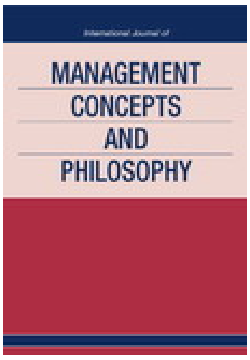


International Journal of Management Concepts and Philosophy

ISSN online: 1741-8135 - ISSN print: 1478-1484
https://www.inderscience.com/ijmcp

A case study of safety, theft and vandalism on Digicel cellular sites at Trinidad and Tobago

Kuldeep Ojha, Saiid Khan

DOI: 10.1504/IJMCP.2023.10054576

Article History:

Received:	04 January 2023
Last revised:	18 January 2023
Accepted:	25 January 2023
Published online:	30 November 2023

A case study of safety, theft and vandalism on Digicel cellular sites at Trinidad and Tobago

Kuldeep Ojha* and Saiid Khan

Department of Mechanical and Manufacturing Engineering,
The University of the West Indies,
St. Augustine, Trinidad and Tobago
Email: kojha.gvc@gmail.com
Email: saiidkhan88@gmail.com
*Corresponding author

Abstract: Vandalism and theft are ever so present in our society. It is a problem that cannot be solved easily and cannot be addressed with a single solution. With varying factors contributing to it, there is a need for some sort of study to be done to address these issues. This study proposes to find the factors leading to vandalism and theft at Digicel Trinidad and Tobago cellular sites. The study investigates the effect of vandalism and theft on business and workers as well as recommends solutions based on current good prevailing practices. With vandalism and theft prevalent in recent years, and losses being incurred heavily, there is a great need to address these issues.

Keywords: safety; vandalism; theft; Digicel; cellular.

Reference to this paper should be made as follows: Ojha, K. and Khan, S. (2024) 'A case study of safety, theft and vandalism on Digicel cellular sites at Trinidad and Tobago', *Int. J. Management Concepts and Philosophy*, Vol. 17, No. 1, pp.34–57.

Biographical notes: Kuldeep Ojha has joined The University of The West Indies in year 2016 as Lecturer. He has about 16 years of industry, teaching and research experience. He is currently involved in research work in the field of electrical discharge machining, renewable energy management and lean manufacturing. He published 28 research papers in international journal and conferences. His areas of specialisation are production engineering, industrial engineering and management. His areas of research interest are EDM, renewable energy management and lean manufacturing.

Saiid Khan currently holds a BSc degree in Electrical and Computer Engineering and a MSc degree in Production Management from The University of The West Indies, Trinidad and Tobago. He works as a Field Engineer at Digicel Trinidad and Tobago Ltd.

1 Introduction

Digicel is a regional communication's company. In Trinidad and Tobago, it's headquarter is located in Port of Spain. Digicel, in its role as a telecommunications' company, provides its customers with the ability to make calls, data services and SMS, via a cellphone and SIM card. In order to get reception on their cell phones, one needs to be connected to a cell site in order to establish a connection to the Digicel network. At these sites, cellular equipments are present which provide the necessary hardware for providing the service. A total of 366 cell sites are distributed between Trinidad and Tobago.

Digicel Trinidad Limited has laid down some safety polices in place for employees working at the cell sites. Despite it, the company suffered a loss in revenue in the past two years as a result of equipment down time due to vandalism. The same issue occurred at approximately 100/366 cellular sites throughout the country. This is also supplemented by the issues of the safety of workers and thus their lower productivity due to this issue. Losses in revenue stem from stolen batteries, stolen copper, damaged RBS cabinet, damaged fencing, lost hours of operation due to lack of battery backup and vandalism. The losses in productivity resulted in workers not 'feeling' safe in certain areas and would require an additional worker to accompany them. It would also lead to a quickly completed job or routine on the cell site, which would not have been detailed as required, as a sense of uneasiness would be in the back of one's mind. This would have led to multiple visits to these cell sites in certain instances.

The aim of this research paper is to propose the measures to reduce and even eliminate the vandalism and theft on Digicel cell sites thereby improving the safety conditions and thus the productivity which will result in reducing the loss of revenue by the company. Recommendations are to be derived using the root cause analysis processes with the strategies for implementation, compliance and continuous improvement.

2 Literature review

Theft and vandalism have been a major cause of concern for industries and the service sector. Many researchers have investigated the issue and proposed specific solutions. Mazikana (2019) explored strategies to curb vandalism in ZESA: a case study of ZETDC. This study was undertaken to investigate poor performance of the organisation due to vandalism. Hidayat (2020) proposed a design using IoT to reduce vandalism in tower communication. Liu et al. (2020) have put forward an application system for monitoring, inspection, security, and interactive service of layered power transmission and distribution system. This system was capable to warn against theft and vandalism. Ahuna et al. (2020) proposed an anti-theft system applying machine learning technique to monitor the pylon's environs against vandals. Results of the study reveals that the system can detect human images with confidence levels between 68% and 97%. Archibong et al. (2020) presented an Internet of Things (IoT)-based solar powered street lighting system with anti-vandalisation mechanism. Fahim et al. (2021) developed a GSM-based transformer theft protection and monitoring system to protect the distribution transformers from thieves. This system can also monitor the health parameters of a transformer. Modipa (2022) investigated the impact of cable theft on the free flow of traffic in South Africa. He suggested the steps to counteract the problem. He proposed a model for better coordination between law enforcement agencies and business community. Tarahi et al. (2022) designed and implemented a smart online protection system (SOPS), based on the concept of internet-of-things (IoT), to reduce the security risks from invasion against lattice towers of transmission lines.

The same issue of safety, theft and vandalism can be found in local context of Trinidad and Tobago. The Telecommunications Services of Trinidad and Tobago, Digicel's leading competitor, has also been a victim of vandalism and cable theft as they have reported 181 incidents during the year 2017, in which incidents occur almost daily. TSTT has spent over TT$25 M to complete copper and fibre optic repairs at various sites. TSTT also increased surveillance to lessen the damage and this led to the arrest of over 50 persons since 2006 on theft and damages to cell sites. Thieves usually target cell sites in the remote and sparsely populated areas either late at night or in the early morning for diminished chance of being caught.

The literature review presented above provides a solid rational for the research work undertaken. Scrutiny of published literature not only highlights the importance of work but also indicate the gap in literature because of absence of published literature in the context of Trinidad and Tobago.

3 Research methodology

3.1 Method of data collection

Primary data is collected by following means.

3.1.1 Questionnaire

To create questionnaire, a number of factors were taken into consideration, such as, the stakeholders in the questionnaire, the objective of the study, collecting unbiased and accurate data, defining the information required, length of the questionnaire and ethical consideration to the respondents. Due to time constraints and the needs of the business, where field engineers, for most of the time, are not in the office space, a questionnaire method was selected.

3.1.2 Site routine reports

The Site routine reports are the reports that the field engineers fill out when visiting a cell site to perform bi-monthly routine checks. Some of these checks include RBS cabinet type present, generator present, batteries present, ground present, etc.

3.1.3 Trouble tickets

Trouble tickets are tickets that are logged when an outage occurs, or an alarm is flagged. Outage tickets are created by the NOC who then escalates to the relative teams to action. In the case of cell site outages, they would contact the field engineer responsible for the said site. Faults on the other hand can be created by the NOC or the field engineers for the respective cell sites. Common faults may include battery faulty, fan fault, hardware fault, software fault, etc.

3.1.4 Cellular traffic records

These records would be historical records of cellular traffic for all site cell sites by daily measure. This record would be directly proportional to the revenue generated by the cell sites, i.e., high traffic corresponds to high revenue.

3.2 Validation of data

The field engineering team leader approved for this data to be used. The manager ensured the validity and proper use of the questions being asked in the questionnaire as well as information being gathered from the trouble tickets, the cell traffic reports and the site routine reports.

3.3 Procedure

3.3.1 Distribution of questionnaire

The questionnaire created had 18 questions with multiple choice answers. It could be completed in 5 to 15 minutes. After the team's weekly meeting on Monday, the questionnaire was given to the field engineers to complete.

3.3.2 Gathering of reports

Trouble tickets and site routine reports were 'pulled' for the past two years. Historical data was needed to determine the affected sites as well as the frequency of occurrence of revenue loss due to vandalism/theft. The latest cell traffic report was used as it gave a current and up to date representation of high, medium and low traffic sites.

4 Presentation and analysis of data

The presentation and analysis of data stage entails the proper sorting, displaying and analysis of data.

4.1 Data from questionnaire

The questionnaires were used to gather information about the cell sites being visited as well as safety issues faced by the field engineers.

From the results, it can be observed that:

- rural sites are thought to be more unsafe than urban sites
- vandalism usually occurs in rural areas than urban ones
- vandalism/theft occurs primarily on greenfield cell sites
- some sites were vandalised repeatedly
- a security solution would be beneficial to both company and workers.

Figure 1 Graph showing the number of sites versus alarming issues, copper missing, batteries missing, and sites vandalised (see online version for colours)

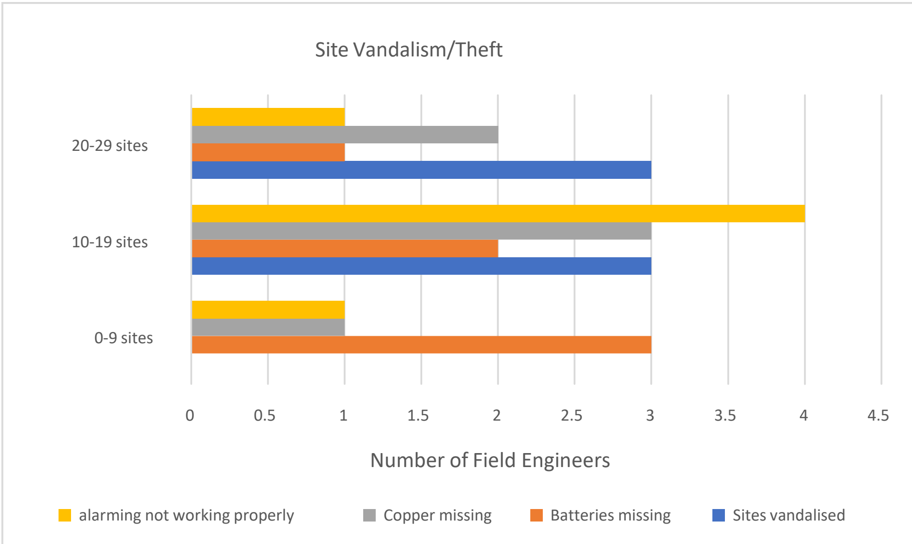
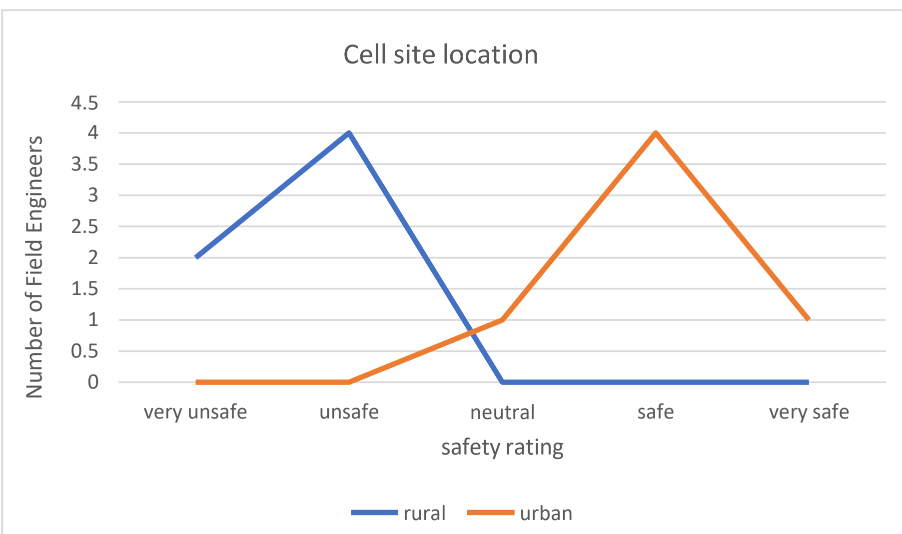


Figure 2 Graph showing the number of field engineer's choice for safety rating of rural and urban sites (see online version for colours)



4.2 *Site routine reports*

The site routines reports give an indication of the most recent state of the cell sites as well as historical data. This report is separated into three categories:

- infrastructure checks
- RBS checks
- power checks.

Data was collected for 1.5 years from the site routines report. The data that was needed was filtered and is shown in Table 2.

Table 1 Total number of sites missing grounding, fencing/gate vandalised and generator present

	Total sites grounding missing	*Total sites fencing/gate vandalised*	*Total sites cabinet damaged/batteries missing*	*Generator present*
January–February 2017	156	86	111	65
March–April 2017	156	86	111	65
May–June 2017	158	86	113	65
July–August 2017	165	98	128	65
September–October 2017	165	84	108	65
November–December 2017	165	84	110	65
January–February 2018	167	76	114	65
March–April 2018	167	68	116	65
May–June 2018	169	70	124	65

Table 1 shows an overall increase in grounding missing during the 1.5-year period. The number of generators remained unchanged during these periods.

Table 2 Grounding replaced, fencing repaired, batteries replaced, and generators added

	Grounding replaced	*Fencing/gate repaired*	*Batteries replaced*	*Generator added*
January–February 2017	0	0	0	0
March–April 2017	0	0	0	0
May–June 2017	0	3	0	0
July–August 2017	0	4	0	0
September–October 2017	0	12	22	0
November–December 2017	0	0	4	0
January–February 2018	0	8	0	0
March–April 2018	0	0	0	0
May–June 2018	0	0	0	0

Table 2 shows no grounding was replaced nor was any generators added to the cell sites for these periods.

Table 3 shows 34 generators located on greenfield sites, 31 generators located on shelter sites and none present on rooftop sites. These numbers remained constant for the 1.5-years' time span of data collection period.

Table 3 Generators present at different cell site types

Period	*Generators present*		
	Greenfield	*Shelter*	*Rooftop*
January–February 2017	34	31	0
March–April 2017	34	31	0
May–June 2017	34	31	0
July–August 2017	34	31	0
September–October 2017	34	31	0
November–December 2017	34	31	0
January–February 2018	34	31	0
March–April 2018	34	31	0
May–June 2018	34	31	0

Table 4 Grounding missing is different cell site types

Period	*Greenfield*	*Shelter*	*Rooftop*
January–February 2017	145	11	0
March–April 2017	145	11	0
May–June 2017	147	11	0
July–August 2017	154	11	0
September–October 2017	154	11	0
November–December 2017	154	11	0
January–February 2018	156	11	0
March–April 2018	156	11	0
May–June 2018	158	11	0

Table 4 shows pattern of missing grounding for the period January–February 2017.

Table 5 showing damaged cabinets/stolen batteries in different cell site types

Period	*Cabinet damaged/batteries missing*		
	Greenfield	*Shelter*	*Rooftop*
January–February 2017	111	0	0
March–April 2017	111	0	0
May–June 2017	113	0	0
July–August 2017	128	0	0
September–October 2017	108	0	0
November–December 2017	110	0	0
January–February 2018	114	0	0
March–April 2018	116	0	0
May–June 2018	124	0	0

Table 5 shows that batteries were only stolen from greenfield sites.

Figure 3 Graph showing the number of sites versus the total number of sites with grounding missing, batteries missing and fencing vandalised (see online version for colours)

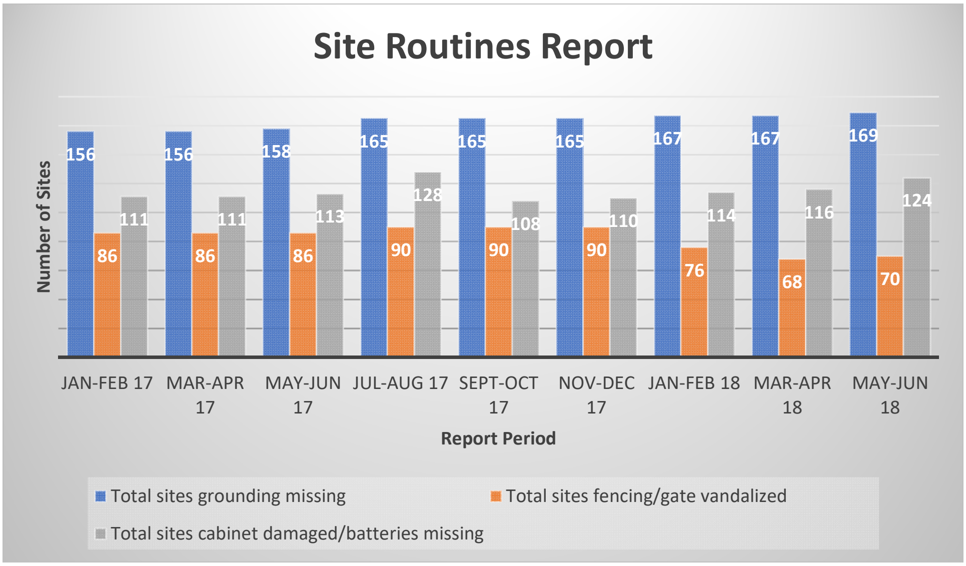
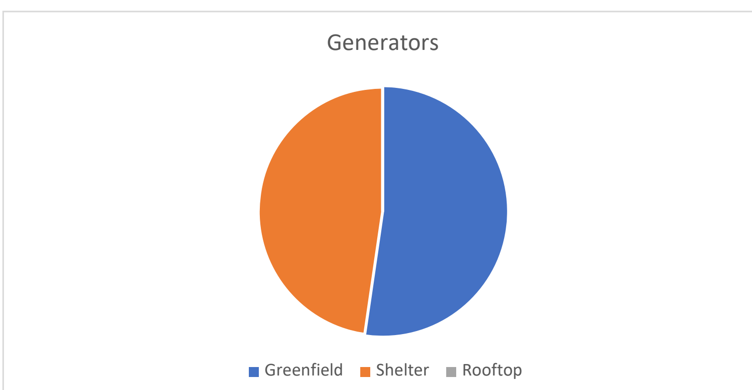


Figure 3 shows that in more than 50% of the periods investigated, batteries missing coincided with missing copper on sites. In most of these instances, they also were associated with vandalism of the fencing and/or gate. The graph also showed a decrease in the number of sites with damaged fencing and missing batteries, as this would have been due to repairs being done on site as well as batteries being replaced.

Figure 4 Distribution of generators for the different cell site types (see online version for colours)



The distribution in Figure 4 shows that all the generators are installed on shelter sites and greenfield sites.

Figure 5 shows that most of the missing grounding from cell sites are at greenfield cell sites. No rooftop sites were affected.

Figure 5 Number of sites versus the type of cell sites with ground missing (see online version for colours)

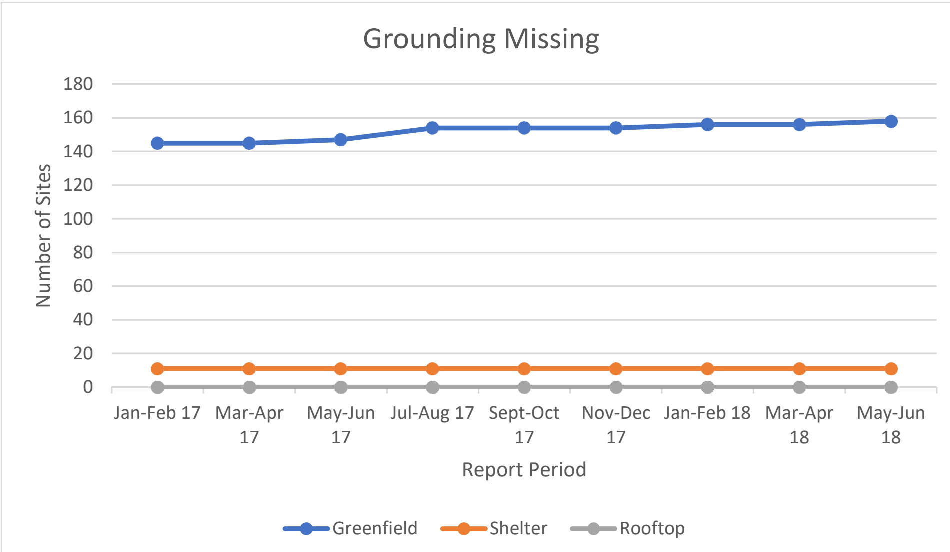


Figure 6 Number of sites versus the type of cell sites with batteries missing (see online version for colours)

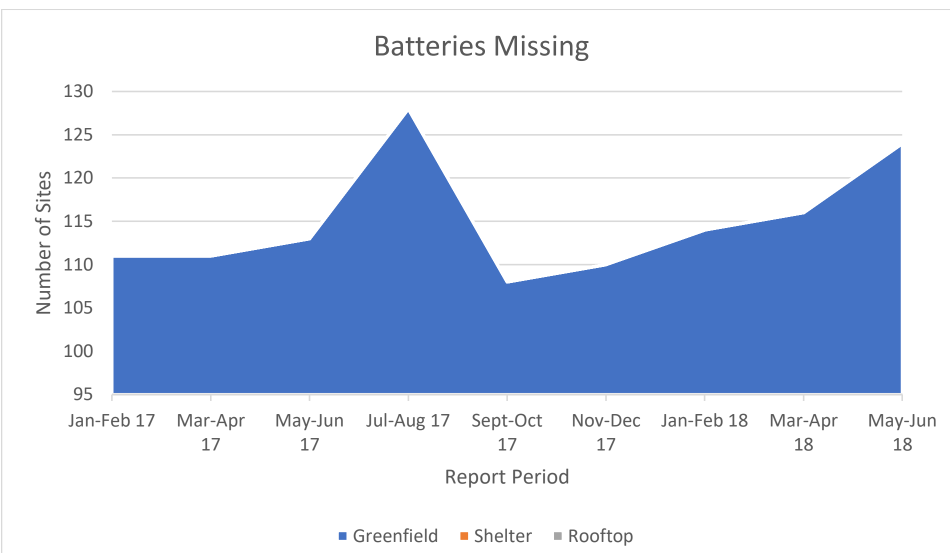


Figure 6 shows the trend pattern for missing batteries. All missing batteries were found only on greenfield sites.

Figure 7 Number of cell sites with fencing damaged versus those that fencing was repaired (see online version for colours)

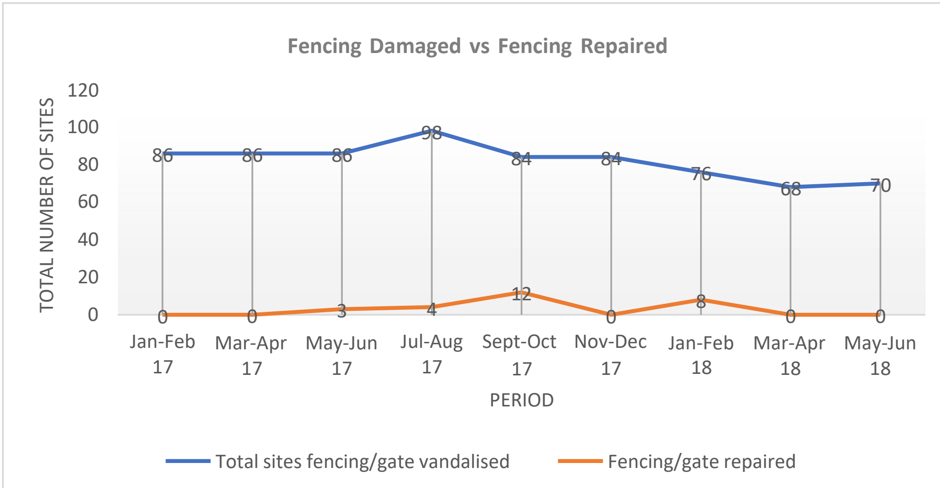


Figure 7 shows a general sense of decline with respect to fencing damaged on sites.

Figure 8 Number of cell sites with batteries missing versus those that batteries were replaced (see online version for colours)

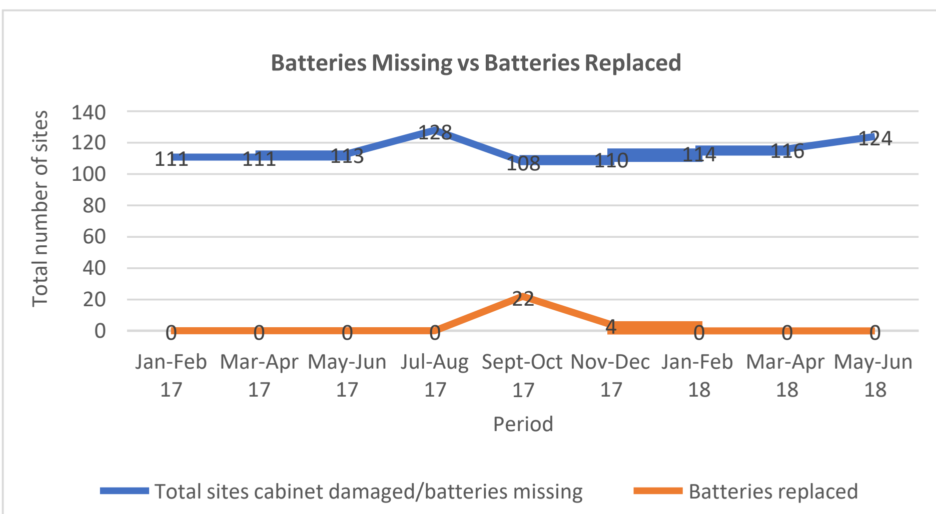


Figure 8 shows pattern of batteries missing in data collection period.

Table 6 Safety ranking system for sites

Site type	*Rank*	*Condition*
Sites located in remote areas or ‘hot spot’. RBS cabinets used. Vandalism/theft occurs occasionally/frequently.	3	High risk, remote areas, little to no vehicle traffic and resident owners, area not easily accessible
RBS cabinets used in urban, ‘safe’ populated areas. Vandalism/theft occurs occasionally/rarely.	2	Medium to low risk, medium to high vehicle traffic, neighbouring residents present, area easily accessible
Rooftop RBS cabinets used on sites and shelter sites. Vandalism/theft never occurred or was a rare occasion.	1	Virtually no access to unauthorised personnel on rooftop, shelters very robust

To determine the safety level on the cell sites, each type of cell site were ranked as shown in Table 6. All rooftop, special access and shelter sites would be listed as the least risk to vandalism, due to its limited access and security. Factors taken into consideration were location, vandalism/theft history and cell site type.

4.3 Trouble tickets

The trouble tickets are tickets that would have been created for an outage and faults on the cells sites. From the trouble tickets logged, the number of cell site outage that occurred in that time due to no power backup can be determined. As with the site routines report, this data will be represented in a bi-monthly format. This can be seen in Table 7.

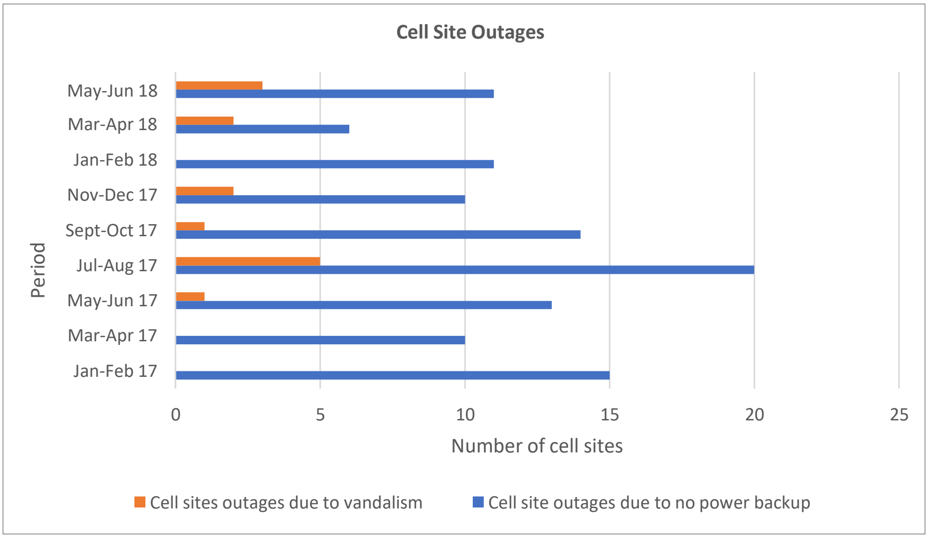
Table 7 Showing the number of outages due to lack of power backup and vandalism

Period	*Cell site outages due to no power backup*	*Cell sites outages due to vandalism*
January–February 2017	15	0
March–April 2017	10	0
May–June 2017	13	1
July–August 2017	20	5
September–October 2017	14	1
November–December 2017	10	2
January–February 2018	11	0
March–April 2018	6	2
May–June 2018	11	3

Table 7 shows a random pattern as it relates to outages for both lack of backup power and vandalism.

Figure 9 shows the vast difference between outage due vandalism and lack of power at the cell sites.

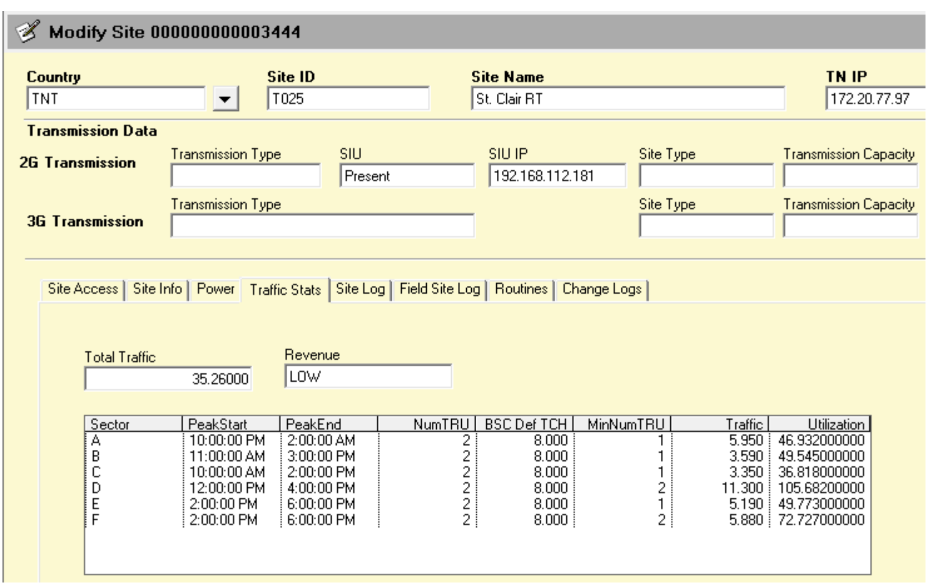
Figure 9 Graph showing the number of cell sites with power outages versus vandalism related outages (see online version for colours)



4.4 Cellular traffic records

Cellular traffic is dependent on the cell site transmission type. The more subscribers latched on to the network, via the cell site radio frequency signal, the higher the traffic utilisation on the cell site. This would in turn lead to more voice calls, SMS and data usage, resulting higher revenue.

Figure 10 Remedy traffic/revenue stats (see online version for colours)



Modify Site 000000000003444

Country: TNT | Site ID: T025 | Site Name: St. Clair RT | TN IP: 172.20.77.97

Transmission Data

2G Transmission — Transmission Type: | SIU: Present | SIU IP: 192.168.112.181 | Site Type: | Transmission Capacity:

3G Transmission — Transmission Type: | Site Type: | Transmission Capacity:

Site Access | Site Info | Power | Traffic Stats | Site Log | Field Site Log | Routines | Change Logs

Total Traffic: 35.26000 | Revenue: LOW

Sector	PeakStart	PeakEnd	NumTRU	BSC Def TCH	MinNumTRU	Traffic	Utilization
A	10:00:00 PM	2:00:00 AM	2	8.000	1	5.950	46.932000000
B	11:00:00 AM	3:00:00 PM	2	8.000	1	3.590	49.545000000
C	10:00:00 AM	2:00:00 PM	2	8.000	1	3.350	36.818000000
D	12:00:00 PM	4:00:00 PM	2	8.000	2	11.300	105.68200000
E	2:00:00 PM	6:00:00 PM	2	8.000	1	5.190	49.773000000
F	2:00:00 PM	6:00:00 PM	2	8.000	2	5.880	72.727000000

A hub site is a cell site that serves as the centralised transmission point for all other sites in the hierarchy. If these hub sites were to lose transmission by interference, hardware failure, software failure or power failure, all the site in the hierarchy would in lose transmission and would become non-operational. An end site is the last site of the transmission chain. It does not influence other sites but would reduce cellular coverage for an area. The Remedy tool will be used to determine if a site is high or low revenue generating. This can be seen in Figure 10.

Remedy was also used to verify if a site is an end site or hub site, as shown in Figure 11.

Figure 11 Remedy transmission type/PDH type info (see online version for colours)

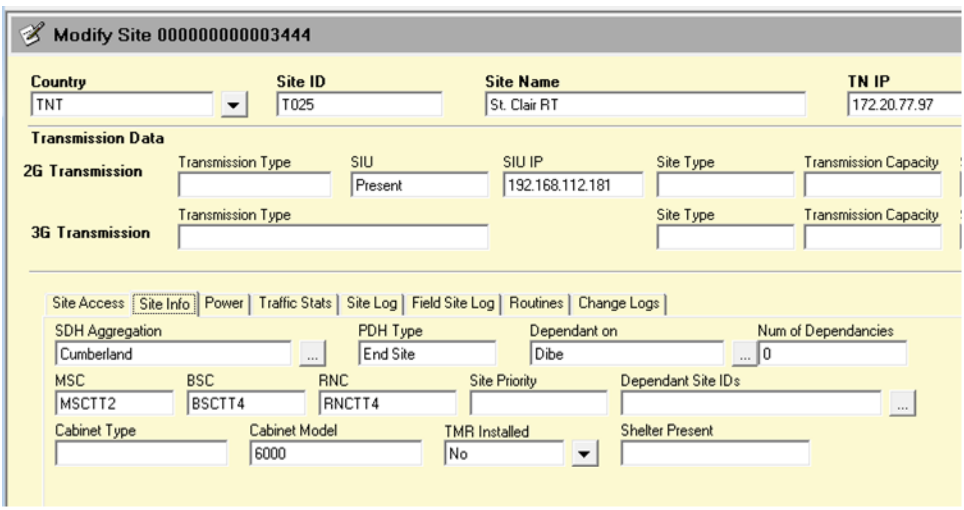


Figure 12 Graph showing the distribution of sites with high traffic versus those with low traffic (see online version for colours)

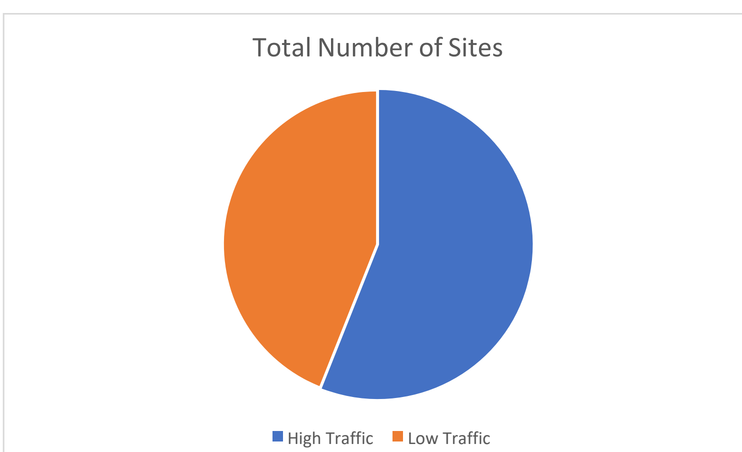


Figure 13 Graph showing the number of end sites versus hub sites (see online version for colours)

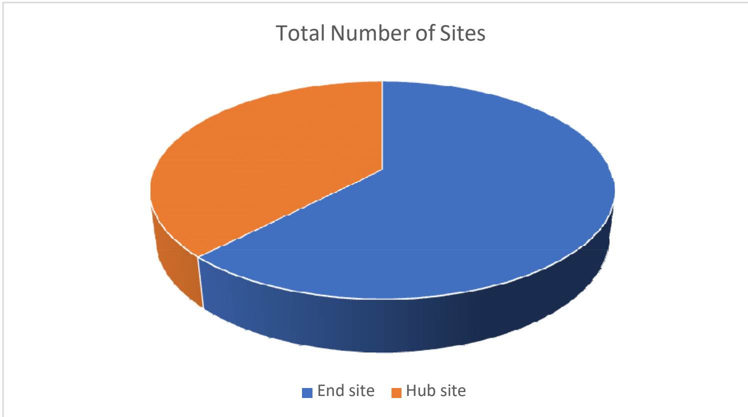


Figure 12 and Figure 13 shows the distributions of end sites versus hub sites and low traffic sites versus high traffic sites respectively.

Figure 14 Graph showing high traffic and hub sites with generators versus the total number of high traffic end site and hub sites (see online version for colours)

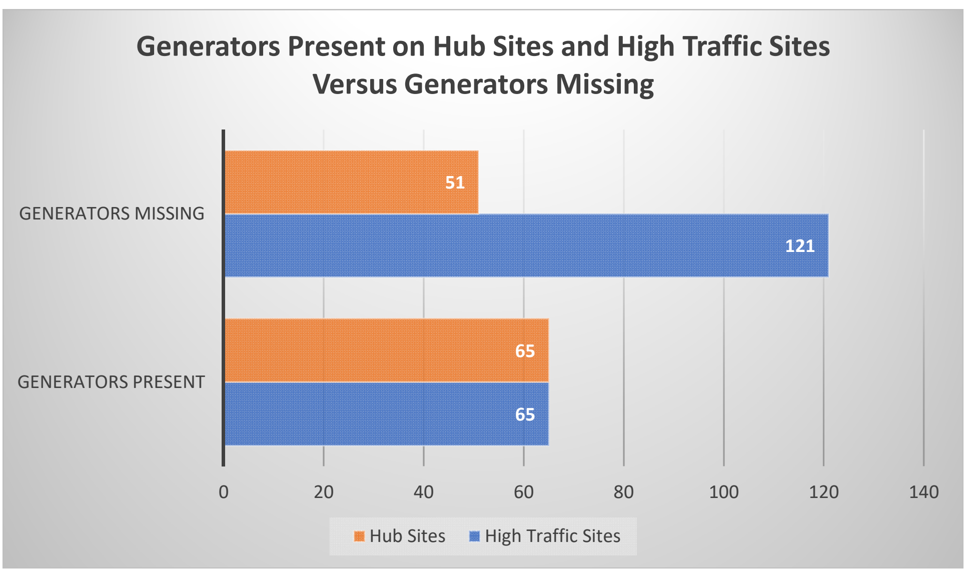


Figure 14 shows that 44% if all sites in Trinidad are low revenue generating, while 56% is high revenue generating.

Figure 13 shows 62% of sites in Trinidad are end sites while the remaining 38% are hub sites. From Table 4, it shows that 31 sites in Trinidad are shelter sites. Therefore, of the 126 hub sites, 31 sites are shelter sites, as all shelter sites are hub sites. The remaining 95 sites would be hub sites. Of these 95 sites, 10 are rooftop sites, therefore 85 of these sites are greenfield hub sites. From the 85 greenfield hub sites, only 34 have generators installed. Therefore, there are 51 greenfield hub sites that have no generators installed.

From the 186 cell sites that are high traffic, only 126 of these sites are hub sites. Therefore, 60 of these high traffic sites are end sites. Therefore, since all generators are installed on shelter and hub sites, 65 sites in total, then there are 121 high traffic sites without generators.

5 Discussion of findings

Previously, the results of the survey for the Digicel Cell Site safety questionnaire were analysed. Lastly, the outages due to lack of battery power and vandalism will be addressed.

5.1 Cell site safety for engineers

From the previous discussion, it was determined that the cell site type and location affect the safety of the Field Engineers. In order to assess the safety on cell sites, the cell sites need to be distinguished according to their differences, which would affect the safety of the engineer(s) working there. Also, the present state of the sites and factors contributing to the safety of these individuals should be taken into consideration. These are:

- type of cell site
- location
- time of access
- security
- lighting.

An existing working state and recommended state would be discussed.

5.1.1 Existing solutions

5.1.1.1 Site type

At Digicel, there are three different classifications of cell sites. They are:

- greenfield
- shelter
- rooftop/special access/security on site.

Greenfield sites are the most common sites where all equipment is fenced in a lot of land, locked by a padlock. There is an RBS cabinet, which is a dual cabinet, that houses the radio equipment and transmission equipment on the top part and batteries are stored in the bottom part. There is also the cell tower which houses the antennas and transmission dishes for the equipment in the cabinet. Grounding is also important on the cell site, which is present on the RBS cabinet, the fence and cell tower.

A shelter site is like the Greenfield site, except for the cell equipment and batteries being housed in a steel shipping container. This container has a metal door bolt lock, with a metal bar and padlock as additional protection.

Rooftop and special access sites are typically the same as Greenfield sites, except for restricted access. Normally, proof of identification and/or prior site visit arrangements must be made before entering this type of site.

5.1.1.2 Location

The location of the cell site is a major factor of vandalism in recent times. Sites are located all over the country, strategically placed in order to provide coverage to customers and transmission to other cell sites. The sites located in the remote areas tend to be targeted more than those in urban areas, due to lesser presence of persons and vehicle traffic.

5.1.1.3 Time of access

Accessing sites at different times have its obvious safety risks. At night, engineers are more at risk to being robbed by bandits or even being damaged in some form on the cell site, e.g., loose barbed wire or missing concrete covers for grounding. There are a few sites that are not to be accessed at night, even with security, due to numerous factors, such as bad roads, crime hot spot, drug block/route or an area with little to no vehicle traffic and people.

5.1.1.4 Security

Security is essential when it comes to working in remote and dangerous high crime areas, especially at night. At Digicel, a field engineer is required to engage with the security firm to have a security escort the engineer to the cell site or meet at the cell site. They would stay for the duration of the work.

This same availability should be extended to those requiring a security escort to areas where they may feel unsafe, at any time of the day.

5.1.1.5 Lighting

When working at night, visibility is poorer than during the day. Proper lighting ensures that the work is done properly as well as safely. There are obstacles such as the concrete plinths, copper grounding, loosened barbed wire as well as holes or loose material on the ground that can injure workers at the cell sites. Currently, approximately 50% of security lighting works at the cells site, most at the shelter sites.

Probability of injury is lessened with good lighting as opposed to no lighting.

5.1.2 Recommendation

From the information gathered as well as the factors influencing safety on the cell site, a cell site safety ranking system was developed in order to maximise the safety of the engineers. This would serve as a guide to the field engineers when called upon to work at specific cell sites, at any time.

At Digicel, health and safety are a top priority along with service to the customers. Reporting is done via site routines reporting done bi-monthly. Training is done for new engineers by the engineering by the present workers. Continuous improvement is always welcomed as it pertains to the safety of the engineers as well as customer service

Based on the information gathered, the following guidelines for accessing sites of varying risk levels are given below.

Rank 1 – low risk sites

Due to the restricted access of the rooftop and special access sites, as well as the presence of security at most of the shelter sites, these sites are generally safe to work at any time. Follow protocols in place for special access sites. Security escorts should accompany the engineer for nighttime work, only if security is not present at the site.

Rank 2 – medium risk sites

These sites should be also accessed at any time, but with additional caution, paying special attention to the surroundings and persons in it. These sites have some history of vandalism or theft and precautions should always be followed, such as completing the work as fast as possible. Also, a security escort must be used to access these sites once work is being done in the nighttime.

Rank 3 – high risk sites

These sites should only be visited at daytime with the use of the buddy system, either two engineers should go to the site or they should be accompanied by a security escort. If there is an emergency outage that requires the field engineer to visit at night, they should be accompanied by at least two security vehicles, properly armed, with one to stay with them on site and another to monitor the surroundings.

5.2 Vandalism and theft prevention

To protect the cell sites from vandalism and theft, several concerns needs to be addressed. Currently, these are the measures present to fight against vandalism and theft present at the cell sites:

- alarming
- security
- lighting.

5.2.1 Existing solutions

5.2.1.1 Alarming

At all sites, there is some form of alarming that is tested during site routines. For the purposes of this investigation, the door open alarm is the alarm that would or should be tested for functionality each time someone visits the site or routines are being done. The batteries missing alarms would have had to been tested when the site was being brought into service or when the batteries were being changed or replaced.

While having the NOC monitoring 24/7, their duties are not only limited to monitoring alarms, but other checks and reporting. Having worked at the NOC previously, little to no emphasis was ever placed on monitoring the minor or lesser priority alarms on the night shift, 6 pm to 6 am. It is common knowledge that during this time most crime or theft takes place.

On checking the alarm tool used for viewing alarms, there seemed to be over 100 sites with the open cabinet door/battery door alarm generated. Some of these are false alarms, but it shows that some action is needed to address this alarming.

5.2.1.2 Security

There is security situated on some shelter cell sites. These sites are the top of the hierarchy with respect to hub sites. If any of these shelter sites were to become non-functional, a majority section of the country would lose service. In order to protect against potential vandalism and continuous monitoring of the surroundings, security personnel remain on site 24/7. As for other the other sites, there is no monitoring other than the routines checks made by the field engineers on a bi-monthly basis.

5.2.1.3 Lighting

Vandalism and theft are most prominent at nighttime. Visibility is poorer during this time than the daytime and lessen the chances of being targeted by thieves due to chance of being seen. It is vital to have good lighting on cell sites to prevent or lessen the likelihood of being targeted.

5.2.2 Recommendations

With only some form of alarming present on all cell sites and only some security present on a few cell sites, there are several improvements that can be added that would deter vandalism and theft.

5.2.2.1 Alarming

The current state of alarming on cell sites can be deemed as problematic. With over 100 sites having insufficient alarming, 80% of these sites was vandalised in some form.

The main alarm that should be dealt with is the door open alarm. When the Field Engineers are performing routines, they should ensure that the NOC verifies that this alarm is working properly. This would be for the battery door, equipment cabinet door and the door to the shelter sites. These 'door open' alarms should also be placed at the highest priority in the alarming tool. In this way, when an alarm is fired, and no one is authorised is on site, a security patrol can be called out to investigate.

Another form of alarming that may be practical is having an RFID tag on the batteries. If it moved a specified distance, set the user, it will trigger an alert. The tacking application can be used with a test phone in the NOC or with the field engineers to alert them when the batteries are being moved. It would also be cost effect as tag can be as cheap as 25 USD.

5.2.2.2 Security

There is only security presence at the top priority shelter sites currently. The best option, and most cost-effective option would be to have security patrols, visiting multiple sites daily, at varying times in stipulated areas. Not only would this deter potential vandalism and theft, in the event that it does occur and an alarm is triggered, the NOC would be able to inform the patrol in the area, and they would respond in a short space of time compared to a call out scenario.

5.2.2.3 Monitoring

There is no active monitoring system set up at the cell sites. This type of system can be very effective in deterring and catching criminals in their unlawful act. Video surveillance would be helpful in preventing vandalism and theft. This would be very difficult and expensive to set up for 336 sites all over the country. These systems can be set up strategically on the high-risk sites initially.

The use of batteries as backup power is standard when it comes to a lower costing backup power solution when compared with generators. To determine if sites should have a generator installed, there should be thorough analysis of how often power outage occurs in that area. If this is then crossed referenced with the revenue generated by the cell site after the batteries are drained (provided that the batteries are present and not stolen), then this would be enough information to determine if it is optimal for the business.

Copper cannot be traced and so is an easy target to make a quick buck. There have been other cellular carriers that has switched from using copper to hollow aluminium cables to provide grounding. Aluminium has the same conductivity as copper, while being lighter. The price of aluminium compared to copper is significantly lower and thus can be used as a replacement.

5.2.2.4 Branding

Branding refers to imprinting or stamping the company’s logo, symbol or name. By branding those items that are stolen frequently, i.e., copper and batteries, can reduce the likelihood of those criminals repeating the act.

Copper is unlikely to be branding, as only its insulating housing can be branded. These are either burned off or stripped before selling at the scrap yards. Batteries on the other hands can have the Digicel name or some identifier branded via melting the plastic and imprinting the name or marker on some part of the body.

5.2.2.5 Neighbour watch

By creating or improving relationships with the neighbours next to the cell sites, for those that would have, it could help with monitoring and alerting the engineers assigned to the cell site of any abnormal behaviour.

5.2.2.6 Lighting

Ensuring proper lighting on vandalism prone cells sites should reduce occurrences of vandalism. Proper lighting gives a greater sense of security and visibility. With approximately half of the cell sites without a working security light, this needs to be addressed on the vandalism targeted sites before ensuring all sites have a proper lighting.

Tables 8, 9, and 10 show the different criteria used in the determination of solutions for vandalism/theft on the cell sites.

Table 8 Vandalism (1 of 3) solutions versus variables that determines suitability

	Weightage	*Aluminium grounding*	*Security patrol*	*Neighbour watch*
Cost	35.00%	80	30	90
Implementation time	15.00%	80	90	30
Readily available	10.00%	70	90	90
Reliability	15.00%	50	80	10
Functionality	25.00%	50	70	20
Total	100.00%	67%	63%	52%

Table 9 Vandalism (2 of 3) solutions versus variables that determines suitability

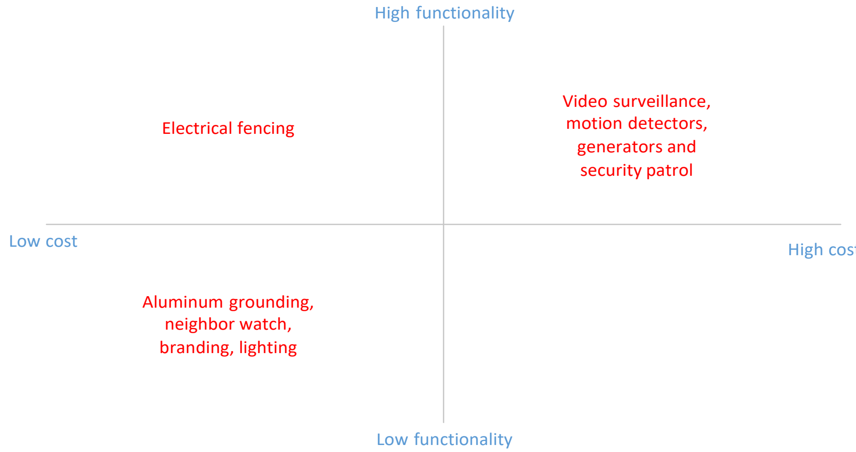
	Weightage	*Electrical fencing*	*Video surveillance*
Cost	35.00%	80	40
Implementation time	15.00%	30	60
Readily available	10.00%	50	80
Reliability	15.00%	60	60
Functionality	25.00%	50	80
Total	100.00%	59%	60%

Table 10 Vandalism (3 of 3) solutions versus variables that determines suitability

	Weightage	*Motion detectors*	*Branding*	*Lighting*
Cost	35.00%	50	80	80
Implementation time	15.00%	60	80	90
Readily available	10.00%	70	70	90
Reliability	15.00%	60	20	70
Functionality	25.00%	70	20	20
Total	100.00%	60%	55%	66%

From Table 8, Table 9 and Table 10, aluminium grounding scored the best. This would only be in relation to copper theft on cell sites. This was followed by lighting, if improved or fixed (in instances where if bulb is blown or non-existent), would help in battling vandalism. These were followed by a security patrol, who would periodically patrol sites at varying times. Video surveillance and motion detectors are next, and these can come separate or be integrated together. Electrical fencing, branding and neighbour watch rounds up the other options.

Figure 15 Cost-benefit analysis of solutions to vandalism and theft (see online version for colours)



5.3 Outage reduction

Outages have adverse effects on company revenue as well as customer service, as they are in fact directly related to one another. Outages come in the form of loss of power, hardware faults and software faults. There are currently mechanisms in place to reduce outages caused by these issues.

5.3.1 Existing solutions

5.3.1.1 Loss of power

The most typical type of outages is due to loss of power. These usually occur on sites with no battery backup, as a result of loss of mains from TTEC, whether it be a planned maintenance work or restorative work. Planned outages usually occur between 8 am and 4 pm whereas unplanned outages can occur at any time.

In Trinidad, there are 65/305 generators presently installed at Digicel cell sites. These generators are placed on all shelter sites, as well as hub and end sites. From the data collected, there were more than 100 sites with stolen batteries at any point in time. Since all shelter sites did not have any batteries missing and had generators installed, they would not be included here. The highest loses in revenue would be on hub sites and high traffic end sites without any batteries or generator installed.

5.3.1.2 Hardware/software faults

All nodes on the Digicel network have alarming is some form. On the cell sites, alarming for the nodes that are responsible for the transmission from site to site as well as the radio signals received by the customers, are monitored by the NOC and field engineers. There are both preventative and reactive auctioning of faults.

With preventative action, when these faults are found while performing routine checks on the nodes or from an activated alarm, tickets are created, and the parts are changed by the field engineers at times fit for the business. Spare parts are normally stocked at the warehouse for collection in addition to the field engineers keeping spare in their vehicles for emergencies.

With reactive action, the node shows no signs of issues and becomes non-functional or not fully functional. When these issues arise, the field engineers are normally called to actioned at any point in time, based on the severity of the issue. High severity issues, such as multiple sites off-air, are resolved as fast as possible, whereas the lower priority issues, such as a partially site off-air, are resolved during normal working hours.

5.3.2 Recommendations

About outage reduction, optimisation can be done on those due to power loss as well as hardware and software faults.

5.3.2.1 Loss of power

The first course of action would be to install batteries onto the hub sites followed by high traffic end sites without any battery backup. This should be done in conjunction with the points mentioned from the vandalism and theft prevention subsection, such as the burglar proofing the RBS cabinets. Using these methods, the batteries would be more secured. They should be less prone to being stolen as well as the cabinets being vandalised and losing power as a result.

Breaker panels should always be kept locked. If these breakers are easily accessible, the vandals could directly power down the cabinet before removing the batteries. By locking these panels, it would add another hurdle to their task as it could lead to potential shock.

Hub sites are responsible sites in its hierarchy. Luckily there are no hub sites with 3 or more dependencies on the Trinidad network without a generator installed. This is needed for the needs of the business as well as its customers, to ensure proper coverage as well as to protect against loss in revenue.

In addition to having the generators installed on these sites, there should be adequate generators available in the event of malfunction of generators installed or extended outages on sites.

5.3.2.2 Hardware/software faults

Even though there are precautionary measures taken against these faults, still some optimisation can be done on the operations. Firstly, ensure that all critical spares are always in stock at the warehouses. Secondly, in addition to having them physically present, the field engineer should ensure that they are set to the software base band model and has been tested for functionality.

Lastly, when outages occur, the NOC is usually the first line to troubleshoot the issues. They would first try to rectify or diagnose the issue, where it would then be handed over to a field engineer. In the event of multiple site outages, the field engineer should be notified immediately to reduce outage time as soon as possible.

5.3.2.3 Cell outage management

In Digicel, the radio frequency team is responsible for the areas in which the antennas for coverage are directed. They also ensure optimisation on the networks for call quality, frequency band use and interference prevention. Greater coverage areas have more antennas facing those areas as well as more cell sites. This is present in highly populated areas. In these areas, if a cell site has an outage, service is merely diminished. For rural areas, there is less cellular coverage hence less cell sites. With less cell sites, there are fewer antennas for coverage. With cell site outages in these areas, service is not only diminished but can be completely lost for certain areas.

6 Conclusions

The intention of this study was to determine the factors that lead to vandalism and theft, the effects it had on workers and the business as well as solutions to prevent them from occurring. From the analysis of the site outage reports and site routine reports, it was found that the location, time of day and security presence affected vandalism and theft. Vandalism and theft were found to be mostly prominent in remote or low traffic areas. From the outage reports, theft of the batteries usually occurs at night/early morning intervals. Those sites with security present were not affected.

The effects of this were seen to cause losses to the business as well as increased safety risks to the engineers to who work on site. The losses included loss and damages to equipment, no backup power in event of a power outage as well as outages due to the vandalism itself. This led to increased security patrol call outs where the engineers would have had to restore power/service at the cell site. From the survey concerning site safety, it was evident that safety on the cell sites are an issue faced by the engineers who frequent them.

Existing solutions to the vandalism and theft issue were found to be backup generators at some sites, security lighting, security, alarming and barbed wire/locks. The generators are effective in its role, to provide backup power in the event of a power outage. If batteries are stolen from a cell site, the generator would take the load, not before a brief interruption between losing power and the generator turning on. These are only present on high traffic/hub sites due to the high cost of purchasing. Security lights are a deterrent for criminal acts, but in rural areas, this may not be effective. Alarming is a reactive solution to the issue, where an alarm is raised if triggered by an event, e.g., battery door open. These need to be tested routinely as well as competent workers are needed to monitor at night/early morning periods were criminal activity is most prevalent. Barbed wire and locks just force the criminals to use alternative means to get into the site, e.g., cutting the fence. This is mildly effective but necessary on cell sites in order to protect its contents.

In the fight against vandalism and theft, there are number of upgrades and solutions available. These can be used individually with existing solutions or in any sort of combination, based on the vandalism threat on site. It all depends on the vandalism risk the site poses and the willingness of the company to implement solutions. Aluminium grounding was found to be the best option but is limited to only copper theft. Security patrol is the next best option but is associated with high costs. Improving the lighting is the next feasible option, where no major upgrade is needed. After lighting, video surveillance and motion detectors would improve detection and would work together with a security patrol who would respond to any unusual activity occurring on sites. Electrical fencing is then next best option but would be ideal in places of very high crime and multiple vandalism occurrences. Branding and neighbour watch would be the less feasible options but may be the cheapest. It would help to some extent but not as effective as the other options.

A safety rating system was developed to rate the cell sites. Three categories were created to distinguish cell sites, based on their location, vandalism history, accessibility, lighting and vehicular/foot traffic. Low safety risk cell sites are the safest, based on their location, vandalism history and security presence. Medium safety risk cell sites are those that may have been vandalised but are in generally populated areas and easily accessible. High safety risk cell sites refer to those sites that have been frequent to vandalism as well as those rural, not easily accessible areas.

In comparison to international safety standards, Digicel Trinidad and Tobago Ltd. was found to adhere to most of these standards, when it comes to assessing hazards in the workplace, reporting, training, check-ins and using the buddy system or security escort when needed. There has never been a report of assault or robbery of personnel working on these cell sites. While this is great for the company and its workers, it should not be taken for granted. Caution and preventative measures should always be taken to maintain the safety and welfare of the workers at the cell sites. Continuous measurement and improvement of these safety practices should always be followed.

References

Ahuna, M., Muumbo, A. and McLean, J. (2020) 'Pylon anti-vandalism monitoring system using machine learning approach', *2020 IEEE PES/IAS Power Africa*, IEEE, August, pp.1–5.

Archibong, E.I., Ozuomba, S. and Ekott, E. (2020) 'Internet of things (IoT)-based, solar powered street light system with anti-vandalisation mechanism', *2020 International Conference in Mathematics, Computer Engineering and Computer Science (ICMCECS)*, IEEE, March, pp.1–6.

Fahim, A., Chowdhury, M.A., Alam, M.F., Elahi, F., Shourov, E.C. and Hasan, M. (2021) 'Smart transformer theft protection and maintenance monitoring system', *2021 2nd International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST)*, IEEE, January, pp.607–612.

Hidayat, S.L. (2020) 'Enabling of technology in preventing vandalism in tower communication', *International Journal of Advanced Trends in Computer Science and Engineering,*, Vol. 9, No. 5, pp.8488–8456.

Liu, J., Zhao, Z., Ji, J. and Hu, M. (2020) 'Research and application of wireless sensor network technology in power transmission and distribution system', *Intelligent and Converged Networks*, Vol. 1, No. 2, pp.199–220.

Mazikana, A.T. (2019) *An Exploration of Strategies to Curb Vandalism in ZESA. A Case of ZETDC. A Case of ZETDC*, 29 June, SSRN: https://ssrn.com/abstract=3412221 or http://dx.doi.org/10.2139/ssrn.3412221.

Modipa, M. (2022) 'An evaluation of the impact of cable theft on free flow of traffic in South Africa', *International Journal of Research in Business and Social Science (2147–4478)*, Vol. 11, No. 6, pp.542–551.

Tarahi, H., Haghighat, H., Ghandhari, N. and Adinehpour, F. (2022) 'Smart online protection system for power transmission towers: an IoT-aided design and implementation', *IEEE Internet of Things Journal*, DOI: 10.1109/JIOT.2022.3194904.