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RESEARCH ARTICLE

VEHICLES REPLACEMENT: A SUGGESTED POLICY

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ABSTRACT

At the point, which it becomes more expensive to extend the service life of vehicle than owning and operating a new one, it becomes economic to replace it by a new one, present less operating costs, less out of working periods and more income. However the procedure of replacement vehicles, after determining the optimal economic lifetime, are very useful, where decision makers are facing with complex tradeoffs involving economic, environmental, or policy impacts of fleet management decisions or regulations. This paper reports a scientific concept, for replacing or choosing vehicles. Several widely microbus vehicles run in ministry of health, ambulance sector, Egypt, are used in this study. The results indicated that each vehicle has its own history, so the best time to get rid of one vehicle is not necessarily the best time to get rid of other vehicles of the same age and type. In addition, the decision of replacement is part of a wider problem involving many factors other than depreciation and maintenance costs.

INTRODUCTION

Introduction introduces the main factors of replacement decision-making such as vehicle-operating lifetime, repair limit, depreciation and vehicle emissions discussed below.

Vehicle-Operating Lifetime

During vehicle-operating lifetime, elements are consumed or damaged, therefore, a periodical maintenance, repair, half-overhaul or full-overhaul is needed. The time used for these operations is a wasted time without generating any income. For example, planned maintenance occurs at known periods through the vehicle-operating lifetime, while the repair does not occur at periods but when damage has happened and it needs time to be completed. Year after year, the number of stoppage increases, and the vehicle income decreases. At a certain time, the amount of cost exceeds the income. This means that the vehicle owner losses money. Therefore, it is very important to determine the exact time to replace the vehicle.

Repair Limit

The actual maintenance costs differ from theoretical, predicted by the routine schedules (Eilon *et al.,* 1996; Berg, 1995). Therefore, when the repair cost is found to be greater than the estimated value of the vehicle (the repair limit) no further repairs should be undertaken and new one should replace the used vehicle. For example, if a vehicle damaged in an accident, an estimate of the repair cost is made and if that cost is greater than the estimated value of the vehicle, in its repaired state, then the vehicle is written off and not repaired. In the case of a large fleet of vehicles, the repair limit can be established by observing that the cost of actual repairs and going beyond the limit. The attention was paid to mileage than age, but recently interest has shifted from the problem of determining the optimum life to financial problems of deciding on the best strategy for acquiring vehicles (Jhang, 1969; Hastings, 1969; Mahon, and Bailey, 1975).

Depreciation

Depreciation is the reduction in its value. The way in which a vehicle depreciates in value from one year to the next depends on its age and condition. There are several approaches to this problem listed as below.

1. Straight-line method; it assumes the vehicle to have a life of x years and depreciates it by 1/x of its purchase price each year.
2. Reducing-balance method; it depreciates a vehicle by a fraction of its residual value each year. In theory, this approach implies an infinite life, but in practice, this life is cut short when the balance reaches some arbitrarily low value equivalent to the scrap value of the vehicle.
3. Sum-of-years digits method; this method takes a life of, say, five years and then takes the sum of years (5 + 4 + 3 + 2+1 = 15) and depreciates 5/15 in the first year, 4/15 in the second, 3/15 in the third, 2/15 in the fourth and 1/15 in the fifth.

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Vehicle Emission

Decision makers are faced with complex tradeoffs involving economic, environmental, or policy impacts of fleet management decisions or regulations, where the problem of car emissions (pollutants and noise) is intensified in cases (Miguel *et al.,* 2011). The average age of the car fleet is relatively high, since older cars not only produce higher emissions but also fail to use new and environmentally friendlier technologies. Supporting the efficient replacement policies to minimize the vehicle noise and pollutants will increase the vehicle operating costs. This leads to a change in the database used to get the efficient solutions. Therefore, it is important to give idea about these elements that could be change using decision support Systems. The permitted emission level on retest and in-use vehicles is about 20 % higher than the permitted level for new vehicles.

Replacement Decision Making

There are two kinds of error in making the decision of replacement, one is to replace vehicles too soon, and the other, is to replace the vehicles too late. Therefore, companies must adopt maintenance strategies, such as planned maintenance or condition monitoring, to maximize the total profit or minimizing the total cost of maintenance. In addition, the success of the company to do that should be builds on correction planning (Kobbacy and Nicol, 1994). The use of a statistical method to evaluate the expected life has the advantage that replacement time and failure probability of the parts can be predicted in advance (Azrulhisham *et al.,* 2010; Cleroux and Tuquin. 1979). The decision-making is short-cycle policy decision or long-cycle, the short-cycle is better than the long-cycle because there is a ready market for four or five year's old vehicles (Hyung *et al.,* 2003). The vehicle replacement problem solution can be done by many different techniques as; the enumeration (Rai and Singh. 2003), the shortest path, and the integer programming (Rai and Singh. 2004), regeneration point approach and the dynamic programming technique (Pillay, 2001). In some cases, the replacing of vehicles depend on the lowest purchase price, this may lead to a big loss of money. Anyway, repairing or replacing operations without planning are very complicated and very expensive, therefore, it is important to replace or choose vehicles according to a scientific concept. The objective of this paper is to report a scientific concept to replace or choose vehicles in case of the availability of operating costs and vehicle purchase price.

Data Source of Paper

Actual data for vehicles used in the article, such as type, purchase price, model, service date and total operating cost, as input for the proposed concept, taken from the ministry of health, ambulance sector, Egypt. The vehicles names start with the capital characters M, T, N, D and F (Table 1).

Algorithm and Formulation

This section describes the algorithm of suggested model factors. The policy of it, is a function of one variable, namely the total operating cost/year [TOC], which is normally, not available in vehicle fleets documents. Therefore, it is predicted by the model, by plotting the available and makes a best fit.

Model Summary

The suggested model is formulated as follow;

(1) C= rP, where, r is rate of inflation and =1.15 (Christ, and Goodbody, 1980), P is the vehicle purchase cost.
(2) D*=0.25C, where D*is depreciation/year (Christ and Goodbody,1980).
(3) SV= 0.75C, where SV is the scrape value of vehicle at the end of year.
(4) TOC=O+D*, where O is the operating cost/year
(5) $\sum TOC_n/n = \left(\frac{O_n + D_n}{n}\right)$, where $\sum TOC_n/n$ is the average accumulative operating cost and , n is number of service years.
(6) Economical service years, ESY is the turning year of ∑TOC n/n from decrease to increase.

Model Application

The application of six steps stated before on vehicle type D to calculate SV, ESY and ∑TOCn/n for three years, as an example, listed as below.

First Year

Step 1: $C_1 = rP = 1.15x84727 = 97436$ *L. E*
Step 2: $D^*_1 = 0.25C_1$ =24359 L. E.
Step 3: $SV_1 = 0.75C_1$ =73077 L. E
Step 4: O_1 from Table 1, =5500 L. E
Step 5: $TOC_1 = O_1 + D^*_1$ =29859 L. E
Step 6: $\sum TOC_n/n = \left(\frac{O_n + D_n}{n}\right)$=29859 L. E/year

Second Year

Step 1: $C_2 = 1.15\ SV_1$ =84038 L. E
Step 2: $D^*_2 = 0.25C_2$ =21009 L. E.
Step 3: $SV_2 = 0.75\ C2$ *=63028 L. E.*
Step 4: O_2 from Table 1, =7000 L. E
Step 5: $TOC_2 = O_2 + D^*_2$ *=28009 L. E*
Step 6: $\sum TOC_n/n = \left(\frac{TOC_1 + TOC_2}{2}\right)$ = 28934 L. E

Third Year

Step 1: $C_3 = 1.15SV_2$ *=72482 L. E*
Step 2: $D^*_3 = 0.25C_3$ =18120 L. E.
Step 3: $SV_3 = 0.75\ C3$ *=54361 L. E.*
Step 4: O_3 from Table 1 =8000 L. E
Step 5: $TOC_2 = O_3 + D^*_3$ *=26120 L. E*
Step 6: $\sum TOC_n/n = \left(\frac{TOC_1 + TOC_2 + TOC_3}{3}\right)$ = 27996 L.E….etc

(Table 2 show the calculation of D, SV, O, TOC and $\sum TOC_n/n$ from year 4 to year 16).

Table 1. Vehicles (V) type, purchase (P) prices, models, Operating costs of studied vehicles and service (S) date

V. Type	V. Model	P. Price, LE	S. Date	Operating costs, L.E					
				1993	1994	1995	1996	1997	1998
M	Sprinter	100000	1992	8500	9000	12500	10200	10400	-
F	Transit	106000	1996	-	4000	5000	6300	-	7500
T	Hiace	90360	1994	-	7500	7400	-	9500	8000
D	Delta	84727	1993	5500	-	8000	10000	11000	-
N	Nissan	88000	1995	-	8000	10900	-	11000	12500

Table 2. Turning Point of vehicle type D

Y	C	SV	O	D*	TOC	$\sum TOC_n/n$
1	97436	73077	5500	24359	29859	29859
2	84038	63029	7000	21009	28009	28934
3	72482	54363	8000	18120	26120	27996
4	62516	46888	10000	15629	25629	27404
5	53920	40441	11000	13480	24480	26819
6	46506	34880	12500	11626	24126	26370
7	40111	30084	14000	10028	24028	26035
8	34596	25947	15000	8649	23649	25737
9	29839	22379	16500	7459	23959	25539
10	25736	19302	17500	6433	23933	25379
11	22197	16648	18500	5549	24049	25258
12	19145	14358	20000	4686	24686	**25210**
13	16512	12384	22000	4127	26127	25281
14	14241	10680	23000	3560	26560	25372
15	12282	9211	24500	3070	27570	25518
16	10593	7944	26000	2648	28648	25714

Vehicles Total Operating Cost

Figures 1-5 show both actual TOC for the five vehicles, taken from the ministry of healthy (marked points) and predicted TOC from the best fit for the actual values, to cover the 18 years study range.

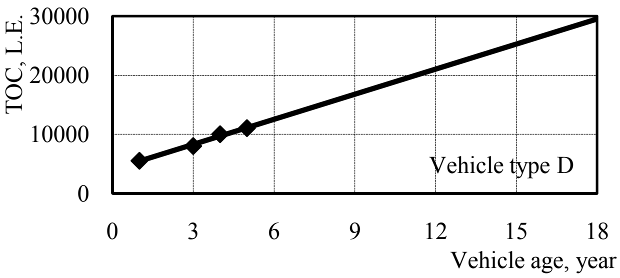

Fig. 1. Influence of vehicle age on actual and predicted TOC, for vehicle type D

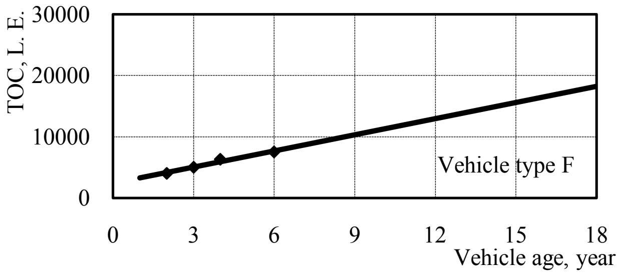

Fig. 2. Influence of vehicle age on actual and predicted TOC, for vehicle type F

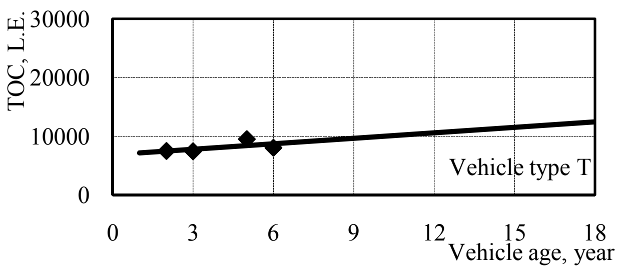

Fig. 3. Influence of vehicle age on actual and predicted TOC, for vehicle type T

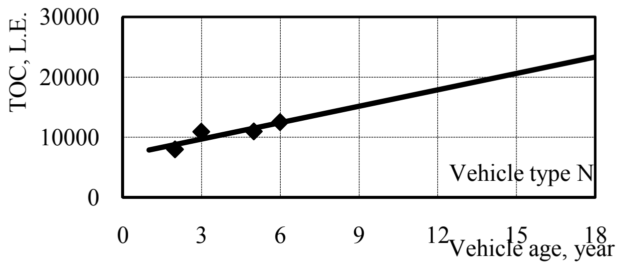

Fig. 4. Influence of vehicle age on actual and predicted TOC, for vehicle type N

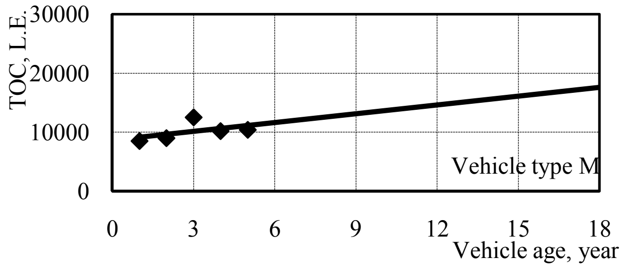

Fig. 5. Influence of vehicle age on actual and predicted TOC, for vehicle type M

Vehicles Scrap Values (SV)

Figures 6-9 show SV for different types vehicles (F, N, T and M), while values of SV for vehicle type D is clear in the Table 2.

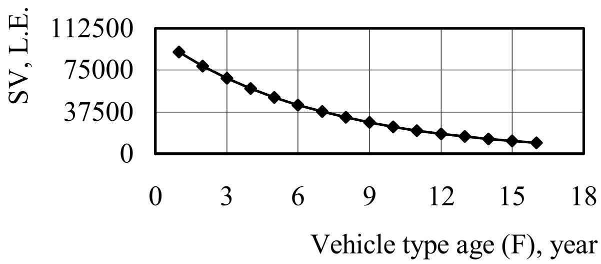

Fig. 6. Influence of vehicle age on SV for type F

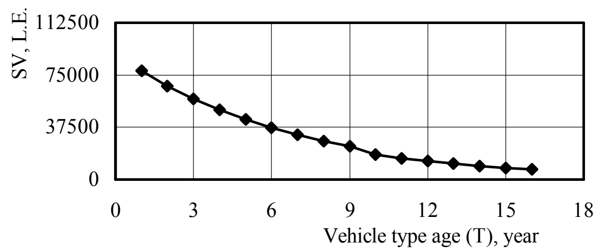

Fig. 7. Influence of vehicle age on SV for type T

Average Accumulative Operating Cost ($\sum TOCn/n$)

Turning of $\sum TOCn/n$ from decrease to increase considers the economical service years (ESY). It is 12 years for D type

(Table 2). By applying the model on the rest of vehicles, as shown in Figures 10-13, ESY for F is 9, both T and N has the same ESY of D type (12 years), while M is 15 years.

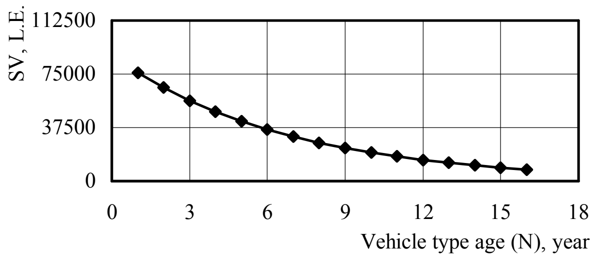

Fig. 8. Influence of vehicle age on SV for type N

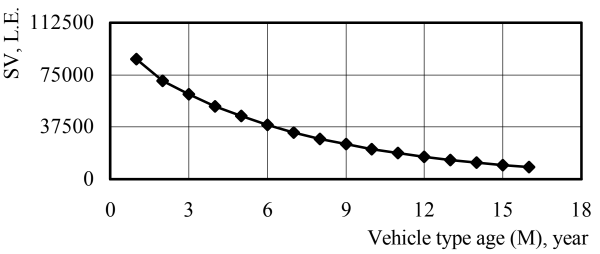

Fig. 9. Influence of vehicle age on SV for type M

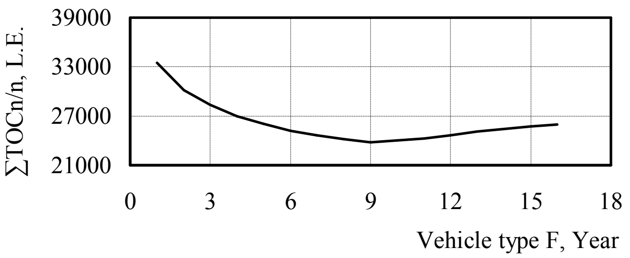

Fig. 10. Vehicle age and ∑TOC n/n for type F

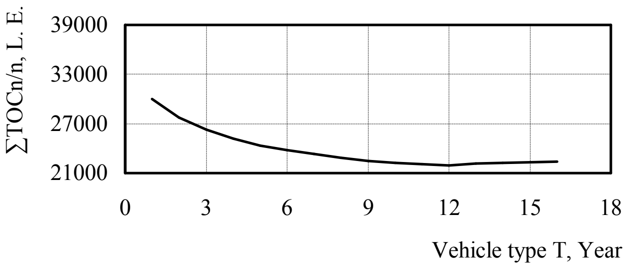

Fig. 11. Vehicle age on ∑TOC n/n for type T

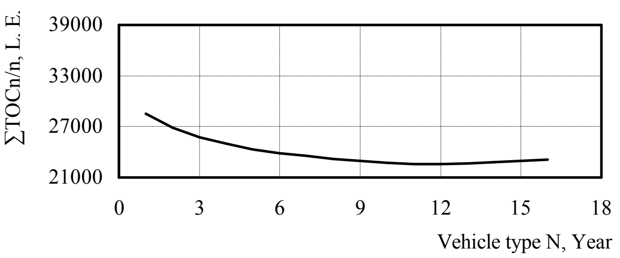

Fig. 12. Vehicle age and ∑TOC n/n for type N

RESULTS

ESY Results

Vehicle type M has 15 years ESY, whereas F has 9 and the other types lie between the both (Figure 14).

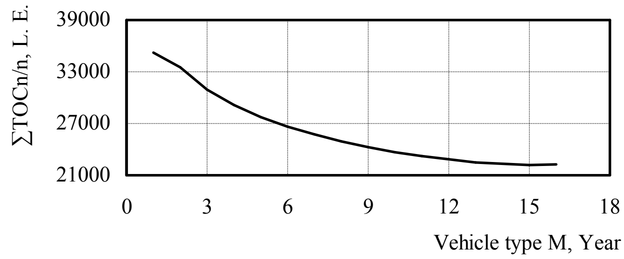

Fig. 13. Vehicle age and ∑TOC n/n for type M

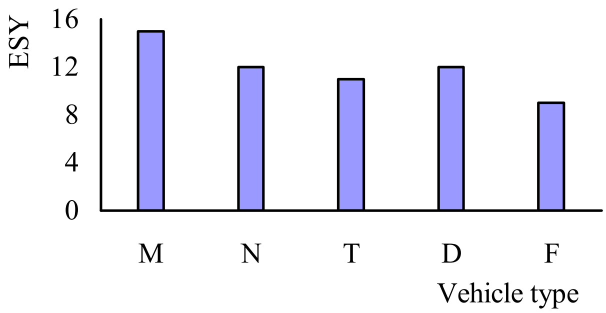

Fig. 14. Vehicle type and ESY

SV Results

Vehicle type M has the lowest value of SV, at its ESY, relative to the others, whereas F has the largest value, the other types lie between the both (Figure 15).

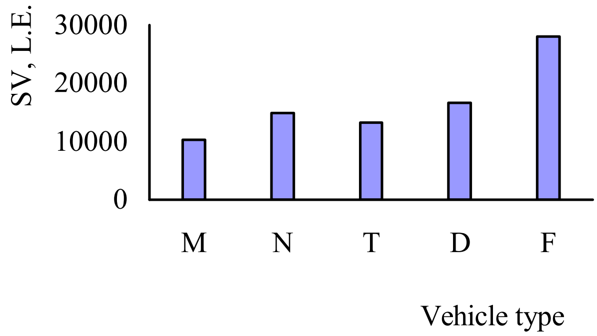

Fig. 15. Vehicle type and SV

∑TOCn/n Results

Vehicle type T, has the minimum value of ∑TOCn/n relative to the other microbuses, whereas the vehicle type D has the largest value, other types of vehicles lie between them (Figure 16).

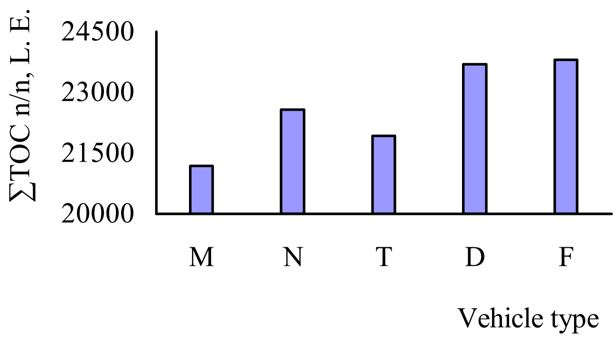

Fig. 16. Vehicle type and ∑TOC n/n

CONCLUSIONS

Three different conclusions on replacement decision-making listed below.

(1) The best time to get rid of one vehicle is not necessarily the best time to get rid of the other, of the same age and type.
(2) The replacement decision is part of a wider problem involving many factors other than depreciation and maintenance costs, such as composition of the vehicle fleet, age profile, interest rates... etc.
(3) The model was formulated on the data of ambulance vehicles, so the study results may change if the same fleet is used in other application.

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