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Computer Applications for Asset Management in Passenger Terminals

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***Abstract*— At present asset management has become one of the significant areas demarcating its key concepts in every nook and corner of the local industries even though it has branches in worldwide. Condition assessment is a major discipline of the asset management that makes the foundation to develop systematic models that many of the organizations are experimented for, since maintenance of the assets have made real-time challenges for them. The objective of this study is to introduce a Computerized Maintenance Management System developed for asset management in Kandy Multimodal Transit Terminal. Hence, the outcome of this study facilitates the users to monitor and record any and all maintenance work, as well as to keep a historical record of work and track the asset conditions for future references.**

Keywords*— *Asset maintenance management, Condition evaluation, Risk score value, Passenger terminals

I. Introduction

Asset management, as defined by ISO 55000, is the coordinated activity made by an organization to derive value from its assets [9]. Although it was first practiced in oil and gas industry, currently it has been able to become one of the most trending aspects in the world which plays a significant role in optimizing the performance of both public and private sectors [8]. On the other hand, many sectors have encountered challenges in maintenance management of non-current assets. However, similar to other sectors, asset management holds a prominent place in the transportation sector too as passenger terminals are with a wide variety of assets including architectural, structural, mechanical, electrical and outdoor elements. Thus, maintenance management of assets is an essential requirement in passenger terminals since the terminal environment quality is directly linked to passenger satisfaction.

Practice of these aspects in Sri Lankan passenger terminals is at a very low level narrowing towards the facilitation of basic facilities, yet at minimum conditions with few seats to accommodate waiting passengers, no updated bus schedule and less security arrangements. Bus terminals like these and other bus terminals around the country currently have issues with overcrowding, ticket issuing, over loading, safety issues, passenger dissatisfaction due to the lack of dynamic timetable information, limited seating arrangements for waiting passenger and lack of sanitary and restroom facilities [1]. Further the poor arrangement of these terminals as well as the unseparated circulation of vehicles and passengers add no value to the user convenience. This all add up to the ad hoc nature of the asset management in Sri Lankan passenger terminals.

At present, there are several frameworks, but there are no models that detail all fundamental processes and change management approaches for asset management deployment [6]. Therefore, a computer-based condition assessment system which incorporates key concepts of asset management, while meeting challenges of field work is a need now and future. The study focused on this problem taking passenger terminals as an example.

II. Literature Review

A. Asset Maintenance

Implementing and sustaining the provision of facilities are two different issues, but both will create barriers for them when nothing is being done [4]. Sustaining is effectively managed through the maintenance. Nevertheless, at the early stages maintenance, of course made a simple impact on the functionality, but at present with the technological development its significance has been considerably increased merely as it creates a dilemma to measure the results of investments in maintenance in total economic terms. At the same time, the equipment that is not well maintained and fails periodically tends to produce defects whereas the poorly maintained equipment may lead to more frequent failures, scrap or questionable quality [4]. Literature suggests that the asset maintenance management consists of three key processes as corrective maintenance, preventive maintenance and predictive maintenance. Further it elaborates that there are a lot of factors (criticality, cost to maintain, the cost of downtime, data required, safety risk & required compliance) to consider when deciding and implementing the best plan for an asset while no two assets or operations are the same [10]. Thus, it creates the foundation for a balanced maintenance framework giving performance baselines and benchmarks [10].

B. Condition Assessment

Modern maintenance management is not merely to repair the assets rather to keep the assets operating at optimum conditions. Yet this real maintenance is impossible without condition assessments. However, condition monitoring is a procedure in which the physical status of an asset can be examined whereas performance is defined as the ability to address the required level of service and can be measured in terms of reliability, availability, capacity, and meeting customers' demands [5]. According to [3], asset management

Funded by the World Bank for the development of Asset Management System.

and maintenance process consist of key processes as condition assessment at inspection year, deterioration prediction condition at any year, selection of repair strategies, option, cost, condition after repair improvement and life cycle analysis in which it explains the condition assessment as the initial step.

On the other hand, condition rating's two key outputs are the determination of an asset's residual life, and consequently its effective life, as well as the appraisal, if required, of its maintenance management program in order to optimize the asset's life or accept greater risk [5]. Hence, condition assessments play a key role in asset maintenance management, although there are different types of condition assessment methods depending on the organization policy and defined factors like age, serviceability and maintenance cost etc. However, in most of the cases, assessments are carried out via visual inspections and the five-point condition rating system where condition 1 is "very good" and condition 5 is "very poor" and vice versa has been adopted appropriately to the organization. As such, condition assessment criteria identified in literature can be cited as in Table I [3].

TABLE I. CONDITION RATING SCALES; REPRESENTATION

Reference	Asset Type	Condition Scale	Linguistic Representation
Greimann et al. 1997	Locks and Dams	0 - 100	Maintenance need [(0 - 39) = only after further investigation, (40 - 69) = only if economically feasible, and (70 - 100) = no action is required]
Pontis 1995	Bridges	1 - 5	Deterioration process (1 = protected, 2 = exposed, 3 = vulnerable, 4 = attacked, and 5 = damaged)
Lounis et al. 1998	Any Asset	1 - 7	Condition category (1 = failed, 2 = very poor, 3 = poor, 4 = fair, 5 = good, 6 = very good, and 7 = excellent)
WSDOT 2000	Buildings	1 - 5	Condition category (1 -2 = meets current standards, 3 – 4 = adequate, 4 – 5 = poor)

C. Condition Assessment Software Systems

Condition assessment is the basis for the development of software-based systems to determine the level of maintenance of assets for future endeavors. Such systems developed for infrastructure assets are briefly tabulated in Table II [3].

TABLE II. CONDITION ASSESSMENT SOFTWARE SYSTEMS

Software	Features
BUILDER	• Detailed building hierarchy • Standard deficiency check list for all subcomponents • Add pictures, notes, general information • Industry standard (AutoCAD) • Numeric scale
RECAPP	• Detailed building hierarchy • Detailed deficiency descriptions for each component • Add pictures, notes, general information • Less complicated as only severities need to be checked
TOBUS	• Detailed database for building macro and micro-objects • Evaluates physical degradation of the condition • Works for retrofit up-gradation for improvement
	• Fast (on-line)

In overall, all these software have general issues such as time-consuming, subjectivity, no mechanism for prioritizing the inspection tasks and not linking the components to their location within the building, etc. Accordingly, this study introduces an open-source software that was developed by considering the drawbacks of the existing frameworks.

III. ASSET MANAGEMENT SYSTEM

A. Asset Registry

Considering the inventory records of the terminal, asset hierarchy was developed with main categories, subcategories, and asset models and the assets were linked with their locations to manage maintenance practices more conveniently. Table III and IV briefly illustrate the asset registry of the Asset Management System (AMS).

TABLE III. ASSET CATEGORIES, SUBCATEGORIES AND MODELS - AMS

Main Category	Subcategory	Model
Buildings	Walls	Brick wall, Block wall
Bus Terminal	Display Boards	Display Board – Time Table, Display Board – Route Number
Furniture	Office Chairs	Conference Chair, Lobby Chair
Firefighting Equipment and Tools	Fire Extinguisher	Water fire extinguishers, Dry Powder fire extinguishers
Electrical and Mechanical	Split Type Inverter	9000BTU, 12000BTU
Equipment Office	Photocopiers	Small, Medium, Large
Water Facilities and Toilet Fittings	Commodes with Cistern	Commode with cistern close couple Medium, Commode with cistern close couple small

TABLE IV. ASSET LOCATIONS - AMS

Parent Location	Sub Location
Bogambara Terminal	Bogambara Terminal CCTV Room
Bogambara Toilets	Bogambara Terminal Toilet Female 1
Bogambara Terminal Offices	Bogambara Terminal Office 1
Bogambara Terminal Shop	Bogambara Terminal Shop 1
Bogambara Terminal	Bogambara Terminal Generator Room

B. Condition Evaluations

A five-point condition rating scale was developed interpreting one for the best and five for the worst conditions of the assets. Both the physical and performance condition variables for each and every asset/asset component were defined whereas weightages were assigned for the assets that have more than one condition variable. Table V, VI and VII present the condition assessment scale developed in AMS for sanitary fittings.

TABLE V. ASSET PHYSICAL CONDITION RANKING

Condition Variable	Rating	Condition Description
Physical condition	1	As new
	2	Few scratches and discoloration
	3	Moderate damages
	4	Lot of physical conditions
	5	Cannot use

TABLE VI. ASSET PERFORMANCE CONDITION RATING

Condition Variable	Rating	Condition Description
User acceptability	1	Very good
	2	Good
	3	Acceptable

	4	Not acceptable
	5	Unable to use

TABLE VII. ASSIGNED WEIGHTAGES OF PERFORMANCE CONDTION VARIABLES

Performance Condition Variable	Assigned Weightages
User acceptability	0.4
Item smell performance	0.3
Water service performance	0.3

Considering the literature findings, visual inspections were used as the condition monitoring technique in AMS. Asset data modifications (facilities for edit, delete etc.) can be done as shown in Fig. 1. Also, AMS facilitates to upload photographs depicting the asset existing conditions to apt with the predefined conditions while assessing the conditions of the assets during the field surveys as in Fig. 2 and 3.

Fig. 1. Asset data modification

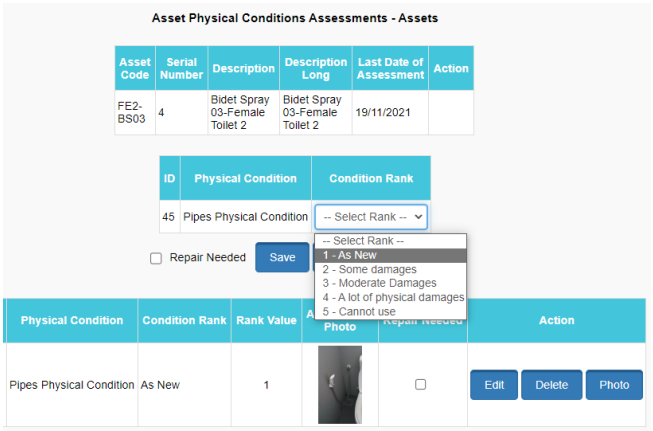

Fig. 2. Physical condition assessment of the sanitary fitting

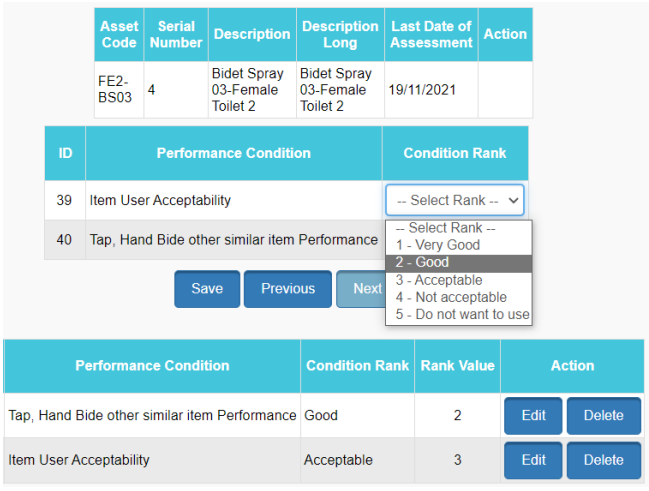

Fig. 3. Performance condition assessment of the sanitary fitting

Further, AMS facilitates to assess the criticality of the asset that prioritizes the asset maintenance level using a three - point rating scale with one for general, two for medium and three for high criticality as illustrated in Fig. 4.

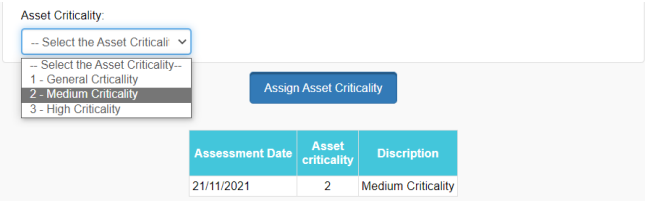

Fig. 4. Criticality assessment of sanitary fittings

C. Asset Management

Risk score value calculated as per the (1) [7], is in cooperated in determining the maintenance strategy for each asset. Sample risk score calculation is shown in Table VIII and the risk score values auto calculated in AMS are illustrated in Fig. 5.

Risk score of an asset

= (Physical condition + Performance condition)*(Criticality) (1)

TABLE VIII. SAMPLE RISK SCORE CALCULATION

Physical Assessment			
Condition Variable	***Rank***	***Weightage***	***Score***
Physical condition	3	1	3
Performance Assessment			
Condition Variable	***Rank***	***Weightage***	***Score***
User acceptability	3	0.4	1.2
Item smell performance	2	0.3	0.6
Water service performance	2	0.3	0.6
Assessment Total = 5.4			
Let the criticality = 1			
Risk score value = 5.4			

Location	Asset Code	Asset Description	Date of Assessments			Repair	Risk Score
			Criticality	Physical	Performance		
Bogambara Terminal Toilet Female 2	FE1-BS01	Bidet Spray 01-Female Toilet 2	21/11/2021	19/11/2021	19/11/2021	No	6.40
	FE1-BS02	Bidet Spray 02-Female Toilet 2	21/11/2021	19/11/2021	19/11/2021	Yes	19.60
	FE2-BS03	Bidet Spray 03-Female Toilet 2	21/11/2021	19/11/2021	19/11/2021	No	6.40
	FE2-COM01	Commode with Cistern 01-Female Toilet 2	21/11/2021	19/11/2021	19/11/2021	Yes	9.60
	FE2-COM02	Commode with Cistern 02-Female Toilet 2	21/11/2021	19/11/2021	19/11/2021	Yes	9.60

Fig. 5. Risk score values of sanitary fittings

D. Asset Maintenance and Repairs

Risk score values of assets make the foundation for the determination of maintenance and repair works. AMS facilitates to assign the repair type (Emergency/Preventive/Predictive), repair work flow process (External repair, Internal repair/Agent repair) and to enter the initial repair estimate. Further, it enables to suggest the next repair date based on the assessments of the asset as in Fig. 6. Additionally, asset repair job reports can be obtained through AMS, either location wise or as a whole.

Asset Description	Repair Type	Repair Description	Initial Estimate	Repair Process	Suggested Date	Repair Status		
Commode with Cistern 01- Female Toilet 2	Preventive Maintenance	Commode with cistern cleaning	2000.00	Internal through Work Order	25/01/2022	Not Commenced	Edit	Delete
Commode with Cistern 02- Female Toilet 2	Preventive Maintenance	Commode with cistern cleaning	2000.00	Internal through Work Order	26/01/2022	Not Commenced	Edit	Delete
Commode with Cistern 03- Female Toilet 2	Preventive Maintenance	Commode with cistern cleaning	2000.00	Internal through Work Order	14/02/2022	Not Commenced	Edit	Delete
Toilet Paper Holder 01- Female Toilet 2	Emergency Repair	Replacement of a toilet paper holder	2000.00	Internal through Work Order	21/02/2022	Not Commenced	Edit	Delete

Fig. 6. Asset repair jobs

Accordingly, assessor needs to update the asset repair jobs based on the condition evaluations and risk score values at inspection intervals defined in the organization policy.

IV. Discussion

Considering the literature findings, AMS was developed based on a knowledge-based approach which takes the expertise experiences and judgements as prominent. This approach was selected based on the data collection since most of other approaches demand more historical data for the simulations. AMS is the initiative to address the computer application in asset management of the terminal. Under such conditions it will be necessary to utilize the judgement of the experience engineers or use standard curves to make a first cut estimate of the deterioration curve such that these first cuts then provide a framework for collecting future data upon which to improve the reliability of the models [2].

Accordingly, assessor is responsible for condition evaluation mechanisms and updating the maintenance records. However, determinations of the maintenance aspects of the assets by the assessor is subjective in nature since it depends on the varied perspectives of the assessors. Considering this, AMS facilitates to upload photographs of the assets as mentioned earlier which leads to a homogeneous analysis of the conditions independent of the experts knowledge and further supports for the continuous improvements in the system.

Compared to existing software-based applications, AMS is significant considering following features except to the features discussed above.

- Enables to assign the physical and performance conditions for the subcategories as in Fig. 7 and 8
- Enables to enter asset data in bulk amounts via excel sheets (.csv format)
- Can align maintenance strategies with the organizational policy
- More structured and less time consuming
- User friendly interface

Rank Value	Condition Rank	Action	
1	Very good	Edit	Delete
2	Good	Edit	Delete
3	Minor Water Leak	Edit	Delete
4	Water leaks and other operational difficulties	Edit	Delete
5	Need replacement, No water or continuous running	Edit	Delete

Fig. 7. Condition ranking of the asset subcategories

Unassigned To Subctegories			Assigned To Subctegories			
ID	Performance condition			ID	Performance Condition	Weightage
36	Item Water Service	>>	<<	496	Tap, Hand Bide other similar item Performance	0.80
37	Item Smell Performance	>>	<<	497	Item User Acceptability	0.20
38	Commode Seat Cover Performance	>>				

Fig. 8. Assigned performance conditions to asset subcategories

V. Optimization of the System

Considering the optimizations of the processes, reviews of the expertise were consulted through the workshops conducted via online platform. Two such workshops were held with the expertise of the field in worldwide and with the stakeholders of the Kandy Multimodal Transit Terminal (KMTT) project. Feedback received for further amendments can be pinpointed as follows.

- Need to in cooperate the facility management aspects (inventory management, finance and procurement modules) into the AMS
- Procedure for major repairs need to be elaborated
- Predictive cost modelling adopting depreciation of asset values needs to be in cooperated
- Maintenance back logs can be adopted, if repairing does not occur on time
- Determination of assessment interval needs to be reviewed further particularly it depends on the asset category
- Weightages for the of the assets need to be reviewed further

Accordingly, concerns received through the expertise were facilitated for the future improvement proceedings.

VI. Recommendations

Considering the condition evaluation mechanisms, it is recommended to familiarize both the assessors and the end-users through training programmes for effective and efficient implementation of the AMS.

VII. Conclusion

At present, managing assets and the maintenance cost have been a great challenge. Hence, a computer application

for asset management in passenger terminals was presented in this study by introducing an open-source platform; AMS developed focusing the KMTT. This system integrates all the modules (asset registry, condition assessments and maintenance and repairs) related to the asset management into a single database in which the assessors and the end-users can involve the information in decision making processes. Nevertheless, AMS fills the gap by addressing the traditional approaches of asset management in local context. Further, it is expected to optimize the AMS so that it can be adopted for passenger terminals in global context. Ultimately, future researchers are recommended to introduce these open-source systems to other industrial sectors with improved features.

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