754 wireless phone service customers. On comparison with year 2015 for this same month of September, currently the company has 782,477 wireless phone service customers. There has been a loss of 110,277 wireless phone service customers in just one year approximately. Although, the company has had new customers month to month, it is notable to see mayor decrease over this subscriptions. Approximately, this represents a loss of $4,962,465 throughout this year. Being this on comparison to September 2014 with year September 2015.

This wireless subscriptions are divided on two categories: post-paid and pre-paid. For post-paid there are around [1] 567,853 and for pre-paid there are around 214,624. Totalizing 782,477 [1] wireless subscriptions.

RBS stands for radio base station. It provides the connection between mobile phones and the wider telephone network. Radio transmitter and receiver used for transmitting and receiving voice and data to and from mobile phones in a particular cell.
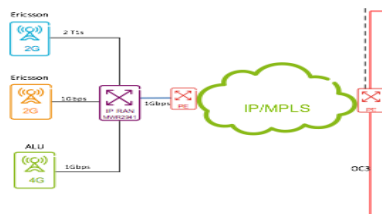

Figure 2
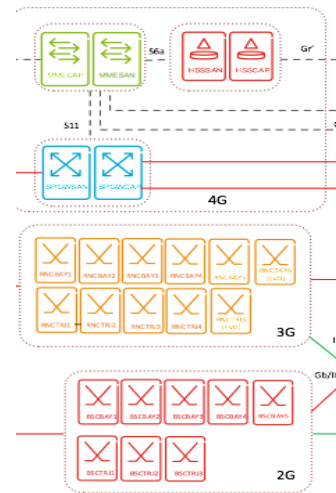**First Section Divided for Wireless Telecomm Network**

Figure 3
Second Section for Divided Wireless Telecomm Network
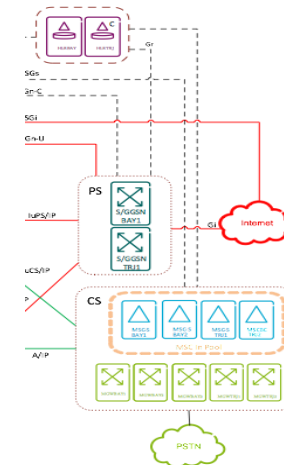

Figure 4
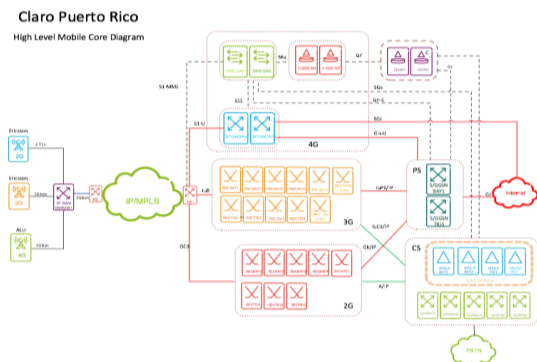**Third Section for Divided Wireless Telecomm Network**

Figure 5
Entire Wireless Telecommunications Network Diagram

METHODOLOGY

To achieve the goals and objectives of this design project, it is necessary to follow and execute

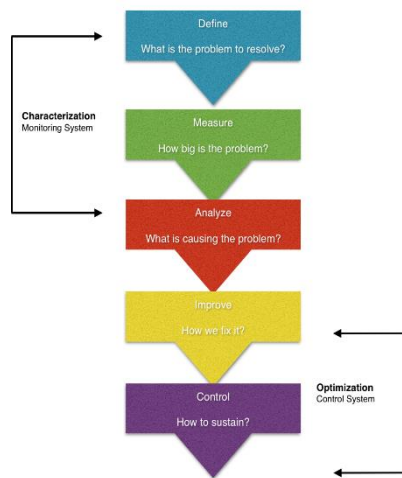a systematic methodology. This is [2]-[3] DMAIC methodology:

Figure 6
DMAIC Methodology

First phase of the DMAIC methodology [2] [3] is Define phase. This stage will be used to design the projects goals in a way that there is consistency with the customer demands. So, for this, making use of Voice of Customer (VoC) and collecting the data is critical and important.

There is a Japanese phrase that is [4] "Going to the Gemba" that means "go to the source of information" Gemba Walk. (2013, December 28), will be the way of collecting the voice of customer for this project, since it consists in observing the way customers work without the artificiality of interviews and conference rooms. It is in the source of information where the people can see and understands who our customers are, what their real problems are, how the product will be used by the customers, and how real the product will be working for the customers. The voice of customers collected through the employees (manager and analysts) of *Centro de Operaciones de la Red* and end user customers (service subscriptions) is expected to reduce uncertainly and gain insights that will help make better decisions since when we actually go out and talk and observe customers, we learn that the pre-conceived notions were wrong.

Measure phase will determine what is important to the key customers and establish how to measure it. This project, will explain the actual alarm manager software that is being used at *Centro de Operaciones de la Red*. This, tool will help translate customers and equipment requirements into events. Then, all this events are monitored. Following the events discrimination system, this incidents could be transformed on alarms. Its structured is normally used for complex situations that deal with multiple customer's needs.

Next will be Analyze phase, and is where the real thinking will happen. For this phase, the method to use is going to be [2] [3] Why's Methodology. It is because it helps shows the casual links between the causes and the ultimate root causes. It helps to determine the cause-effect relationships in a problem or a failure event.

Next, is the improve phase. On this phase, will show the data collecting plan to be applied on the *Centro de Operaciones de la Red*. With this, the managers, technical staff as well as wireless phone service customer will provide information that is going to be useful on the operations especially on maintenance. This data collecting plan will be required to collect information for alarms manager software daily. Also, a survey will be provide to offer the opportunity to listen what the managers, technical staff as well as customers thinks about the wireless phone service.

Finally, the last stage is Control phase. On this phase, [2] [3] we can see the implementation, testing and generation of data. In this way, the performance required to maintain the operations on good standing and give the customers the service that they deserve can be controlled, manage and verified. When it is maintained and constantly verified, the equipments, platforms and nodes are proven mistake proof and problems do not tends to grow or best of scenarios, do not come. Full control and operation in hands of final owners (employees and technicians on charge of manage the different telecommunication equipments) establishes that future improvements are now managed through either another DMAIC project, leaving the improvements life cycle back to phase one, phase of Define. It is because they are the completely owners of this equipments and therefore, they have to give a good maintenance on each equipment to give an excellence service.

RESULTS AND DISCUSSION

On this section, is going to be discussed the results obtained while this project was being developed.

Define Phase

On this phase is the first survey done on *Centro de Operaciones de la Red* as well as wireless phone service customers to know the problems that they understand that are affecting the network. It was done using Voice of Customer methodology.

Next is a Pareto diagram on figure 7. This results represent the mayor network offenders. The radio base stations represents [1] 48.6% of the network problems. Following, is provisioning. It is when a wireless phone device was not configure correctly. Next, are situations that cannot be manage and improve by any process or recommendation, this are decisions made by top managers, like company president and vice presidents. This three offenders, represents [1] 81.1%.
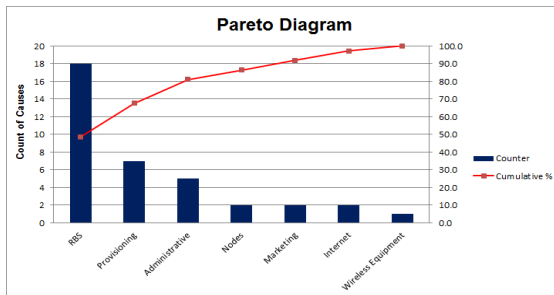

Figure 7
Pareto Diagram following VoC Results

Here can appreciate the Voice of Customer on details, following people answers:

Table 1
Pareto Analysis with VoC Results

Network Problems

Problems (Causes)	Counter	Cumulative Counter	Cumulative %
RBS	18	18	48.6
Provisioning	7	25	67.6
Administrative	5	30	81.1
Nodes	2	32	86.5
Marketing	2	34	91.9
Internet	2	36	97.3
Wireless Equipment	1	37	100.0

The figure 8 is a mayor failure for mobile services. It is about radio base stations (RBS). It presents total radio base stations out of service by any situation/failure for [1] year 2015.
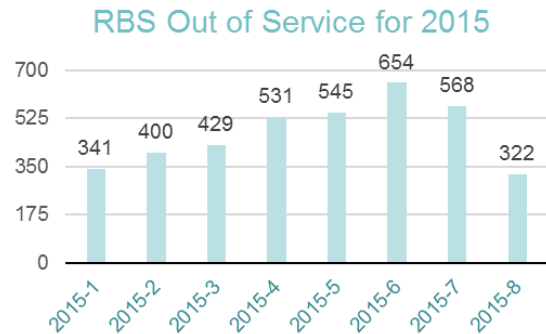

Figure 8
Total RBS Out of Service for 2015 Up to the Month of August

The next table represents some categories for problems that possibly causes this radio base stations to failure for the [1] year 2015. The mayor cause is electrical power situations. This is a situation that affects the radio base stations by maintenance of Puerto Rico Electrical Power Authority or weather conditions. This values were collected to identify the possible cause of radio base stations problems, therefore, categorize this causes as shown below on table 2:

Table 2
Possible Problems for RBS Out of Service for 2015 Up to the Month of August

Categoria	Hits
PROB. ENERGÍA ELÉCTRICA (AEE)	1549
PROB. EQUIPO (HARDWARE) RBS	555
PROB. TRANSMISIÓN FIBRA	517
PROB. TRANSMISIÓN IP/CISCO	337
PROB. EE – EQUIPO DE POTENCIA	306
PROB. CONFIGURACIÓN/SOFTWARE RBS	250
PROB. AIRE/ACONDICIONADO	84
PROB. ING./RELOC./EXP./INT.	46
PROB. ACCESO/CONTRACTUAL	37
PROB. VANDALISMO RBS	31
PROB. TRANSMISIÓN COBRE	21
PROB. TRANSMISIÓN MICROONDA	20
SIST.RADIANTE (ANT/FEED/CON/VSWR)	16
PROB. PLANTA FISICA	10
PROB. HURTO COBRE	6
CATEGORÍA AUN NO DEFINIDA	5
Grand Total	**3790**

The table 3 represents opened and closed cases [1] for radiant system that has been attend and resolved for the year 2015. This radiant system is another cause that avoids the radio base stations to work correctly. The reason for this cause is vandalism. On some cases, this occurs because a maintenance to the radiant system was not made appropriately.

Table 3

Open and Closed Cases for Radiant System Up to the Month of August 2015

Month	Open Cases	Closed Cases
January 2015	384	152
February 2015	257	221
March 2015	343	306
April 2015	330	349
May 2015	208	257
June 2015	180	246
July 2015	190	313
August 2015	53	95
Total	**1945**	**1939**

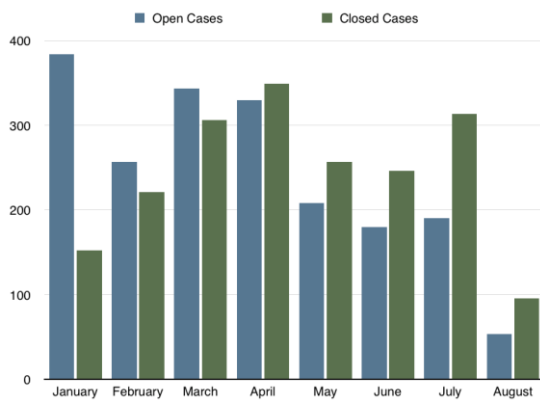The next figure presents graphically this information:

Figure 9

Open and Closed Cases for Radiant System for 2015 Up to the Month of August Represented Graphically

Pareto Analysis: Here you can see a Pareto Diagram made with data collected by possible problems that affect the radio base stations.
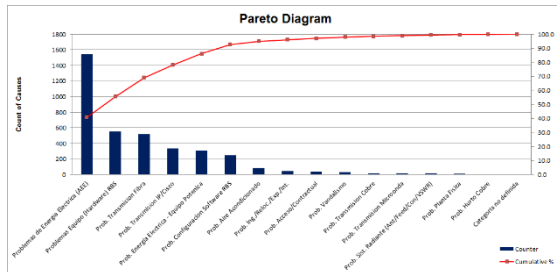

Figure 10

Pareto Diagram made with Data Collected of Possible Failure Problems Affecting the RBS

The next table represents the data collected on *Centro de Operaciones de la Red* of possible failure problems affecting the radio base stations. The mayor cause is electrical power situations. This is a situation that affects the radio base stations by maintenance of Puerto Rico Electrical Power Authority or weather conditions. This values were collected to identify the possible cause of radio base stations problems. It was by collecting information by a Voice of Customer survey.

Table 4

Pareto Analysis made with Data Collected of Possible Failure Problems Affecting the RBS

Network Problems

Problems (Causes)	Counter	Cumulative Counter	Cumulative %
Problemas de Energia Electrica (AEE)	1549	1549	40.9
Problemas Equipo (Hardware) RBS	555	2104	55.5
Prob. Transmision Fibra	517	2621	69.2
Prob. Transmision IP/Cisco	337	2958	78.0
Prob. Energia Electrica - Equipo Potenica	306	3264	86.1
Prob. Configuracion Software RBS	250	3514	92.7
Prob. Aire Acondicionado	84	3598	94.9
Prob. Ing./Reloc./Exp./Int.	46	3644	96.1
Prob. Acceso/Contractual	37	3681	97.1
Prob. Vandalismo	31	3712	97.9
Prob. Transmision Cobre	21	3733	98.5
Prob. Transmision Microonda	20	3753	99.0
Prob. Sist. Radiante (Ant/Feed/Con/VSWR)	16	3769	99.4
Prob. Planta Fisica	10	3779	99.7
Prob. Hurto Cobre	6	3785	99.9
Categoria no definida	5	3790	100.0

Measure Phase

On this phase this data collection to measure will be provided by alarm manager software application that is in charge to received events, interpreted and analyze this events, to then transform this events to alarms; critical, mayor or minimal. It is a software application called TSRM. It stands for Tivoli Service Request Manager. It involved managers and technical personnel of *Centro de Operaciones de la Red*. It is divided on Front Office and Back Office. This application manages many process that normally should involve many human intervention or hours. Example of this is network alarms, planned interventions, man hours and itineraries. This tool capture all the network elements and redirect all the events and alarms to the user in form of graphical user interface to monitor this equipments.

This tool is designed to be used by any kind of user. On *Centro de Operaciones de la Red* is used by Back Office Technicians, Front Office Technicians, supervisors, managers, consultants and contractors. Front Office technicians are in charge to monitor the alarm manager application. They look to this tool to find any anomaly on any RBS node and equipment.

Next are examples of graphical data of RBS events and average duration in hours between

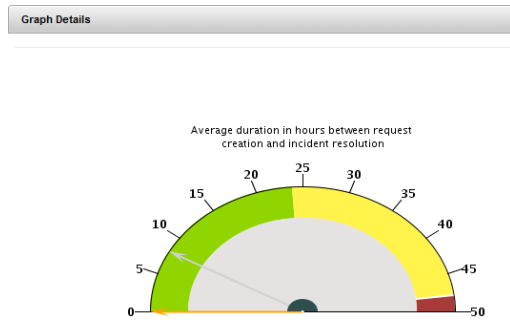request creation and incident resolution and total open incidents.

Figure 11
RBS Events and Average Duration in Hours between Request Creation and Incident Resolution
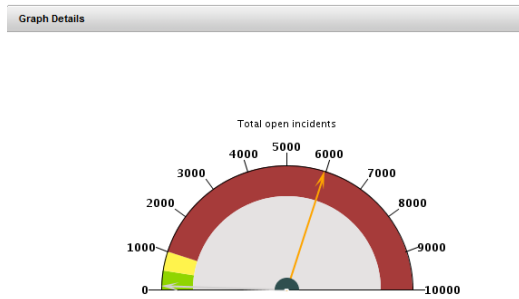

Figure 12
Incident Resolution and Total Open Incidents

This is an example of [1] TSRM software application. Here, can be appreciate the incident number at the left of the figure. Next is the date that the event/incident occurred. Next to it, is the priority that *Centro de Operaciones de la Red* gives to every event or alarm. Following it, is the classification of technology. On this, you can see events for 3G and LTE network. Finally, is the event summary for any node or equipment.

Figure 13
Incidents shown in TSRM Software Application

With this system, the radio base stations components are monitored. Every incident that occurred in this equipments, sends an events, and then following the alarms criteria in the TSRM software application system, this events are transformed on alarms. Every single alarm and event, are monitored by the front office technician. This technicians, work around to resolve any problem with this alarm. If this technician could not resolve the alarm, then have to transfer this alarm to a back office technician. There, this alarm finally is resolved and the case is closed.

Analyze Phase

For the analyze phase, a [2] [3] Why Fault Tree was made to evaluate the real root cause. For this, a [1] site survey was made and asked many questions of why is this problems occurring. So, next step was to look for people responsible and interview them to find possible causes on this faults. Below, you can appreciate this root cause analysis using Why Tree methodology.
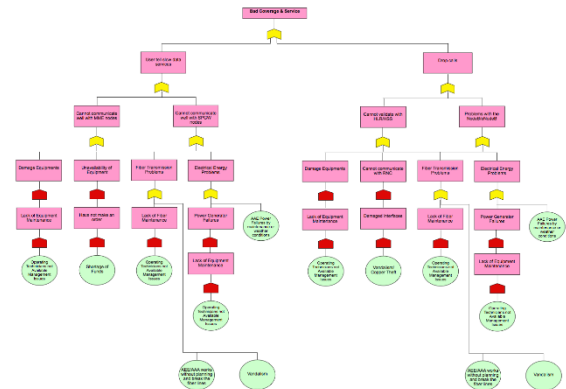
Figure 14
Why Tree to Find the Root Cause of the Faults.

Improve Phase

On this phase, data collecting plan is being offer to collect the necessary data to present statistics in *Centro de Operaciones de la Red*. With this data collecting plan, *Centro de Operaciones de la Red* should analyze the acquired data to be able to improve the operation. It is a useful plan because surveys can be highly accurate, reliable and valid; and easy to generates quantitative data. It is a rapid data collection, and offer some opportunity to explore issues depth.

Table 5
Data Collecting Plan to be Follow in *Centro de Operaciones de la Red*

Data Collecting Plan

Item Number	What I want to measure?	What I want to collect?	What questions do you want to answer	How measured?	Where the data is collected?	When the data is collected?	How data is displayed?	Actions	When the VoC is collected?	What can I do with the info collected from VoC?
1	RBS Equipment/ Nodes	RBS failures causes	What are the possible causes of failures?	Continuous	TSRM - Alarm manager	Daily	Pareto Diagram, Bar Chart and Tables.	VoC from managers	Weekly	Analyze and look for improvements to avoid repeated scenarios
2	RBS Equipment/ Nodes	RBS failures causes	What are the possible causes of failures?	Continuous	TSRM - Alarm manager	Daily	Pareto Diagram, Bar Chart and Tables.	VoC from technical staff	Weekly	Analyze and look for improvements to avoid repeated scenarios
3	RBS Equipment/ Nodes	RBS failures causes	What are the possible causes of failures?	Continuos	Customer	Daily	Pareto Diagram, Bar Chart and Tables.	VoC from wireless phone service customer	Weekly	Analyze and look for improvements to avoid repeated scenarios

Control Phase

Next is the control phase. To maintain the operations on quality conditions, it is necessary to have:

- Qualify and certified staff.
- Committed staff members with the company.
- Eliminate contractor and consultants.
- Necessary that the staff has a good work environment.
- Have supervision on the necessary areas with the necessary knowledge to execute and help with troubleshooting in case that the technical staff has its doubts.
- Standard Operational Procedures for every process related to the fix of any node or equipment of *Centro Operaciones de la Red* island wide.
- Provide constants technical trainings keeping staff enabled to do fixes and find solutions.
- Have managers evaluating results and data acquisition from VoC's and TSRM key performance indicators.

This points will help have a better network monitoring and help maintain the operation on quality conditions.

RECOMMENDATIONS

- Use the included basic KPI that the tool offers, as is shown on figure 11 and figure 12.
- Automate the alarms manager software TSRM to present key performance indicators (KPI's) out of the box without human interventions. It is by using the included KPI creator. It is a graphical user interface where a user can create and automate KPI for all equipments. Once the statistic is created, then the user can use the same KPI creator to automate this statistics.
- Provide training on how to use the alarm manager software TSRM to avoid delays on cases attention. It should be when a new technician enters to front office, and to all employees every 3 months. This training for newcomers should be "on the job training" and for experienced staff should be answering questions digitally on a computer.
- Implement HTML5 and eliminate JAVA language on this application. It stops the system and avoid technician monitor the network. It is by requesting TSRM manufacturer (IBM) to install its HTML5 base code in the computers that runs TSRM, located in *Centro de Operaciones de la Red*, replacing the actual Java code. It is included in the service and technical support contract. It is an administrative recommendation. It would represent about 25%-30% of improvement on generally software management as well as human work.
- Attend radio base station equipment problems by: replacing damaged components and/or equipments on the different locations island wide, adding hardware capacity to equipments that need it and optimize this equipments. It would represent about 20% of improvement on the network operation. It will be reflected on customer's subscriptions. This is attacking directly customer's situations and complains.
- In case of new events on the alarm manager software, the user should give priority to the equipments that are essential to the network and to offer a constant service to customers. An example is: radio base stations.
- When the alarm manager software TSRM report a damaged radio base station equipment, the technician should inform the involved

departments to attend, resolve and document the problem. This departments are: Wireless, Transmission, Customer Service and Field Technicians.

- A repository for maintaining customer agreements. A repository is a central location in which data is stored and managed. This repository can be used to store: documentation of the services that will be performed for the customer, entitlement checks against these agreements allowing you to ensure the customer is entitled to that service under the requested conditions, and, most importantly, the prices that will be charged for the services provided.

- A maintenance routine program to avoid constant damaged equipments, hence, lower operational costs. This maintenance routines should be for all the equipments that *Centro Operaciones de la Red* manage. This routines should be: equipment monitoring every week, hard disk backup every week to avoid configuration problems if the equipment fails, and equipment fans cleaning at least once monthly to avoid overheating.

- Installation of power generator on different locations island wide where is necessary to avoid electrical power failures in the central offices and maintain the wireless phone services online.

- Maintenance routines to the power generators, and monitoring of the gasoline/diesel gauges to maintain the services online.

- Installation of camera devices on different locations that resist all weather conditions to reduce vandalism.

CONCLUSION

Throughout the research of this project, you may see some problems that really affects the wireless phone service. To know this problems, "voice of customer" surveys were conducted to operations managers, supervisors and customers. This study shows what the critical problem was, and it was radio base stations malfunctions. Further investigation details that this malfunctions comes from lack of maintenance to the different radio base station equipments (hardware) and electrical power failures (originated by Puerto Rico Electrical Power Authority).

For hardware, the recommendation is to attend radio base station hardware problems by: replacing damaged components and/or equipments on the different locations island wide, adding hardware capacity to equipments that need it and optimize this equipments. Also, monitor the different elements to avoid further failures and visit site biweekly to provide maintenance to this equipments. It would represent about 20% of improvement on the network operation. It will be reflected on customer's subscriptions. This is attacking directly customer's situations and complains.

For the electrical power failures is important the installation of power generator on different locations island wide where is necessary to avoid electrical power failures in the central offices and maintain the wireless phone services online.

Also, implementing HTML5 language on alarm manager software (TSRM), would represent about 25%-30% of improvement on generally software management as well as human work.

In conclusion, with the implementation of this project design, Puerto Rico Telephone Company/ Claro Puerto Rico could have a decrease of about 60% of the actual losses (110,277 wireless customer subscriptions). This represents approximately 66,166 wireless customer subscriptions. In terms of financial subjects it will traduce to a gain of about $2,977,470; with a total of 848,643 wireless customer subscriptions.

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