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Overall Service Effectiveness on Urban Public Transport System in the City of Addis Ababa

Eshetie Berhan[1*]

[1]School of Mechanical and Industrial Engineering, Addis Ababa Institute of Technology, Addis Ababa University, P.O.Box: 385, Addis Ababa, Ethiopia.

Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Overall Equipment Effectiveness (OEE) concept has been practiced in the manufacturing sectors. However, there is no model so far in the service sector to measure its system performance. This paper is therefore tries to develop an Overall Service Effectiveness (OSE) model for service industries by extending the concepts from OEE model which is used in the manufacturing system. The OSE model was fitted and tested using data collected from the Anbessa City Bus Service Enterprise (ACBSE), Addis Ababa, Ethiopia. The findings of the study show that, the OSE of the ACBSE system is found to be low (41.83%) indicating that the overall service performance systems of the enterprise is very low as compared to the world class standard that is 85% to 95%. This is resulted from the fact that, the enterprise has exhibited low availability, poor performances and low passengers' satisfaction, which requires the enterprise to improve its operational plan so that it will improve its availability and level of customer satisfaction.

Keywords: Overall service effectiveness; urban public bus; performance; quality; availability.

**Corresponding author: E-mail: berhan.eshetie@gmail.com;*

1. INTRODUCTION

Overall Equipment Effectiveness (OEE) is a measure of the performance of a manufacturing unity or system by considering the Availability, Performance, and Quality as the three main parameters [1,2]. Within this context, OEE is considered to combine the operation, maintenance and management of manufacturing equipment and resources [3]. Further, considerable efforts have been made in the literatures in relation to the definition of OEE and its applications in various areas. In this regard various authors dealt on OEE as a tool for decision making, for profit improvement, and measure of performance [4-7]. Though OEE has been developed as a method to measure performance effectiveness, it has been improved and modified in practice in different approach and environment other than a manufacturing industry. For instance, Raouf [8] formulated a new metric for OEE measurement by giving different weight for the factors. Moreover, various authors also extended OEE to overall process effectiveness (OPE) that can encompass processes rather than a unit. They measured Overall Craft Effectiveness (OCE) as well as labor productivity [9-11].

Like any manufacturing or process industries, it is in fact that, effective maintenance system is also the backbone for the service sectors. To this effect, this paper attempts to develop a new performance measurement concept in the public transportation service that uses bus as a means of transport to achieve its goal. However, there has not been a study so far that used the concept of OEE to measure the performance of a service system. The study takes Anbessa City Bus Service Enterprise (ACBSE), as a case company and tries to extend the concept of OEE measurement mechanism to develop a new concept that is *Overall Service Effectiveness (*OSE) to measure the performances of the enterprise. Anbessa city bus is the only public enterprise in the city of Addis Ababa, Ethiopia that provides an urban public bus transport since 1943. It was started with 10 buses and four routes, however, as of July 2015, the enterprise provides its services from 3 central depots, 4 bus terminals, more than 120 routes, 16 check points and 1,500 bus stops throughout the city with an average number of 700 operational buses of various models. Though, its service has been expanded and tremendously increased from time to time, its performance remains below the world class standard in the public transport system [12,13]. The study in the year 2013 has revealed that, the enterprise has a major problem and low performance on the percentage load factor, its fleet utilizations and higher operating cost. According to the Eshetie et al. [12], both the percentage load factor and the fleet utilizations are less than the international standard by 20%. Therefore, this study tries to develop an OSE model to measure its performance.

2. LITERATURE REVIEW

Maintenance is the combination of all technical and administrative actions that intended to retain an item in, or restore it to, a state in which it can perform a required function [14]. And Like any processing or manufacturing industries, maintenance is the most imperative and significant elements in transportation enterprise. Moreover, maintenance cost is the second highest expense category of running cost of transportation enterprises, next to operational costs [15,16].

Most maintenance research works were being focused in the manufacturing industries. The scientific method of maintenance approaches dated back to 1950s and 1960s [17,18]. Since then, various maintenance concepts and models were developed. In most of the models, both expenses and welfares maintenance were calculated and optimum negotiations among the two were required. More recently, a very successful systematic method for establishing maintenance programs are Reliability Centered Maintenance (RCM) and Total Productive Maintenance (TPM) [19].

TPM implementations truly reduce manufacturing complex problem with a key objective of maximizing overall equipment effectiveness through the elimination or reduction of losses [20-22]. OEE measurement is a modern key performance indicator of machine or an integrated machines commonly used in the manufacturing industries. Especially in those that are implementing TPM, OEE is one of the pillars of TPM. It includes availability, performance rate and quality rate [19]. Mathematically the OEE is formulated as follow:

$$OEE = Availability\ (\%) x\ Performance\ (\%) x\ Quality\ (\%) \quad (1)$$

where:

$$Availability = \frac{Total\ Time\ Available - Down\ Time}{Total\ Time\ Available} x100 \quad (2)$$

$$Performance = \frac{Number\ of\ Units\ Manufactured}{Possible\ Number\ of\ Units\ to\ be\ Manufactured} x100 \quad (3)$$

$$Quality = \frac{Number\ of\ Unit\ Produced - Number\ of\ Defects}{Total\ Number\ of\ Units\ Produced} x100 \quad (4)$$

Moreover, various authors proposed different models to measure performances of a system. For instance, Mehdi et al. [23] used mathematical models on finding the optimal balance between costs and benefits of maintenance; Borgonovo, et al. [24] Monte Carlo simulation model that provides a flexible tool which enables one to describe many of the relevant aspects for plant management and operation; Thomas et al. [25] reliability model for scheduling and optimization of maintenance; Ahad et al. [26] system design and maintenance scheduling schemes that evaluates their effects on the overall system performance, and Dijkhuizen & Heijden, [27] develop optimal preventive maintenance interval that can be determined from an interval availability point of view, rather than from a limiting availability perspective.

However, so far, the OSE is not a common practice to measure the performance of service system due to the fact that OEE is focused on implementing TPM and RCM on tangible equipment. The attempt used by airlines companies, which considered as originating and exercising RCM even do not practice the techniques of OSE on their services. Therefore, the objective of this paper is to introduce a new approach in the service sector to measure OSE.

2.1 Overall Service Effectiveness Model

In this paper, OSE is modeled by analogy from OEE. Due to this reason, all the parameters of OSE is extended from the parameters of OEE and are explained in this section. OEE is commonly a measure of three major losses. Similarly, in this paper, the OSE is analogously developed and measured from the three major losses. The first loss is down time losses. In related to public transport, in this paper it is a measure of all down times that are related to employee shift, lunch break, and passenger demand fluctuation, extended time on dropping and alighting of passengers, road call maintenance, regular maintenance time, and all down time related to administrative, logistic, traffic congestion, and others.

The second loss is operational losses. In the case of OEE it considers all losses that are beyond or just after maintenance work. However, in the case of transport service, it is the difference between the targeted number of passengers to be transported based on the operational plan of the enterprise and the actual number of passengers transported in a given operational time horizon. This variation occurs mainly: Passenger demand fluctuation, unprecedented failure of buses, speed loss, variability on time plan and bus headway, etc.

The third type of loss is maintenance rework or quality loss. This is used to take into consideration time and material loss because of rework in relating to OEE. It is used to figure out how many maintenance reworks are being performed that brought down time and material loss in a considerable time period. In the same analogy as OEE, OSE measures the effectiveness of service quality based on the proportion of passengers' satisfaction level. This indicates that out of the total number of passengers actually transported by the enterprises, there are certain proportions of passengers who are satisfied with the service due to various factors. The dissatisfaction comes from variability on schedules, congested service during peak time, unprecedented bus failure, courtesy and treatment of drivers and ticket officers. The overall analogous model is shown in Fig. 1.

Therefore based on the analogy made on Fig. 1 and explanation in section 3, the three performance parameters of OSE are given in Eq(5) to Eq(7). Based on these equations and Eq(1) the performance of the ACSEB is evaluated and presented in Table 1.

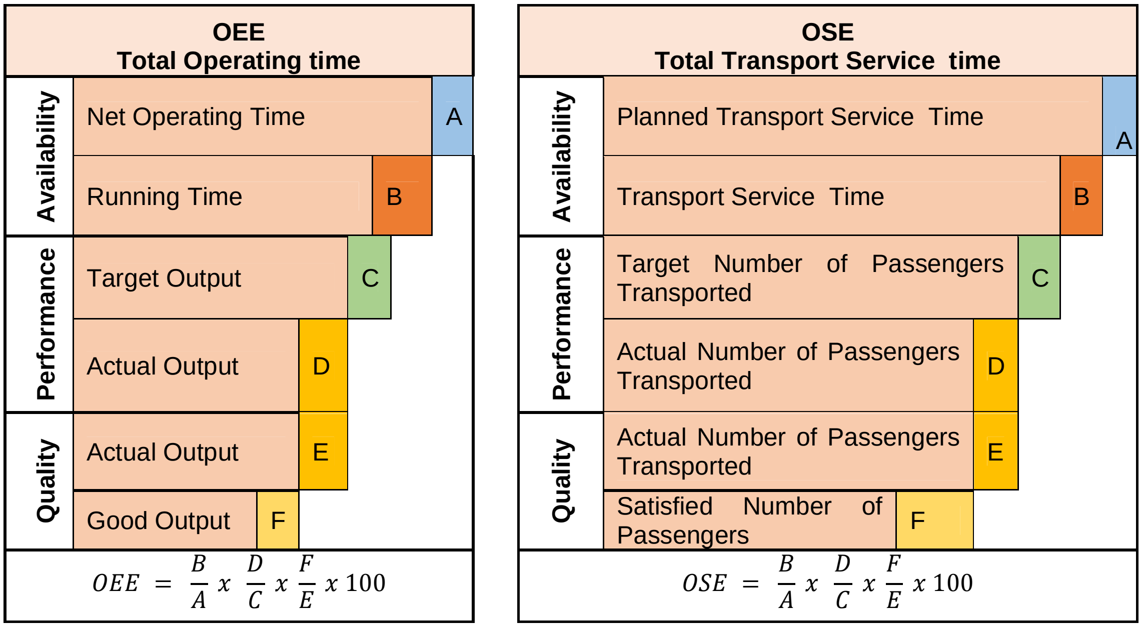

Fig. 1. The analogy model of OSE developed from OEE

$$Availability = \frac{Total\ \ Transport\ Serivce\ Time\ Available - Lost\ Transprt\ Time}{Total\ Time\ Available} x100 \quad (5)$$

$$Performance = \frac{Number\ of\ Passengers\ Transported}{Target\ Number\ of\ Passengers\ to\ be\ Transported} x100 \quad (6)$$

$$Quality = \frac{Number\ of\ Passengers\ Transported - Number\ of\ Dissatisfied\ Passengers}{Total\ Number\ of\ Passengers\ Transported} x100 \quad (7)$$

3. RESULTS AND DISCUSSION

Both primary and secondary data related to availability of transport service time, various losses of transportation service time, the planned and actual number of passengers transported, number of buses operating in a given schedule were collected. With this regards, the planned transport service, speed loss, the actual transport service time and the total daily trips made by each bus were also collected from the secondary data in monthly bases from the year 2010/11 to 2011/12 but the parameters are computed on daily basis. All the remaining data were collected from the primary sources. Based on the data collected from ACBSE, the average values for those parameters that are used in the model of OSE is analyzed and presented in Table 1.

In order to validate this model, the service operational time of the enterprise was taken as a basis for measuring its performance. The enterprise is planning to operate 17hrs (1020minutes) and transport 1050.44 passengers in a day. It is planned to operate from 6:00AM up to 23:00PM according to the planning horizon and operational plan of the enterprise. Moreover, the following bullets show that how some parameters are computed from the enterprise operational plan and the research assumptions.

- Total Target Transport Service Time = 17 hrs* 60 min/hrs= 1020 minutes
- Total lunch and shift change break = 1 hrs* 60 min/hr= 60 minutes
- Target passengers transported per day per bus = 1050.44 passengers per day per bus
- Total passengers Transported per day per bus = (total number of passengers transported)/ (the number of days in a month* total number of buses used in that month) see appendix.
- Quality = (total number of passengers transported per month)*(proportion of passengers satisfaction level divided)/ (number of days* no. of buses) see Appendix.

Table 1. OSE for ACBSE

Major service losses:	**Data**	**Comments and calculations**
A. Planned transport losses:	**(Minutes)**	
1. Planned lunch break & shifts change	60	Shift change for drivers and ticket officers , Daily lunch break for drivers and ticket officers
Total planned TST loss	60	
B. Downtime losses:*	**(Minutes)**	
2. Waiting for passengers	31.46	On the regular waiting time on bus stops
3. Waiting due to low demand	34.17	Buses are forced to wait long on low demand time
4. Road call maintenance	35.25	Due to failure there are road call maintenance
5. Average daily maintenance service time	29.79	Regular maintenance service time
6. Speed loss	25.04	Due to mixed traffic system and congestion
Availability losses: (A+B hours)	215.71	**1020-215.71 = 804.29; 804.29÷ 1020 x 100 = 78.85%**
C. Performance efficiency losses:	**Count**	passenger count
7. Target output	1050.41	Target passengers transported per day per bus
8. Actual output*	786.64	Actual passengers transported per day per bus
Sub total efficiency losses:		**786.64 ÷ 1050.41 x 100 = 74.89%**
D. quality and yield losses:	**Count**	passenger count
9. Actual output	786.63	Actual passengers transported per day per bus
10. Satisfied passengers*	546.23	From the appendix the mean satisfaction level is 53.04%
Sub total quality and yield losses:	229.47	786.63 -229.47 = 557.17satisfied passengers, **557.17÷786.63 x 100 = 70.83%**
Overall service effectiveness %		**78.85% x 74.89% x 70.83% = 41.83%**

**see appendix*

With in-depth analysis of each of the parameters, the OSE of the ACBSE is evaluated using the model. The findings show that transport service time available is 804.29 minutes out the total 1020 minutes. This implies that an availability of 78.85% of its total planned operational time. The company has lost 21.15% of its planned operational time every day.

Based on its target and actual output, the transport system performance of the enterprise is found to be 74.89%. This shows that on the average there are 25.22% of losses on the number of passengers transported on daily basis. Moreover, the level of quality in its service operation is about 70.84%. As shown in Table 1 and Appendix the level of customer satisfaction very low which is 53.04%. By taking all these inputs into account the OSE of the enterprise is found to be 41.83%. This implies that though the individual values of its availability, performance and quality are relatively above 70%, their combined OSE is very low. This show that the OSE of the Enterprise is relatively low as compared to the international world class standard as reported in Harsha et al. [27] which is 85% to 95%.

4. CONCLUSION

OSE is a new concept in the service industries and attempted the first time in this paper based on the analogy from the OEE model. The OSE model is tested on urban public bus transport system in Anbessa City Bus Service Enterprise (ACBSE), Addis Ababa, Ethiopia. The findings of the study show that the OSE of the enterprise is lower than the world class standard, which is 41.83% in its service provision. It can be concluded that the enterprise has losing 21.15% of its availability, 24.11% of its performance and 29.17% of unsatisfied passengers. In order to improve OSE it requires to improve all the three parameters. Therefore, the enterprise need to revise it service time and improve the availability of the transportation service time by improving its schedule, maintenance policy. This may lead the enterprise to revise its maintenance and operational policy in its service provision. Therefore it is recommend that the enterprise should improve its performances by implementing proper bus schedule techniques, customer handling system and maintenance planning which they subsequently improve its availability, performance and quality.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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APPENDIX

Daily performances of ACBSE

Years	Month	The mean daily values of (the monthly data are converted into daily and reported in this table)						
		Waiting for passengers	Waiting due to low demand	Road call maintenance	Maintenance service time	Speed loss	Average passengers transported	Passengers' satisfaction level
2010/11	1	40	40	34	30	22	732.08	0.46
	2	40	30	38	29	27	674.78	0.49
	3	36	27	36	39	24	697.84	0.61
	4	28	36	36	34	27	680.92	0.55
	5	30	37	31	30	27	664.29	0.5
	6	31	26	33	20	27	711.36	0.49
	7	27	36	33	27	26	692.47	0.52
	8	34	30	40	29	25	644.11	0.59
	9	25	39	38	33	30	718.26	0.52
	10	39	36	37	33	26	701.49	0.5
	11	31	32	33	31	23	767.70	0.56
	12	36	36	30	38	22	753.90	0.5
2011/12	13	29	27	40	30	23	860.81	0.57
	14	29	39	36	23	28	858.24	0.5
	15	25	31	38	32	28	950.96	0.64
	16	26	33	36	24	22	909.11	0.46
	17	32	32	39	24	30	892.25	0.49
	18	31	40	37	38	29	736.56	0.51
	19	40	34	33	27	24	932.71	0.6
	20	25	40	34	38	21	947.76	0.49
	21	38	38	38	29	20	862.98	0.5
	22	34	30	30	27	24	786.63	0.47
	23	32	35	36	30	21	780.45	0.59
	24	32	40	32	20	24	733.45	0.47

Years	Month	The mean daily values of (the monthly data are converted into daily and reported in this table)						
		Waiting for passengers	Waiting due to low demand	Road call maintenance	Maintenance service time	Speed loss	Average passengers transported	Passengers' satisfaction level
Min		25	26	30	20	20	644.11	0.46
Max		40	40	40	39	30	950.96	0.64
Mean		31.46	34.17	35.25	29.79	25.04	786.64	0.53
Std.		4.77	4.46	3.27	5.72	3.19	102.92	0.05

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