DEVELOPING INNOVATION THROUGH DATA COLLECTION AND ANALYSIS

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Abstract

This paper is part of the study, for the creation of maintenance engineering culture and a system capable to control the input and output of vehicles operation and maintenance in developing countries. The focus of this paper will be the use of digital technologies to change business models, basing on the analyses of the data collected to develop innovation in transport system by creation of a system that works according to the local needs. This work has, as case of study, the transport system in Cape Verde (Praia city); a bus company, operating in the city for more than 40 years, will provide the data for analyses. The study of the exploitation efficiency of the transport system will focus in the analyses of the data collected, after the definition of the data for collection, is defined how the data will be analysed and used in order to create the desired solution. In this paper is also defined the platform used for data collection. The definition and selection of the vehicle systems/components for data collection has been supported by engineers and mechanics with long experience and knowledge of the local situation as well as vehicles operation and maintenance. The information that, if collected and analysed correctly, can help transform the vehicle operation and maintenance, data collection can empower us to direct resources toward the modules that are in most pressing need of technical refinement. With this knowledge base, we will be able to use predictive analysis to identify what, how and where to improve the services and manage the vehicle maintenance and operation.

Keywords: vehicle maintenance, digitalization, data analyses

1. Introduction

With this work is intended to support the design of a system capable to provide changing from unsatisfactory to satisfactory situation of the vehicles operation and maintenance in developing countries by studding the case of Cape Verde (Praia City). The main target of this study is to support the creation of a system capable to make the exploitation process of public transport much efficient. Previous studies made by the authors have shown the importance of the study and development of a reliable transport maintenance in developing countries [2, 3]. From another studies made by the authors, focusing in the transport system in Cape Verde / Praia City, was possible to conclude that, the introduction of new vehicles technologies has been a high challenge for maintenance and vehicle operation in the city, compromising their reliability, there is need to create a system capable solve the existing problems [4, 5].

This study will analyse data collected from the selected bus company. The bus company support the public bus service in the city of Praia [7]; they have as target to bring a new concept of public transport in Cape Verde, for this they focus on few points as:

– everywhere, the bus service cover of the entire city of Praia. The bus company has at this moment 62 busses, all bus are monitored from the station using GPS. They cover 12 different blocks of bus lines in the city,

– ecologic, reducing paper printing with the use of prepaid. All buses in the fleet are equipped with an android device Telpo TPS586, which is a tablet equipped with an RFID reader and a printer Thermal. In this equipment is used to read the electronic card from users and to print the in time ticket from other passengers who does not have the electronic card. The Reviewers has a smartphone with two readers, one Infrared for Bar Code of Tickets and Another Reader RFID to read the electronic card. The electronic card has Radio frequency technology, this, can

be charged on the balconies, using a credit card or through the ATM machine, the payment is done using a personal recharge code. For those that has not the electronic card, they have the possibility to buy the ticket in time on the bus driver, with a paper receipt,

– communication, easier communication with the fleet. The bus driver has the possibility to know the location of the other busses giving them the real time information if there is more buses in the same line, and if they have some delay, this can allow them to control the number of empty busses or not efficient lines,

– integration, more integrated with customers and partners, the online platform allow the company to have faster and easier communication with the customers and partners. The company has partnership with many other local entities,

– online, online access to your data. The user has the possibility to create an online account where is possible to visualize all Payments in "My Account",

– satisfaction, increase of the general satisfaction of the client. According to some interview done in February 2016 (Tavares C.) the users are more satisfied with the development and modernization of the fleet.

The bus company is developing their services, the focus has been the fleet management and it is still under development, now the focus is in the fleet maintenance and operation in which this work is concentrated on. The bus company has a private maintenance workshop, although they use external services when necessary.

For this work, the proposed exploitation efficiency study, related to the data collected in the diagram presented at Fig. 1, the exploitation efficiency would focus on the availability, reliability, maintainability and engineering efficiency analyses. The diagram shows the strategy for the analyses of the input (data related to vehicles operation and maintenance) for the study of the exploitation efficiency of vehicles, in order to develop a solution that can allow the desired output. First, we will study the existing vehicle operation and maintenance by analyses of the data collected, after we will propose a solutions basing on the results of the analyses. In this paper, we will define the data necessary related to the vehicle exploitation, as well as the platform for the data collection. After this, we will point out the analysis necessary to undertake with the collected data and how is expected to use the results of the analyses.
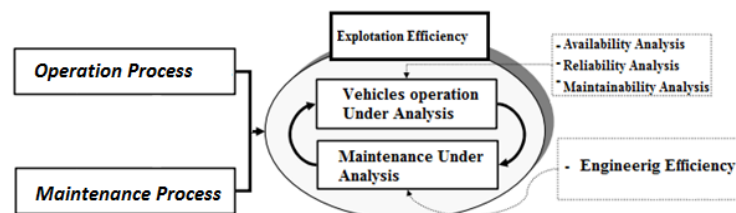

Fig. 1. Transport devices exploitation efficiency study

The data collected must be necessary and adequate for the exploitation efficiency analysis, for the creation of a maintenance strategy and engineering culture. In this work we will paying special attention in the problem related to new vehicles technology (vehicles with electronic fuel injection system), this, as shown in the previous studies [6, 8], has been affecting the vehicles maintainability and consequently operation.

The information that, if collected and analysed correctly, can help transform the vehicle operation and maintenance. By quantifying the strengths and weaknesses in the maintenance and operation of a vehicle, data collection can empower us to direct resources toward the modules that are in most pressing need of technical refinement. With this knowledge base, we will be able to use predictive analysis to identify what, how and where to improve the services and manage the vehicle maintenance and operation [9, 11].

The bus company under study is in development state, they are using many technologies to improve the flee service but no attention is given to the bus maintenance. At this moment they can

monitor the service of all vehicles of the fleet, the management of the delivery of the busses is in development state, also they use many telematics application for the users as electronic they can also manage the delay of the bus.

2. Data collection and analysis

In this chapter, we will specify the data for collection as well as the platform used to collect the data. In addition, we will be talking about how we will use the data collected, how we can manage the data collected and the analysis we want to perform.

In this work, the data collection and management will be thought the use of the PostgreSQL database and phpPgAdmin, connected to the operation system Linux. PostgreSQL is an open source object-relation database system. It is known for its reliability, data integrity and correctness. The database helps store binary large objects including audio, video and images. The phpPgAdmin is a very popular IDE in the open source development environment. It is a web-based administration utility, which supports both basic and advanced features of PostgreSQL. Apart from PostgreSQL, it is also used for over 60 different databases. It also enables you to perform some of the difficult tasks like listing all keywords reserved in the database and copying database table from one database to another database. It is a powerful tool, which integrates with all data types of PostgreSQL.
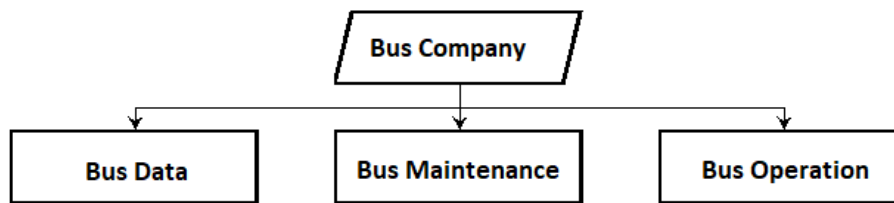

Fig. 2. Data necessary for the bus company

Tab. 1. Basic information for each bus

Bus Data								
Bus ID	Vehicle type	Brand	Model	Licence plate	Year of manufacture	Engine serial number	Fuel injection system	Starting operation date
1	BS	Isuzu	MV SWB 62 seater	ST-34-AT	2010-05-01	225488A	Mechanic	2016-08-04
2	BS	VW	VW T1 75 seater	ST-56-TF	2010-02-02	125467B	Electronic	2017-02-21
...	…	…	…	…	…	…	…	…
60	BS	Isuzu	MV LWB 67 seater	ST-21-AN	2010-05-09	226556C	Electronic	2013-05-08

Tab. 2. Data related to the bus operation

Bus Operation							
Bus ID	Date	Line Operation	Driver	Time start operation	Time end operation	Technical state	OBS
2	2017-06-20	3	Antonio Vaz	08:00	13:30	OK	Driver OBS
10	2017-06-20	7	Pedro Mendonca	09:00	15:00	Default	Driver OBS

Each section will have a group of information to be collected, as shown in the Tab. 1-3. The data presented in the tables are examples, the use of the vehicle ID (Bus ID) will allow us to better and faster identify the vehicle, is the first data to be introduced in the system, it is defined as key.

Depending on the maintenance strategy used in the vehicles, others information's are collected as shown in the Tab. 4 and 5. For the case of preventive maintenance, additional data will be collected according to manufacturer specifications. It is important to mention that, at this moment the bus company only use the corrective maintenance strategy.

Tab. 3. Data related to the technical state of the bus

Bus maintenance		
Bus ID	2	3
Date	2017-06-20	2017-05-01
Driver	Antonio Vaz	Pedro Monteiro
Corrective Maintenance	Yes	No
Preventive Maintenance	No	Yes
Place of Maintenance performance	SA Garage	Other
Vehicle Condition/ by driver	Late response	All fine
Conclusion Date	2017-06-20	2017-05-02
Down Time	2 h	1 day

Tab. 4. Corrective Maintenance Data

Corrective Maintenance	
Malfunction	Late response
Failure Cause	Battery failure
Affected system	Ignition system
Additional work	no
Used materials	none
Total cost	*$*

After collecting the data, analyses will be performed in order to better know and understand the system and quantify the strengths and weaknesses in the maintenance and operation of vehicles [10]. The analyses of the exploitation efficiency will be according to the following equation (1):

$$E_k = \frac{E_d}{L_{CC}}, \qquad (1)$$

where: E_k – Indicates the effectiveness of the system, E_d – Coefficient of the effectiveness of the operating system, L_{CC} – Total cost of the system Maintenance. We want to analyse the effectiveness of the system by analysing each operating system, in this case each bus.

The parameter L_{CC} will measure the cost related to preventive and corrective maintenance

$$L_{CC} = C1 + C2, \qquad (2)$$

where C1 represents the cost related to preventive maintenance, and C2 the cost related to corrective maintenance.

The parameter E_d, can be measured as $E_d = A \cdot R \cdot M$, where, A is the availability, R is the reliability and M the maintainability of the system [1]. The analyses of the Availability, reliability and maintainability can be done using many different methods. These analyses will be done after the data collection.

3. Conclusion

With this work, is intend to support the study of the exploitation efficiency of the bus fleet in Cape Verde (Praia City). The platform for the data collection at this point is under development

and test. At this point, we identify many other aspects that should be included to the system as the management of the vehicle state given by each driver. After finishing the platform, the data will be collected and analysed, as shown in the previous section.

It is important to point out, that the majority of the staff in the company has not enough knowledge to manage the created system for data collection. The make our work process slower, the majority of the population has basic knowledge related to informatics, and the platform is in English language, the official language is Portuguese, this bring some delay to our work.

The bus company has a system to manage the bus exploitation, they are preparing to create the user information related to the timing in each bus stop, but not all bus stop is ready with the required equipment. The management of the bus operation and maintenance is in lack of support. The bus maintenance has been affecting the fleet operation; many busses are in the garage waiting for solutions due to lack of required equipment's, tools and personal, with this, the company is losing money and efficiency.

The today existing technology in the company can be useful to our work; we can use the data from the fleet management in our analyses, especially for the availability analyses. The implementation of the existing telematics application in the fleet was made without any study.

Tab. 5. Preventive Maintenance Data

Preventive Maintenance			
Type of oil			
Mileage date of visit	*30000 km*		
Mileage next visit	*50000 km*		
	Checked	*Changed*	*Cost*
Coolant	x		$
Engine oil		x	$
Speed box oil	x		$
Break oil	x		$
Air Filter		x	$
Oil filter		x	$
Cabin Filter		x	$
Total Cost	$	$	$

4. Future work

Once well-defined the platform and starting the data collection we will be analysing the data, we will be analysing the data collected for each bus, every day, we want to find some tendency so the number of desired sample is not yet defined.

After analysing the data, we want to set a maintenance priority for the fleet. Each bus will be analysed carefully. The above-mentioned analyses (Availability, maintainability and reliability) will empower us to direct resources toward modules that are in most précising need for technical refinement, in this way we can elaborate a solution for each identified weakness. We will be able to point how and where to improve the service and manage the fleet maintenance and operation.

After definition of the solution for the fleet maintenance and operation, we will be analysing the data again to see if our solution is good; and for what has been the benefit for the fleet. Our platform will be in continuous development and improvement.

After having the data from the bus company, we will also analyse the maintenance strategy applied in others maintenance workshop in order to have other data related to vehicles maintenance in the city. We want to understand the behaviour of the local population and find the

real reason for the existing problem with maintenance and operation of vehicles with electronic fuel injection system. The analyses of the engineering efficiency will be done during this phase of the work.

Having all the results, we will be able to have enough data to design system capable to provide changing from unsatisfactory to satisfactory situation of the vehicles operation and maintenance in developing countries by studding the case of Cape Verde (Praia City).

Acknowledgments

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