Development of Vehicle Replacement Programme for a Road Transport Company

A. Offiong
Akpan, W.A
Ufot , E.

Mechanical Engineering Department
University of Uyo
Nigeria

Abstract

This paper discusses a practical replacement method for a transport company. A vehicle annual maintenance cost and depreciation costs were formulated and a replacement model that takes into account of the value of money was applied to determine a suitable replacement interval for various groups of vehicle. A fare model was formulated to determine appropriate fares that accommodate a profit margin and successful vehicle replacement programme.

Keywords: Vehicle replacement, maintenance cost, fare charges, transport management.

Introduction

Transport Corporation in most developing countries are still at a rudimentary level when the fleet sizes are compared with those in advanced Nations .As the fleet size of the system increases, the complexity of the transit operation management tool increases and more efficient management tool that encompasses market and operational coverage, fleet utilization, quality of services, financial control, personnel management and replacement management are required.

The replacement problem usually involves a required service provided by one or more assets over a finite time horizon. The decision is usually to determine the replacement schedules for individual assets so that a particular measure of economy is optimized (Karabakal et al, 1994).Normally, it is the present value of the asset that is to be optimized. A replacement schedule specifies-whether to keep an existing asset (the defender) or to replace it immediately with one of the new assets current challengers; a sequence of future challengers to be installed after the current decision; and how long each asset in the sequence is kept in service. A lot of work has been done on replacement problems, these include Anukam(1987), Etuk, (1986), Kowada(1983), Schwart and Mcnamara(1983), Christer and Goodbedy(1980), Luke and Muhleman(1979) and Kent (9170). The financial control problem usually involves determination of appropriate fares for the various vehicles on the various routes. It also includes annual, monthly, weekly and daily financial appraisals and other performance calculators for mass transit system. Only few works have been done in this area Bablola(1995),Padam (1984), Hamburger(1982) and Vuchic (1981).

The main purpose of this research is to present a replacement model based on competing factors like maintenance cost, salvage value and interest on capital .The study will further progress to examine the existing fare charged by the company, the operating costs and with a projected profit level propose a fare transport charges for different routes that will ensure capital recovery.

Models and Theories

The replacement model assumes that the vehicle is replaced with an identical vehicle and planning horizon infinite. Offiong (2001) assumes that:
That a machine's salvage value function S (T) will generally be given in the form:

$$S(T) = b_s T_s^{\,n} \qquad 1$$

A machine's maintenance cost function m (t) will generally be of the form:

$$m(t) = a_m + b_m t^{n}{}_m \quad 2$$

The replacement time is given by:

$$K(T) = \frac{A - b_s T^{n_s} e^{-rT} + a_m T e^{-rT} [\{b_m T^{n_{m+1}}\} / n_{m+1}] e^{-t}}{1 - e^{-r\{T+J\}}} \quad 3$$

Where

A= replacement cost of the machine

i = interest rate

S=inflation rate

b_s = Depreciation factor

n_s = Accounts for the degree of non-linearity of linearity of the maintenance cost function

a_m = Maintenance cost of the machine at time t=0(when the equipment is brand new)

b_m = Maintenance increment factor

n_m = Accounts for the degree of non-linearity or linearity of the maintenance cost function

T= Optimal replacement interval

K (T) = Total discounted maintenance cost

t=continuous time from purchase

$R = \frac{1}{[\{1+i\}\{1+S\}}$ =discount factor

J= installation cost=0

The annual sum to be paid by the driver in any group to recover the investment is given by:

$$As = [\{P+1\}[Ac + T_r\{F_e + M_c + S_c + R_e) / T \quad 4$$

Where As = Annual sum

P=Expected profit

T_r = Optimal replacement period

F_e = Annual cost of fuel

M_e = Annual cost of maintenance of the vehicle

S_e = Annual cost of staff salary

R_e =Annual cost of rent

n= number of trips possible per day

m= number of passengers the vehicle can carry per trip

T= Time {year, month, week and day)

The Economic fare is E_f :

$$E_f = [\{P+1\}[Ac + T_r\{F_e + M_c + S_c + R_e) / Tnm \quad 5$$

Methodology

For the purpose of this replacement analysis the vehicles were grouped according to their routes and the types of vehicle used. The routes plied by the company and the types of vehicle are shown in table 1.The name of the company use for the study has been retained for confidential reasons. For group 1 vehicle, only details of the maintenance cost of Wagon 1, the lead vehicle of the group will be established. This sampling is necessary because of the excessive data involved in trying to establish the detailed maintenance cost record of all the 30 vehicles used in the study. This approach was applied to other groups. The sampling is justified since all the vehicles in the same group are of the same make ad are plying the same route- operating under the same conditions. A lead vehicle in a group is the vehicle with the median total maintenance cost in the group. The company has one manager, three supervisors and secretaries. The operational base is on rent. The vehicles are assumed to operate on 360 days per year, the assumed interest rate is 32% and the expected profit margin is 20%

Results and Discussion

Table 1 shows vehicle groupings routes ages and the existing fares and table presents the yearly salvage value and maintenance cost. These were computed from data using equations 1 and 2 respectively.

Table 1: Groupings of Vehicles with Existing Fares

Group	Vehicles	Route	Age	Existing Fare(Naira)
1	Wagon 1-4	Uyo-Aba	6	800
2	Mini-Bus	Uyo-Aba	6	750
3	Luxury bus	Uyo-Lagos	6	4600
4	Wagon 1-4	Uyo-Calabar	5	750
5	Mini-Bus	Uyo-Calabar	5	700
6	Luxury bus	Uyo-Abuja	5	4600
7	Wagon 1-4	Uyo-Portharcourt	4	1500
8	Mini-Bus	Uyo-Portharcourt	4	1200
9	Luxury bus	Uyo-Kaduna	4	5150

Table 2: Salvage Value and Maintenance Costs Analysis

Group	Salvage value/maintenance cost	Years					
		0	1	2	3	4	5
1	Salvage value	2000	333.0	203.6	152.6	124.4	106.2
	Maintenance cost	92	95	112.2	153.5	227.8	342.8
2	Salvage value	3000	530.0	328.5	248.3	203.6	174.6
	Maintenance cost	147.0	151.5	178.3	244.5	365.3	554.7
3	Salvage value	31000	21000	12749.0	9521.2	7739.9	6591.1
	Maintenance cost	5450.0	5655.0	6736.7	9218.1	13526.3	20039.0
4	Salvage value	2000	333.0	203.6	152.6	124.4	106.2
	Maintenance cost	92	95.1	113.0	156.3	234.2	355.3
5	Salvage value	3000	530.0	328.5	248.3	203.6	174.6
	Maintenance cost	147.0	151.5	178.7	246.0	369.3	563.1
6	Salvage value	31000	21000	12749.0	9521,2	7739.9	6591.1
	Maintenance cost	5450	5655.9	6736.7	9218.1	13526.3	20039.0
7	Salvage value	2000	333.0	203.6	152.6	124.4	106.2
	Maintenance cost	92.0	95.2	113.3	157.3	236.5	359,6
8	Salvage value	3000	530.0	328.5	248.3	203.6	174.6
	Maintenance cost	147.0	151.5	179.7	250.7	382.5	591.8
9	Salvage value	31000	21000	12749.0	9521.2	7739.9	6591.1
	Maintenance cost	5450.0	5655.0	6745.7	9259.7	13639.0	20275.7

The indexes in equations 1 and 2 were estimated using regression analysis. The proposed Replacement ages from group 1-9 are:10,9,3,11,9,3,10,9 and 3.However the current ages of the vehicles from group 1-9 are:6,6,6,5,5,5,4,4 and 4.

Table 3: Parameters Used for the Determination of Economic Replacement Intervals

Group	i	Parameters					
		A	b_s =	n_s	a_m	b_m	n_m
1	0.32	2000000	333	-0.71	92	3.0	2.75
2	0.32	3000000	530	-.0.69	147	4.50	2,8
3	0.32	31000000	21000	-0.72	5450	205	2.65
4	0.32	2000000	333	-0.71	92	3.10	2.76
5	0.32	3000000	539	-0.69	167	4.52	2.81
6	0.32	31000000	21000	-0.72	5450	205	2.65
7	0.32	2000000	333	-0,71	92	3.15	2.76
8	0.32	3000000	530	-0.69	147	4.53	2.85
9	0.32	31000000	21000	-0.72	5450	205	2.66

The replacement age is therefore obtained from equation 3 and presented in table 4

Table 4: Proposed Replacement Interval for Vehicles in the Company

GROUP	Vehicle	Route	Age	Replacement intervals in years
1	Wagon 1-4	Uyo-Aba	6	10
2	Mini-bus 1-4	Uyo-Aba	6	9
3	Luxury bus 1-2	Uyo-Lagos	6	3
4	Wagon 5-8	Uyo-Calabar	5	11
5	Mini-bus 5-8	Uyo-Calabar	5	9
6	Luxury bus 3-4	Uyo-Abuja	5	3
7	Wagon 9-12	Uyo-Portharcourt	4	10
8	Mini-bus 9-12	Uyo-Port Harcourt	4	9
9	Luxury bus 5-6	Uyo-Kaduna	4	3

With the replacement age of the vehicle known, an economic fare based on expected profit of 20% is computed using data in table 5 and the results are presented in table 6.The Economic fare is quite lower then the current fare as shown in table 1 which shows that the company is operating above the 20% margin. It is important to note that table 5 was obtained from continuous operations of the vehicles for 360 days per year which is unlikely. Thus the current fares may not be out of place because of non-continuous operations, poor roads, inflationary trend and multi-tax system and incentives.

Table 5: Parameters Used In Fare Determination for the Vehicle

Group	P	Ac	Try	Fe	Mc	Se	Re	n	m
1	0.2	500	10	2880	630	1530	160	4	9
2	0.2	500	9	4320	826	1820	301	4	18
3	0.2	500	3	12400	7200	2970	1800	1	59
4	0.2	500	11	3600	819	1530	160	4	9
5	0.2	500	9	5760	844	1820	301	4	18
6	0.2	500	3	12400	7200	2970	1800	1	59
7	0.2	500	10	3600	668	1960	160	4	9
8	0.2	500	9	5760	902	1820	301	4	18
9	0.2	500	3	1440	7200	2470	1800	1	59

Table 6: Expected Revenue and Economic Fare

Group	Vehicle	Route	Annual Revenue	Monthly Revenue	Weekly Revenue	Daily Revenue	Economic Fare
1	Wagon 1-4	Uyo-Aba	6300000	525000	121154	17500	486
2	Mini-bus 1-4	Uyo-Aba	8787067	732256	168982	24409	339
3	Luxury bus 1-2	Uyo-Lagos	29444000	2454667	566231	811787	1386
4	Wagon 5-8	Uyo-Calabar	7485345	615445	142026	20515	570
5	Mini-bus 5-8	Uyo-Calabar	10536666	878055	2022628	29269	407
6	Luxury bus 3-4	Uyo-Abuja	29444000	2453666	566231	81789	1386
7	Wagon 9-12	Uyo-PH	7725600	643800	148569	21460	596
8	Mini-bus 9-12	Uyo-PH	106062667	883856	203967	29462	409
9	Luxury bus 5-6	Uyo-Kaduna	31844000	2653667	612385	88456	1499

Conclusions /Recommendations

The vehicle replacement model presented shows that the company is on a good tract. This
Model has provided a sound analysis to evaluate the performance of the operations of the company and can serve as a blue print for road transport industries in developing countries. This model can be extended to cover transportation in marine industries and is highly recommended.

References

Anukum, J.C. (1987): ‘’Vehicle Replacement Models’’ A Case study of the University of Nigeria, Nsukka, Masters Thesis, Department of Statistics, University of Nigeria, Nsukka.

Babalolo, A. (1995): Trans Seal- A Mass Transit Performance Calculator for Developing Nations, Nigerian Society of Engineers Technical Transaction, OL.30, No.4, PP. 24-28.

Christers, A.H. and Goodbody, W. (1980): Equipment Replacement in an Unsteady Economy’’, Journal of Operational research Society, 31,497-506..

Etuk, U.H. (1986):’’On vehicle Replacement Models: A case Study Adapted to a small Scale Transport Company’’. A Masters, Thesis, Department of Statistics, University of Nigeria, Nsukka.

Glasser, G.J. (1967): The Age Replacement Problem; Technimetrics, Volume,9.83-91.

Hamburger, W.S.; Keefer, L.E. and MaGrath, W.R. (1982): ITE Transportation and Traffic Engineering Handbook’’ Prentice –hallInc-Second Edition

Karabakal, N.; Lohmann, J.R. and Bean, J.C. (1994): Parallel Machine Replacement underCapital Rationing Constraints’’ Management Science, Vol.40, No.3, 305-319

Kent, A. (1970): The effect of Discounted Cash Flow and Replacement Analysis, Operations Research Quarterly, Vol.2i, 113-117.

Luke, D.H. and Mullemann, A.P. (1979):’ An Equipment Replacement Problem’’, Journal of Operational Research Society, Vol. 30.405-411.

Nakagawa, T. and Kolawada, A. (1983): The Decisions to repair or scrap a machine’’, Operational Research Quarterly, Vol.25, 99-110.

Offiong, A. (2001): Determination of optimal Replacement Period for a group of Machine ’Nigerian Journal of Engineering Management, Vol.2, NO.4, pp.74-79

Padam, S. (1984) ‘’ Performance criteria for Public Transport Organization I Developing Countries- The Case of Bus Transport in India’’ Conference Proceeding Second Canadian Seminar on System Theory for Civil Engineer. University of Calgary, Alberta Canada

Schwartz, E. and McNamara, J.R. (1983): The optimal Replacement Cycle given An Efficient

Resale Market for Used Assets’’. The Engineering Economists, Vol.28, 91-100

Vuchie, V.R. (1981): ‘’Urban Public Transport System and Technology-Prentice Inc. New York.