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Availability of Mobile Port Machines at the Dar Es Salaam Port: Mean Time to Failure and Mean Down Time Data Analysis

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Abstract

In this study, the objective has been considered to increase the availability of the mobile port machines of the Dar es Salaam port. The research method was inductive, the approach used was both qualitative and quantitative, the type of research used was applied, the level of research was descriptive and explanatory, and finally, the research design used was pre-experimental. The technique for data collection used were literature review, observation, questionnaire survey and documentary compilation, likewise, the instruments used were reports and observation sheets and data record sheets. The techniques for the processing and analysis of the information were used the Microsoft Excel software and Social Science Statistics Package (SPSS) version 26 for the interpretation of data and the elaboration of diagrams. The results of the study identified the availability of mobile port machine is 65%. This implies that the current maintenance approaches have low availability performance. Also all the factors affecting the current mobile machine maintenance strategy in the port of Dar es Salaam were identified. The study identified five factors and their coefficients, including unavailability of spare parts and tools (0.013), downtime caused by the operating environment (0.005), the effective age of equipment (0.002), availability of effective maintenance plans and schedules (0.001) and downtime due to Human resources (0.008). According to these factors, the availability performance found to be 65.16%. In order to improve the availability performance of mobile machines at Dar es Salaam port, it is recommended to adopt a new and effective maintenance management system (Preventive Maintenance Plan) to the Port of Dar es Salaam. It concluded that, through the implementation of a PMP the availability of mobile port machine will increase, although management should provide adequate availability of spare parts and tools, ensure planning and scheduling to monitor all maintenance activities so as to improve the availability of performance, human resources are composed of labour to promote the availability of performance, operation environment and the service life of equipment and machinery to track the service life to reduce frequent failures.

Keywords: *Mobile Port Machine, Availability, Mean Time to Failure and Mean Down Time*

1. INTRODUCTION

With regard to port activity, Bobadilla and Venegas (2018) explain that this represents a real alternative for economic growth, as well as for commercial growth for countries, since they are essential to carry out commercial exchange between countries since they are places of shelter for the different boats in which loading and unloading services are provided for a significant amount of merchandise necessary for the consumption of the populations.

Bobadilla and Venegas (2018) point out that the increase in the movement of goods goes hand in hand with the economic growth of the countries, despite the fact that for which this occurs for growth, various factors must be given, such as the factor of foreign trade and the influence of ports, which are very significant. Therefore, the port industry is one of the most important today, since, through this activity, a large part of the world can obtain food, clothing and a series of products. In addition, Grandes Medios (2019) considers that the use of crane hooks in industries has allowed port work to be increasingly productive. Reason why it is considered that these port machines have played a fundamental role in the industry, given their functionality and capacity.

Faced with this reality, The Ports Act No.17 of 2004 created the Tanzania Ports Authority (TPA). It runs a network of ports that serve the hinterland of Tanzania as well as Malawi, Zambia, the Democratic Republic of the Congo (DRC), Burundi, Rwanda, and Uganda, all of which are landlocked. TPA now plays the dual roles of landlord and operator, with its primary responsibilities being to encourage the use, development, and administration of ports and their surrounding areas, as well as to engage into agreements to transfer authority from the Authority (via licensing and concessioning ports services). In Tanzania, Ports are facilities which allow the sea and lake transportation vessels to dock to embark and disembark passengers, loading and offloading various types of cargo such as Bulk and containerized Cargo (TPA, 2020).

Port as other companies have equipment and machines that fulfil specific tasks within the organization and are expected to work when they are required and there are no failures or unscheduled stops, many of them directly affect the main activity of the company, so their guarantee their performance is important. Over the years the machines have been modernized and many of them are highly complex and also of considerable economic value. For these reasons, the activities of conservation of the operability of the machines require not only qualified labour, but also an effective, efficient and timely maintenance plan (Monfort etal, 2014). Many companies, mainly companies that carry out extractive and productive activities, have designated personnel who are exclusively dedicated to planning and executing maintenance tasks. But there are also small companies or service companies that have relatively few equipment and machines where maintenance is often considered a secondary activity and is not included in the plans and objectives of the company (Botero & Cañon, 2015).

For smooth loading and unloading of cargo at ports, the availability of port machine is vital. Availability of port machine highly depends on the quality of maintenance services carried out on the machines that make it's used. So far the availability of port machine has faced the challenge of frequent breakdowns that cause operation works to stop and hence the delays occur within the port.

Though in the Port, availability of port machine depends on the maintenance strategies and practice. Currently, TPA provides corrective maintenance attendance. However, due to the high demand for the availability of port machine leads to several numbers breakdowns of some parts. This causes the availability to drop and translates to low port performance and low income of the country. These maintenances practices are insufficient to provide the required availability so it needs the proper actions to ensure this problem will be covered to improve the quality of availability of port machine at the port. According to Dhillon, (2012).

In this work, availability of mobile port machine at Dar es Salaam port will be presented based on Mean Time to Failure and Mean Down Time Data Analysis. Also all the factors which affecting the availability of mobile port will be identified so as to have ground for the strategies to be putted on place.

2. LITERATURE REVIEW

Alba and Chinchay (2019) in their research established the objective: "To determine how, through the implementation of a PMP, the availability of biomedical equipment will increase in the ICU of the HVRG in the province of Huaraz, 2018". His work was of an applied type, the level was of an explanatory type, his approach was quantitative and with respect to his design it corresponds to indicate that he was pre-experimental. Whose population and sampling was defined by a total of 20 ICU biomedical teams. Likewise, they conducted surveys of technical personnel; In addition, they observed, reviewed and analyzed the breakdowns of the equipment noted in the maintenance histories, they verified the current situation of each equipment and the inventory to be able to calculate the initial availability of the machines, with this they executed a strategy, in order to define costs, budgets and financial benefit. They concluded the following: The PMP increased initial availability and achieved a final reliability of 94%. In addition, the quality of patient care and the trust generated by the medical staff increased considerably at the HVRG.

The current status of the situation in the PMP within the HVRG let us see that the cause of the low availability of biomedical equipment was the lack of a PMP. The average initial availability of the 20 biomedical equipment presented at the ICU was 86%. This improved depending on the PMP, which focused on failure modes, as they can lead to equipment malfunction. The PMP was developed in a time of 6 months with 1080 hours of work, which greatly increased the reliability of the sample, this due to the operating time from 3298.61 hours to 4962.50 hours and decreased the intervention time of the stopping time from 564.46 hours to 341.92 hours. The PMP was 6 months with a 1080 hour calendar, increasing time frame reliability from 3,298.61 hours to 4962.50 hours and downtime sustainability reduced from 564.46 hours to 341.92 hours. During the six-month run time of the HVRG in Huaraz, the PMP led to a significant reduction of 25.47%.

Casas (2017) in his research had the objective to "Propose a maintenance plan to improve the availability of the critics that generate delays and unexpected stops during the shipment of containers in the warehouse of the organization Terminales Portuarios Peruanos SAC in the year 2017". For this, he included some RCM actions such as the detection of equipment failures, the main causes, the effects on the activities of the warehouse operations, among others. He concluded

the following: The RCM methodology proposes the maintenance plan for critical machines in this company to improve their availability. With the current availability evaluation in 2016, it was concluded that the container washing system in this company has an availability of 93.5% and 98.7% in truck scales. A maintenance plan was created using the RCM for the equipment inventory; determine the degree of criticality of the equipment; find a maintenance model; identify the causes for which the equipment has an error; classify the consequences of each error and determine the measures to be taken propose preventive measures to avoid the same errors caused previously; determine if the errors are related to the improvements made to the equipment and implement changes to the methods of maintenance and operation.
With the proposal of the plan, through the RCM in the company, the availability was projected to improve for the year 2018, for the G1 container washing equipment its availability would increase by 4%; G2 container washing equipment by 4.7% and for truck weighing equipment by 0.8%, this would mean that by 2018, the aforementioned equipment would increase its availability for said company.

Rojas (2019) in his research had the objective to "Propose a PMP to improve the availability of machines in the new grinding or crushing plant of a mining unit in La Libertad, 2019". The type of research used was experimental and the design was pre-experimental. The sample consisted of the set of crushing unit equipment such as (Sandvik CH-440 Crusher, Sandvik CS-430 Conical Crusher, Telsmith SBS-44 Crusher, Conveyor belts, Apron Feeder, Electroiman Eriez, Screens LF-3070 and Screens grizzly). The data collection instruments used were the equipment manufacturer's manual, maintenance records, shutdown notifications, equipment hour meters, spread sheets, data record sheets and field observation guide. It concluded the following: Due to the fact that a preventive mechanism or also called PMP was implemented, which was based on the criticality of production process equipment with the objective of improving the availability of the mining company, an increase of 84.27% was achieved, which was measured in the 2018 period at 97.81% from January to October 2019. The fulfilment or the realization of the activities that are planned, has managed to increase the availability of the equipment. In the period of 2018, the availability of the availability process was 84.27% and in the month of January to October 2019, the average availability of the total was 97.81%, the same that will continue in the process of improvement given that the team must be in perfect condition. It can be shown that the proposed implementation of the PMP can be realized because the increased availability of the new crushing system was demonstrated.

Casachagua (2017) in his research came to establish as an objective to "develop a PMP based on the RCM to improve the mechanical availability of the CAT 336 excavator of the ECOSEM SMELTER SA organization". The method that he used for the investigation corresponds to the inductive method; the type was technological, with an applied level and the pre-design experimental. The sample consists of three (3) CAT 336 brand excavators from the company ECOSEM SMELTER SA As instruments he came to use the check list, the report of the activities carried out by the team mechanics and the final repair report, which is included equipment downtime, equipment failures and recommendations for improving availability. It concluded the following: Using RCM, the minimum mechanical availability of 81% of CAT 336 excavators has

been exceeded and mechanical availability improved by 9% to 90%. Due to the constant and effective training that the participants who are involved in the company's work had, several qualitative aspects of the organization of ECOSEM SMELTER SA have improved, which has led to an orderly and clean work, while at the same time the quality of work has improved. Through RCM, possible critical errors were identified and the revision of critical equipment was improved when it comes to extending the life of excavators.

Cabrera and Tapia (2019) in their research work had the objective to "Design the proposal for the implementation of the RCM in the generation unit 2 of the Saymirín Power Plant". To do this, they carried out a criticality analysis of the systems that make up the generation unit 2 of the "Saymirín" plant, then they chose the three most complicated systems in the unit and with the RCM decision diagram they obtained a maintenance plan made up of by different activities, their frequency and in addition to the technicians needed to maintain the most complicated systems. They concluded the following: The Saymirín V plant of the company ELECAUSTRO SA has been in operation since its foundation for 4 years. This reason is a relatively new plant, both machinery systems and equipment. It was possible to observe that, in the aforementioned investigation, they only focused on generation unit 2 of the Saymirín V plant, the same one that was exposed to a criticality analysis, in which it was observed that its stopped time and its hours of operation in 2018 and 2019 they generate a very high availability (more than 96.5%), but with the intervention of time, reliability and maintainability would show that the rates of the unit can vary and cause lower availability. This not only increases the number of errors, but also the time to repair the equipment depending on the severity. A critical analysis performed on all generation two equipment revealed that the highly critical equipment associated with this unit is the upper bearing and injectors.

The RCM tries to evaluate seven basic aspects for which it has answered the following questions: What is the error? What is the functional error? What is the failure mode? What effect does the error have? What is the consequence of this error? What can be done to avoid this error? And what do you do if the consequences of a failure cannot be avoided or minimized? The RCM methodology offers you a series of preventive tasks for certain highly critical equipment errors and a series of corrective tasks at the time of the above error.

Trujillo (2018) in his research work had the objective to "Propose an RCM for the water treatment plant that belongs to the Termosuria-Ecopetrol Apiay Meta thermoelectric plant, in order to ensure the proper functioning of the assets". He carried out a study of the initial conditions, which started from the new equipment obtained by Ecopetrol in order to grant an initial assessment of the methodology used for this process. In order to carry out this PMP, I use ISO 14224, which was in accordance with the needs of the company for its operation. I make the hierarchical tree of equipment, to facilitate the failure analysis and optimize the process. Also, the RAM risk assessment matrix that allowed each equipment in the plant to be given an analysis of both consequence and probability, with the intention of knowing what critical level the equipment presents. I conclude the following:

If Ecopetrol wishes to postpone maintenance, it can be noted that, having basic knowledge of the RCM philosophy, this could become much more expensive because the AMEF stores information on the possible effects of errors that could bring about the elaboration. of other activities (even if they are the same). These consequences would be that the economic resources are increased, the increase of personnel for its repair and some costs that would be additional.

The goal of all strategic maintenance work was to keep renovation tasks as low as possible in order to ensure optimum quality status, which will continue to improve. They calculated the historical failure of the equipment according to the MTBF and MTTR methodology of the plant equipment and allowed the Ecopetrol company to predict both profitability and costs for the future. In addition to historical error data, they provide access to average fees for equipment and their proper procedure. Likewise, the MTBF knew the optimal intervention frequencies for each team of which the analyzed system consists.

Getachew (2017) in his thesis established as an objective to "Evaluate the preventive maintenance management and identify the availability of complete resources, inventory of machines and equipment of the Sheraton Addis hotel". This study adopted a descriptive research design. The organization has a population of 750 employees in 11 departments. The sampling technique allowed the selection of 4 departments, which were: engineering, cleaning, food preparation and administration. Likewise, the research sample consisted of 163 employees of the Engineering department. In addition, the data collection technique used was the interview with the hotel's chief engineer and the instrument consisted of a questionnaire addressed to the employees of the chosen department. Finally, the data was classified, edited and analyzed. It concluded the following: This preventive maintenance management is a process that allocates and coordinates resources such as employees, parts, and tools to improve maintenance performance. Machinery and equipment inventory helps perform preventative maintenance, identify machines with shared spare parts, track costs, and replace a piece of equipment. The result of this study has shown that only the technical management considers that the system of managing and controlling the inventory stock is correct for the implementation of preventive maintenance. On the other hand, the departments for non-administrative technology and user technology have the opposite regulation. The computer system automatically calculates the estimated time for preventive maintenance tasks and the average cost of performing each task. In this way, you can manage work orders, orders, inventory records, and maintenance more effectively.

Tabikh and Khattab (2014) in their thesis established the objective to "Identify the optimal moment in which certain preventive maintenance (PM) actions should be carried out and analyze the company's maintenance policy aimed at the availability of machinery (robot)". This report evaluates the maintenance policies that have been applied within the industrial company Dynamate Intralog AB, which found a high cost of corrective and preventive maintenance with lower productivity. The relevance of this report includes the importance of implementing the right maintenance policy at the right time to avoid unnecessary preventive maintenance actions that could affect the availability of the machine. They concluded the following: Company experience is a method for identifying critical components. With FMECA, for example, you can design the

analysis in more detail. The machine error log is the progress in improving the availability of the machine. Historical data analysis is also the second step in improving your health policy. The main purpose of scheduling PM actions is to determine the appropriate time interval in case PM actions are executed. This is based on analysis and knowledge of the behavior of the system or component. The readability and availability of the data plays a significant role in the outcome and can sometimes influence a critical decision that the business needs to make. The FMEA is an integrated tool for reliability analysis that covers all critical errors and their consequences in the system. For example, external factors can improve the occurrence of errors and the environment. To manage better solutions, these factors must be taken into account.

The resulting development of company strategy and a competitive edge in the market increase standards of operations. Business unit strategies developed in the framework of preventative maintenance ensure that guests' needs and expectations are met at all times in terms of production and service standards. This accomplishment opens up a hitherto unappreciated new front in corporate branding for the port business. When this gap in the port business is filled through the implementation of a preventative maintenance program, zero tolerance will be realized for increased operational efficiency, job security, the development of skills and employee acceptability, the shortest mean time between failures, and a better competitive position. Consequently, after reviewing previous studies Al-fares and Duffuaa (2019), Al-turki, U (2014). Okanminiwei1 and Ayoola (2021),Martín etal, (2014), Vilarinho and Oliveira (2017) and Zapien et all, (2017) that contained academic definitions, models, and empirical findings, the study reveals that it appears to be no evidence of any existing study in Tanzania that explained about the port maintenance plan especially for Dar es Salaam port Thus, to fill the gap, the researcher will carry out a study on how to improve maintenance plan to increase mobile port availability in Tanzania particularly at Dar es Salaam port.

3. METHODOLOGY

The research design is a comprehensive plan or programme for conducting research. In addition, research design is the formulation of criteria for data acquisition and analysis with the intention of ensuring method economy and study relevance (Kothari, 2014b). The research method used is inductive, the approach used included both quantitative and qualitative techniques, also the type of research is applied, and the level of research is descriptive and explanatory, finally, the research design was pre-experimental. This approach permitted the use of numerous data collection techniques, including interviews, questionnaires, observations, focus group discussion and document review. Moreover, it preserves the coherence of research and encompasses a vast array of variables. It facilitates triangulation throughout the data validation procedure(Saunders, Lewis, & Thornhill, 2019). The data collection techniques were used individually and in combination. Techniques like questionnaires, observation, documentary analysis, and interviews are used to emphasise the dangers of classifying approaches, strategies, and practises into neat categories (Saunders et al., 2019).

The study carried out at Tanzania Port's Authority Particularly at Dar es Salaam port whereby mobile port machines are used for cargo operations. Hence the selection of area of the study to be conducted based on the nature of the operation conducted at the port, and has more frequent breakdowns that affect the availability performance and causes unachievable goals.
The term "population" describes all individuals who belong to a particular class of objects, persons, locations, or occasions that have been chosen because they are significant to the topic under study. Terminal managers, engineers, terminal operators, supervisors and officers from a particular cargo terminals will comprise the study population (Kothari, 2014b). The population of the study comprises members' representatives at the study area including Engineers, Technicians, Artisan, Operators, and Analysts. Selections of the above population in this study are expected to represent people who work in the machines at the port.

The research employed both simple random sampling and purposive sampling techniques when collecting data. The sample unit selected using simple random sampling based on a set of predetermined criteria. Purposive sampling used to select a cohort of respondents who are believed to be reliable sources of data for the study (Kothari, 2014b).

Out of given population 10,000, a sample of 100 respondents were involved in the study, researcher adopted the devised formula to generate a representative sample of proportions for enormous (infinite population) populations. Mathematical expression derived by Slovin used (Ellen, 2020).

$$Sn = \frac{Pn \times re\%}{100} \quad \text{..... (eqn.1)}$$

Where:
Sn= number of sample to be taken,
Pn= total population,
re%= estimated respondent rate of 100%.
Therefore Sn= 10,000/1000 = 100 Respondents
These 100 respondents will be selected purposively as detailed in Table 3.1.

Table 1 Respondents selected for the study

SN	Respondents	Sampling Technique	Frequency	Percentage (%)
1	Principal Engineers	Purposive	10	10
2	Maintenance Engineers	Purposive	20	20
3	Maintenance Technicians	Purposive	30	30
4	Artisans	Purposive	20	20
5	Operators	Purposive	20	20
	Total		**100**	**100**

This research used both primary and secondary data. Questionnaire and interview provided qualitative data while quantitative data collected through documentary review, observation and

field measurement. A review of various literatures related to the maintenance of mobile port machines provided secondary information (Kothari, 2014b).

In terms of data validity, Saunders, Lewis, and Thornhill (2016) advocated for a pilot evaluation of the questionnaire prior to data collection. The objective was to eliminate contaminants from the questionnaires so that respondents feel at ease when responding. Additionally, data were adequately documented, and questionnaires were field-tested prior to use. The researcher asked questions in the same manner as they appeared in the questionnaire; this aided in determining whether the questionnaire is well understandable, as well as confirming whether the questions elicited the intended information, determining the sensitive questions contained in the questionnaire, and determining the respondent's interest, attention, and cooperation towards the study. Pre-testing and field testing were conducted to improve the questionnaire's face and content validity. Thus, in examining measurement scale accuracy and consistency, the terms 'validity' is commonly applied.

According to the definition of reliability, it refers to how well results hold up over time and accurately represents the overall group being studied. If the results of a study can be replicated using an analogous methodology, then the research instrument is dependable. This was possible because the researcher conducted interviews with terminal administrators, supervisors, personnel, and passengers. Cronbach's alpha was employed to assess the degree of dependability of all constructions. Finally, the researcher restated and summarised facts throughout the interview, and the participant asked to rate correctness. Furthermore, the data collection instrument validated for accuracy and consistency. In addition, respondents for this study are those who work at the Dar es Salaam port on a daily basis. As a result, they had accurate information on the subject under consideration. As a result, their reactions are consistent.

Using a computer spreadsheet, the field data are organised, compiled, categorised, modified, and coded. Version 26 of the Statistical Package for the Social Sciences, also known as IBM SPSS Statistics software is used to manage the data analysis.

4. RESULTS AND DISCUSSIONS

This section provides a thorough examination of the collected data, an insightful interpretation of the analysed data, and a thoughtful discussion of the study findings.

4.1 Response Rate

Respondents received a total of 80 questionnaires, 70 were completely collected for evaluation. Tables present the main results of the research. The success rate is attributed to the self-management of the questionnaire used by the researcher, the potential respondents were notified in advance before the date of data collection and the researcher agreed with the actual date of management of the data questionnaire. Follow up on emails to clarify the query, thereby increasing the over-response rate.

4.2 Reliability and Validity

The reliability statistic package for social sciences (SPSS Version 26) is used with the help of Cronbach's Alpha. It was detected 33 Items of the question were 83.1% that means that the information is credible. A value is higher than 50% is considered sufficient and in this case, it is 83.1%.

Table 2: Cronbach's Alpha

Reliability Statistics	
Cronbach's Alpha	N of Items
.831	33

Cronbach's alpha coefficient test was employed to measure the internal consistency of the instruments used and the coefficient alpha of these variables was reported. According to George and Mallery, (2015), when Cronbach's alpha is greater than 0.9 (>0.9) it means that the internal consistency reliability is excellent. When it is greater than 0.8 (>0.8) the reliability is good; while greater than 0.7 is acceptable and greater than 0.6 is still acceptable. When it is 0.5 to 0.58 is poor and when it is less than 0.5, internal consistency is unacceptable.

The KMO measures the sampling adequacy (which determines if the responses given with the sample are adequate or not) which should be close to 0.5 for satisfactory factor analysis to proceed. According to Bryman et all, (2019). recommend 0.5 (value for KMO) is a minimum (barely accepted), values between 0.7- 0.8 acceptable, and values above 0.9 are superb. Looking at the table below, the KMO measure is 0.610, which is close to 0.5 and therefore can be barely accepted. The researcher should perform a validity test to know whether the instruments used in the study are accurate, correct, truly meaningful, and right (Kothari, 2014). According to Shrestha, (2021), if the value of KMO exceeds 0.5, the data collected are valid. After analyzing data collected on SPSS version.26 the result of KMO was as follow:

Table 3: KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.610
Bartlett's Test of Sphericity	Approx. Chi-Square	28.009
	Degree of freedom	3
	Sig.	.000

The value of KMO of 0.610 was yielded which suggested that the sample was adequate for exploratory factor analysis according to Reio Jr and Shuck, (2015), who argued that KMO should be either 0.6 or above. On the other hand, the Bartlett test in this study yield p-value =0.00 which signify that the variables are correlated highly enough to provide a reasonable basis for factor

analysis that the value for the Bartlett test should be a significance value of less than 0.05 as described above in KMO and Bartlett test.

4.3 Availability Performance Based on the Current Practices

Availability obtained from the observation was very low, which indicated the shortcoming of the current maintenance practices, thereby necessitating the development of a maintenance management system of mobile port machines based on preventive maintenance approaches. The availability performance of mobile port machines, in this case, resulted from MTTF and MDT as shown in Table 4..

Table 4: Mean Time to Failure and Mean Down Time in Hours

MTTF	MDT	TOTAL HOURS
498	232	730
428	308	736
477	248	725
451	275	726
487	243	730
445	290	735
567	166	733
489	240	729
423	308	731
451	280	731
534	186	720
444	290	734
5694	**3066**	**8760**

Therefore; Current Availability Performance of mobile port machines at the Dar es Salaam port for one year (January 2022 – December 2022).

$$\frac{\text{MTTF}}{\text{MTTF+MDT}} \times 100\% \quad \text{.....(Eqn 2)}$$

Whereas

MTTF – Mean time to failure

MDT – Mean down time

The calculation for current availability performance of mobile port machine $\frac{5694}{5694+3066} \times 100 = 65\%$

In the current maintenance practices, the availability of mobile port machine is 65%. This implies that the current maintenance approaches have low availability performance, hence requiring more improvement.

4.4 Comparison of Availability Performance of Mobile Port Machines between years 2021-2022

The calculation of the availability was made based on the implementation of the PMP to mobile port machines in comparison to the previous period (year 2021) obtaining a favourable result as shown in Table 5.

Table 5 shows the Availability of mobile port machine in average rate for the year 2021 compared to the year 2022. It can be seen that the availability of the mobile port machines in the 2021 period (January to December) is lower with respect to the availability in the 2022 period, this is due to the implementation of the new PMP and its respective controls. That is, there is a significant growth in the availability allowed to improve the use of the resources of Dar es Salaam port, in order to give continuity to productivity and in offering a good quality of service to its customers.

Table 5: Comparison of Availability Performance of Mobile Port Machines between the Years 2022 – 2023

MONTH	YEAR (2022)	YEAR (2023)
January	60	71
February	62	73
March	67	77
April	66	81
May	70	83
June	68	85
July	62	88
August	63	90
September	69	91
October	66	92
November	65	93
December	64	93
Availability (Avarage)	**65.16**	**84.75**

In Table 5, it can be seen that the average availability in the 2021 period was 65.16%, but with the implementation of the new PMP and its respective controls, in the 2022 period an average of 84.75% was obtained, that is, there is an increase significant 19.59% compared to the previous period. This increase is significantly decreased the Fault Repair Time (MTTR) in the year 2022 with respect to the year 2021. This is due to the implementation of the new PMP and its respective controls. The MTTR allows us to determine the average time to resolve failures and repair the asset that experienced a breakdown, granting it a correct operation. Likewise, it allows us to verify if the company can act against an incident and be able to solve it quickly.

4.5 Factors Affecting Availability Performance of Mobile Port Machines

Factor analysis is a type of validity and reliability assessment that uses statistics to quantify the relationship between distinct sub-factors and variables, identify the components that different factors and sub-factors will load on them, and assess their dependability. It also improves other deductive analyses such as regression by bringing forth coefficient scores. As independent factors, mobile machine components (dimensions) are available, and competitive advantage is a dependent variable. In factor analysis, however, variables are evaluated using a correlation matrix and an alpha coefficient, regardless of whether they are dependent or independent. Factor analysis can be done in a variety of methods; in our investigation, we loaded factors using the Principal Component Factoring model. The factor analysis was carried out to comprehend the several elements that were forming in the research's key question on improving the availability performance of mobile port machines at the Dar es Salaam port.

4.5.1 KMO Bartlett Test

The Kaiser-Meyer-Olkin test determines the sample's adequacy. The numbers of the KMO test range from 0 to 1. Factor analysis is unlikely to be useful because the sum of correlations for sections of them is large in contrast to the sum of Correlations. Values close to 1 indicate R65 number patterns that are relatively compact. Values greater than 0.766, according to Safak, (2015), are acceptable. The KMO for this investigation is 0.807, which is satisfactory as shown in Table 6.

Table 4.1: KMO and Bartlett's Test for Factors of Independent Variables

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.807
Bartlett's Test of Sphericity	Approx. Chi-Square	128.033
	df	10
	Sig.	.000

4.5.2 Communalities

Communality shows how much of the variance associated with each indicator is shared variance. With principal component analysis, at first, we assume that all variance is common (initial value =1) however after extraction, numbers in the extraction column indicate common variance in the data structure. A higher number of commonalities reflect the proper fitting of indicators for data. The table 7 shows the extraction communalities of indicators.

Table 7: Communalities

Communalities

	Initial	Extraction
Planning and Scheduling	1.000	.678
Operation environment	1.000	.711
Availability of Maintenance spare parts and tools	1.000	.536
Human resource	1.000	.749
Equipment and machinery Age	1.000	.476

Extraction Method: Principle Component Analysis.

4.5.3 Correlation

Table 8: Persons' Correlation Test

Correlations

		Evaluation	Causes	Factors	Dependent
Evaluation	Pearson Correlation	1	.506**	.302*	.265*
	Sig. (2-tailed)		.000	.011	.027
	N	70	70	70	70
Causes	Pearson Correlation	.506**	1	.282*	.247*
	Sig. (2-tailed)	.000		.018	.040
	N	70	70	70	70
Factors	Pearson Correlation	.302*	.282*	1	.421**
	Sig. (2-tailed)	.011	.018		.000
	N	70	70	70	70
Dependent	Pearson Correlation	.265*	.247*	.421**	1
	Sig. (2-tailed)	.027	.040	.000	
	N	70	70	70	70

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The correlation analysis is critical for understanding the relationship between evaluations of existing maintenance practices, causes, factors, and improving the availability performance of mobile port machines. The evaluation of existing maintenance practices has a 50.6% relationship with the causes. The evaluation of existing maintenance practices has a 30.2% relationship with the factors. The evaluation of existing maintenance practices has a 26.5% positive relationship with the improvement of the availability performance of mobile port machines. The correlation is a prerequisite for completing regression on the research data. The data shows that there is a sufficient correlation between all the variables. Too high a correlation will cause the problem of multi-collinearity. The results in the case of the correlation for all the variables were significant as the p-value was lower than 0.05. The sample size of the research is mentioned as 70.

4.6 Discussion

Theoretical analysis of the data and results obtained in relation to the bases research theorists. The preventive maintenance plan will increase the availability of the mobile port machines of the Dar es Salaam port. The results presented in this chapter correspond to the work of Rojas (2019), which implemented a PMP based on the criticality of the equipment in the production process, resulting in the improvement of the availability of the mining company, achieving an increase of 84.27% that was measured in the period 2018 to 97.81% on average from January to October 2019. Therefore, this background shows that there is an investigation related to the result obtained in this report. In relation to the first objective: factors affecting the availability of port machines including planning and scheduling, operation environment, availability of maintenance spare parts and tools,

human resources, equipment and machinery age, supervision on maintenance practices, effectiveness of communication and limited training. Second and third objectives were related to decreasing the MTTF and the MDF which aimed to increase the availability of the mobile port machines of the Dar es Salaam port; and in accordance with the results obtained from Table 4.22, it can be seen that the availability of mobile port machine is 65.16% resulted from MTTF and MDF, but with the implementation of the new maintenance plans and their respective controls, will increase the availability of port machines as evidenced for the increase from 65.16% to 84.75% from the year 2022 to year 2023.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The main goal of the study was to propose the adoption of a new maintenance plan to improve the availability performance of the mobile port machines. In determining factors affecting the availability performance of the mobile port machines in the current maintenance management strategy, the results show that planning and scheduling, operation environment, availability of maintenance spare parts and tools, human resources, equipment and machinery age as well as to monitor equipment age for controlling life span to reduce frequent breakdowns are the major factors. Also it confirmed that through the implementation of PMP will lessen the Mean Down Time and the Mean Time to Failures of the mobile port machines of the Dar es Salaam port, this will allowing to obtain both the operability of the machines and their availability in order to identify the initial signs of a defect to reduce the risk of unscheduled failures and reduce the execution of corrective maintenance. By doing this will give continuity to the productivity and in the offer of a good quality of service to port clients.

5.2 Recommendations

- It is recommended that the Port of Dar es Salaam should control and monitor its maintenance management practices at designated time intervals (daily, weekly, and monthly) to ensure that the maintenance management system operates normally and meets maintenance management standards. Project management shows how the system works and what can be improved.
- To improve availability performance, specific recommendations have been made to Dar es Salaam port. The first is to monitor and control maintenance strategies; of the mobile port machines adherence to effective maintenance Planning and Scheduling, operation environment, availability of maintenance spare parts and tools, human resource, equipment, and machinery age provided by the manufacturer. All these must be well monitored and adhered to, to improve availability performance.

- It is recommended that the port should provide continuous training on improvements in maintenance plan strategies to all personnel of the company Dar es Salaam port, in order to establish compliance with maintenance activities in general, as well as increasing the operability and availability of port machines.

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