

ACTUAL SITUATION OF BUS FLEET RENOVATION IN CONDITIONS OF THE SLOVAK REPUBLIC

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1. Introduction

The problem of fleet renovation of the Slovak Bus Service /SAD/ has been discussed in different relations already for several years. It was the subject of scientific considerations during the time of former Federation and it has remained topical also after its splitting. Levels of discussion this problem are different and reasons for it are several.

Bus fleet renovation has become the subject of business plan of three establishing Slovak producers, the spotlight of several foreign bus manufacturers and their Slovak agents, representatives of respective state administration authorities, first of all ministries of economy, transport, posts and telecommunications and also interests of potential SAD privatisers.

2. Fleet renovation

Bus fleet renovation may be carried out by means of three ways mentioned hereunder:

2.1 Fleet renovation – by maintenance

Scheduled maintenance specifies not only when and which operations are to be carried out, but also their technology and technological equipment at the place of work. Scheduled repairs require necessary machinery and instrumentation equipment of the place of work, spare parts supply and adequate storage facilities.

Maintenance and repair system can be defined by the following:

- Range and content of scheduled maintenance operations,
- Operation periodicity, levels of maintenance and their aggregation,
- Demanding maintenance and duration of maintenance levels.

Scheduled maintenance system is divided according to types of work to:

- Daily operation and inspection of vehicles
- Periodical operating inspection
- Scheduled regular maintenance
- Seasonal maintenance

2.2. Fleet renovation – by repairs

This is the most frequent way of vehicle fleet renovation nowadays. SAD companies carry out small and medium repairs or overhauls either in own workshops or in special repair shops. Repairs include parts or groups of vehicles.

Individual parts during repair after disassembly are divided into two basic groups:

- Parts, damage to which is not exceeding allowable value,
- Parts, damage to which exceeded allowable value.

The parts, damage to which exceeded allowable value may be returned back to the operation only in case if damages from the previous operation were removed and their repair was carried out. The special term „renovation“ is used for the repair of either the part or the unit, which cannot be further disassembled because of its qualitative difference from the repair of higher assembly groups. The term renovation is considered equivalent to the term „repair of the part“. From technical aspect it is possible to define that the basic task of renovation is to renew functional properties of the damaged part and ensure its required service life.

- Recover original dimensions and geometric form of functional surfaces of the part by recovery of required properties changing the functional surface dimensions (by repair of the part to the corrective dimensions). Fig. No.1.

Limited service life is guaranteed for the vehicle, on which medium repair or overhaul was carried out (depending on the range of the repair). Failure rate of the vehicle will be decreased as well as operating costs. Technical and economic aspects determining the economic effectiveness are decisive criteria for repair of the vehicle.

2.3 Fleet renovation – by replacement for new buses

This way of renovation is financially demanding as it requires high investments. SAD companies at present have neither own financial resources nor sufficient subsidies from the state budget. As the vehicle fleet is obsolete and greater part is depreciated the depreciation as the financial source of simple reproduction are very low. As an example we present here below the amount of depreciation in 1999.

As buses are being depreciated for the period of 6 years the yearly depreciation rate is 17% (regular depreciation). Depreciation amount is in due proportion to the acquisition cost of the bus. The bus cost in 1999 is almost doubled against the cost in 1994 and therefore it is necessary to calculate partial depreciation for buses purchased from 1994 to 1999.

Tab.1 List of depreciation amount in respective years

Year	AC [SK]	N	r [%]	PYD [SK]
1994	1 860 000	89	17	28 141 800
1995	1 883 300	211	17	67 553 971
1996	2 142 000	93	17	33 865 020
1997	2 800 000	46	17	21 896 000
1998	2 850 000	124	17	60 078 000
1999	3 180 000	39	17	21 083 400
Total				232 618 191

AC – bus acquisition cost,
 PYD – partial yearly depreciation,
 n-number of buses,
 r- depreciation rate

After summary of partial depreciation we get total depreciation for the year 1999, which makes **232 618 191 Sk.** This sum would be much higher if depreciation are formed by more buses. In 1999 only 602 buses formed depreciation from total 5054 buses in the SR. This is an alarming ratio. Providing that all the vehicles idle in depreciation (4 452) were purchased in 1994 (the lowest AC), depreciation would form 1 640 340 591 Sk. This amount would be sufficient for purchase of new 516 buses (bus AC = 3 180 000 Sk), ie more by 443 buses. Loss from depreciation is equal to absolute value of difference of these two amounts, which is in figures 1 407 722 400 SK. This loss is, however, minimum. Buses purchased after 1994 form higher depreciation as their AC is higher as in 1994.

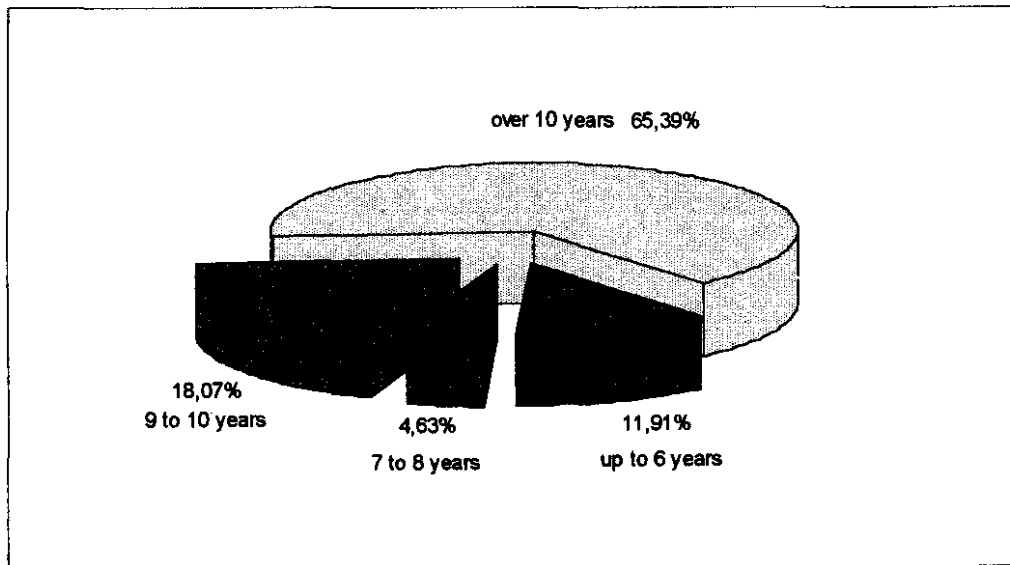


Fig. 1 Age Structure of Bus Fleet of SAD, the State Enterprise, as at 1st January 2000

In evaluation of the actual age structure of the vehicle fleet in SAD companies it is necessary to state that the situation is badly unfavourable. If we consider 8-year service life of buses, then 83,46%, ie. 4218 buses exceed this age and they should be disabled. On the

contrary, there are 16,54% ie. 836 buses within service life. In the age to 6 years 11,6 %, which means that 88,09% of the fleet have been depreciated and depreciation is thus formed by 602 buses only, which is insufficient for natural renovation of the fleet. From the presented data results that the bus fleet of the SAD companies urgently requires renovation.

Last but not least, in the vehicle fleet renovation problem are interested mayors of towns and villages, especially those of terminal villages, which are in charge of passenger transport and which utmost feel shortages in this field or consequences of inherited but after origin of the independent Slovak Republic also own Slovak imperfect and frequently non conceptual solutions, which are, however, strongly determined by present possibilities and weak perspectives of the malnourished state budget. Partial conceptual solution from 1998, under which SAD companies were offered grants for interests from credits in total amount of 50 million Sk for purchase of buses, cannot be considered sufficient. From the present total number of buses less than 15% ie. some 750 buses form depreciation and therefore effect of the above mentioned action of the state administration is sorrowfully weak and negligible. Arguments of regional authorities declaring utmost unfavourable situation in the public transport basically failed to weight during preparation of the state budget.

Despite the existing problem is definite, henceforth prevails apologising for idleness and low capability of competent authorities to solve this problem. Term of acceptance of the principal solution of the situation with the public bus service continues to delay at the expense of average period of use of the bus in operation. This age will soon reach double planned service life of the vehicles with further negative attendant phenomena, e.g. level of operating reliability, emergency, culture of travel, costs on their maintenance in operation conditions, road and passenger safety, etc. This generally known situation, in addition to justification of its present course, brings also different proposals and ways for its solution, which, however, always carry hallmark of its author and his personal interests. Diversity of solutions is evident mainly in estimation of number of buses, which should be renovated yearly. Vehicle fleet renovation is generally understood the number of new buses. Renovation of vehicles by repairs is automatically considered the part of the existing way of vehicle management, the result of which is exceeding the planned and financially justified period of use.

Importers' estimation of necessary number of renovated buses per year results from the size of long term supplies from the monopoly bus manufacturer and supplier to Slovakia, which is about 700 units.

Potential Slovak manufacturers, today already being repulsed and sick, present higher numbers - some 800-900 units - in their effort to supply domestic territory with comparable and still cheaper products.

3. Proposal for proper methodology for decision-taking on fleet renovation

3.1 Theory of renovation

The theory of renovation is applicable if there exist numerous machinery, instrumentation or fleet, which consists of equal objects, the part of which is supposed after time to be put out of the operation either due to crash or long operating time, or as a result of total wear; however, when it will happen is a random quantity. In the renovation theory is not substantial whether and when the vehicle will be in failure state, but how many of them will be necessary to replace by new vehicles. On the basis of observation of sufficiently big group of vehicles of the same type we receive necessary probability characteristics and the process of vehicle ageing and disabling can be described.

Theory of the fleet renovation has a great economic importance. Each idle time of the vehicle decreases its productivity and therefore it is important to find such a moment to prevent losses from delayed putting vehicle out of service as well as to prevent putting the vehicle out of service early.

According to [4] the renovation theory can be applied to the bus fleet, which in general fulfils the condition of sufficient size and homogeneity. From practical point of view under these terms is understood that the greatest possible number of the same type of vehicles is studied. Considering requirements on data processing by methods of mathematical statistics, sufficient size of the studied group is about 40.

In the theory of renovation two principal types of models are distinguished:

- Simple renovation - size of the group is constant
- Extended renovation – size of the group is increasing

Basic reason for putting the vehicle out of service is its physical wear due to its operation, while higher or lower intensity of wearing is not distinguished.

Moral wear in this connection is not considered. Concerning homogenous group of vehicles we admit small, irrelevant deviations between vehicles within the group and we refer to, so called, technical homogeneity of the group.

Presuppositions and simplifications of the model of simple renovation of buses

Vehicle renovation model is based on the following presuppositions:

1. According to the given sources the SAD property included 5 054 buses as at 1 January 2000, more than four thousand of which travel in the urban and suburban traffic. As there is not given exact data on the size of the fleet in the urban and suburban traffic in the cited source, this data will be applied also here for the above given and the following reasons:

- Achieved results to be comparable with cited statements,
- Number of buses in other than urban and suburban traffic is no doubt importantly great, however, in comparison with the size of the bus fleet in urban and suburban

traffic it is substantially lower, while most of them are similar in design to buses of urban and suburban traffic,

- In addition to international buses also long-distance buses contribute to the regional transport services.
2. Basic reason for putting the vehicle out of service is the physical wear of the vehicle due to its operation, while it is not studied in detail how the wear occurs, either intensively or not. Registration of the phenomenon – disabling the vehicle - is substantial.
 3. Moral wear is not considered in this connection. In the present unfavourable economic situation of SAD this aspect even has not a place.
 4. We admit vehicle group homogeneity in the bus service considering reasons stated in article 1. In fact, after removal of non-homogeneity we should admit some small, irrelevant deviations between vehicles of the same type. There should be respected the fact that vehicles of particular type are being manufactured for several years and innovation cannot be excluded. Level of performed repairs has specific influence, as well as diversification of spare parts manufacturers and suppliers, etc. The above said reasons are included in the term, so called, technical homogeneity of the group.
 5. Group of buses we therefore consider technically homogenous, ie, innovated vehicles differ slightly from the disabled vehicles. Technical properties of vehicles are assessed by probability of the vehicle transfer from one monitored life section to another.
 6. Vehicle ageing process we consider and register in specific fixed time periods, e.g. in one year period, ie. the change occurs in the moment of transfer of one period to another.
 7. It is supposed that instead of disabled vehicles new ones are included into the process.
 8. Replacement of disabled vehicles for new ones is carried out in the end of the monitored period so that at the beginning of the new interval the group is complete, ie. in constant or otherwise planned number.
 9. During vehicle renovation neither aspect of moral ageing of the vehicle nor costs on operated vehicles are considered after exceeding the planned period of use.

Another important and considerable component of the model of the fleet renovation is estimation of technical life time or period of use of the bus in urban and suburban services. Data from real operation on bus removal in the transport company after the year 1993 were applied for it, ie. after completion of systematic renovation in 1992 [2].

From own works as well as from the literature it is demonstrable, that reasonable distribution of probability of the period of use of bus is the 3-parameter distribution by Weibull. Its main advantage is that it approximates very well empirical data from the field of reliability of mechanical systems. Another important advantage of this case is that it enables to estimate so called distribution treshold value, ie. time in years from which starts, with non negligible probability, putting buses out of service. In harmony with experience from operation of vehicles there is a low probability that the vehicle – the bus - is put out of service in the first years of operation due to wearing from operation.

Distribution function of the probability distribution applied here is as follows:

$$F(t) = 1 - \exp\{-(t-c)^b/a\}; \quad c \leq t < \infty, \quad b > 0, \quad a > 0, \quad c > 0.$$

where

b - is parameter of shape, a - is parameter of scale, c - is treshold value of distribution.

After empirical data processing by means of computer graphic method we have achieved the following values:

$b = 1,3$ $a = 3,15$ years, $c = 8,5$ years. Theoretical medium period of use is calculated from the relation $T_s = c + a \Gamma \{(1/b)+1\}$, where Γ is gama function.

Medium period of use of the bus in respective calculation $T_s = 11.3$ years. Start of putting buses out of service after time $t \equiv c \geq 8,5$ years, what we round to 9 years in this case of length of the selected 1 year section.

Simple renovation of the bus fleet

By application of mathematical theory of renovation, which is not described here for the space reasons, Table 2 of expected numbers of simple fleet renovation was set up including prediction by the year 2005.

Tab. 2 Expected numbers of buses from simple renovation

age year	99	00	01	02	03	04	05
0	39	1100	817	650	575	493	435
1	124	39	1100	817	650	575	493
2	46	124	39	1100	817	650	575
3	93	46	124	39	1100	817	650
4	211	93	46	124	39	1100	817
5	89	211	93	46	124	39	1100
6	93	89	211	93	46	124	39
7	141	93	89	211	93	46	124
8	226	141	93	89	211	93	46
9	687	203	126	83	80	189	83
10	822	501	148	92	61	58	138
11	688	562	343	113	63	42	40
12	563	582	476	290	96	53	35
13	495	478	423	346	211	70	39
14	321	432	414	370	302	185	61
15	199	199	236	317	306	271	222
16	80	155	184	247	239	121	173
17	39	40	78	92	124	120	106
18	2	17	17	34	40	54	32

From the results of Table 2 we can see that if the bus fleet volume should stay at the same level, ie. at simple bus fleet renovation, SAD companies would have to provide 4070 buses during 2000-2005. For specific years are numbers given in Table 2 in 0 line. In 2005 total number of vehicles should be the same as in 1999, average age 5,47 years, number of buses in age to 6 years forming depreciation would be 70%.

We remind that in this calculations we result from live data from operation. An average age of the vehicle, ie medium period of use according to the applied Weibull model is 11,3 years, so it is practically identical with data in tab.1, the highest age of buses according to this model is 18 years, which is practically identical with relevant number of buses.

It is apparent from Table 2 how the vehicles of specific age categories and years of production are „ageing“ and in what numbers they are being disabled. Also it can be logically assumed that this mechanism will not change substantially in the nearest years. It means that according to this parameters of the „fleet ageing“ from the number of vehicles (year of production 1987), 667 units of which were in operation in 1999, only 52 will remain in operation, while their age will be over 18 years. This example is marked by shading in Table 2. All vehicles manufactured before this year of production should be put out of service as their age will be more than 18 years(!). From the achieved results further issues, that if the regulations on putting buses out of service would not change by 2005 (ie. maximum 18 years old vehicles will remain in operation), then 1072 buses of the present bus fleet will remain in operation in 2005. If we add planned numbers of vehicles which should be provided by SAD companies, there will be 1982 buses in total in the fleet, while their average age will be 8,52 years.

This number of buses, however, will be not sufficient to secure the transport services of the region and if the fleet renovation would represent only the planned 910 buses, it is obvious that solution of this situation will be either to keep also vehicles older than 18 years in operation, what will be probably not possible for different reasons, or constantly repair vehicles, which should have been already disabled according to present criteria. In both cases it, however, means substantial increase of average age of vehicles in operation, notwithstanding the costs on preservation of the fleet serviceability, culture of travel and traffic safety.

4. Evaluation of the designed solution

The objective of the paper was to deal with issues concerning SAD bus fleet renovation and propose the model of renovation.

Due to increase of both individual motoring and unemployment the transport demand dropped consequently and thereby vehicle travel performance was also decreased, see Fig. 2, SAD Zilina was selected as an example. Consequently, the number of vehicles in the fleet was decreased. Further decrease of vehicle numbers could interfere with provision for minimum transport services and therefore we assume the fleet renovation with preservation of number of vehicles.

By means of high quality and responsible maintenance longer service life of parts of vehicles will be reached, failure rate of vehicles will be decreased, thus also their idle times, but first of all costs on failure removal. Failure rate of the vehicle is possible to be decreased, but not removed. From the presented material results that overhaul carried out after the eighth year of the vehicle operation the number of failures will decrease by

substantial value, however, this value is still much higher than with a new vehicle. Regardless moral wear and decreased competitiveness, operating costs and maintenance costs of the vehicle after the overhaul higher than those with a new vehicle. In addition, in the stage II, after the overhaul, failure rate dramatically increases after the eleventh year of the vehicle operation. It is obvious that constant investment of finances in repairs and maintenance is not financially effective and it is necessary to put the vehicles with likely high increase of failure rate out of service and replace them by new vehicles.

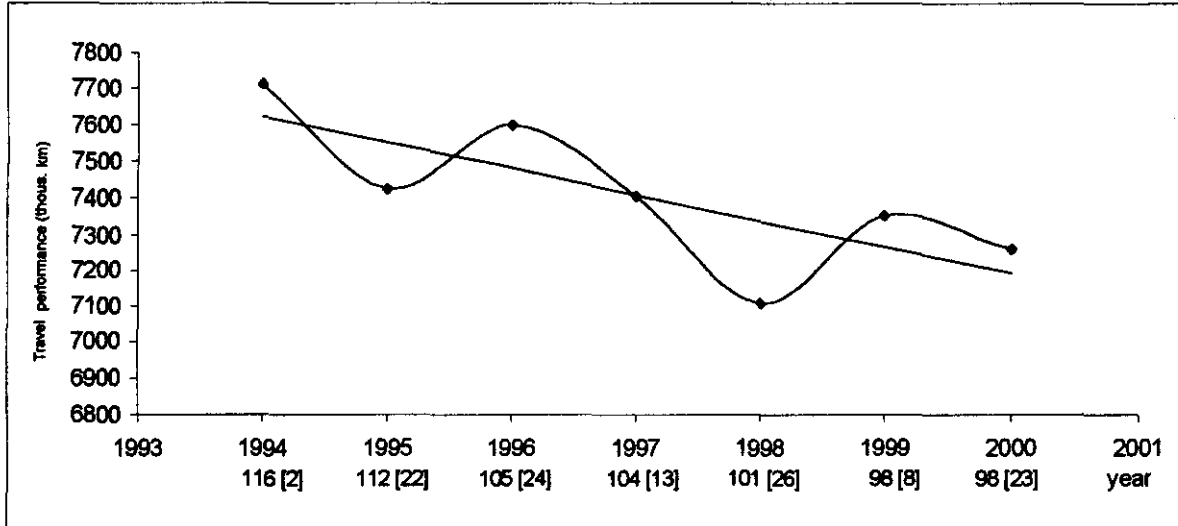


Fig.2 Yearly Travel Performance of SAD Zilina Vehicles

Number under the year gives numbers of vehicles of the fleet and number in bracket gives numbers of renovated vehicles for the respective years.

Considering this renovation and under preserved conditions (preserved number of vehicles, course of failures of vehicles, the vehicle maintenance system, etc.) an average age of vehicles should reach 5,9 years in 2005. (enclosure 4) and fleet age structure would change remarkably, when already 311 from 386 vehicles (ie. 80,6%) would form depreciation as the source of finances for simple reproduction (fig. 5).

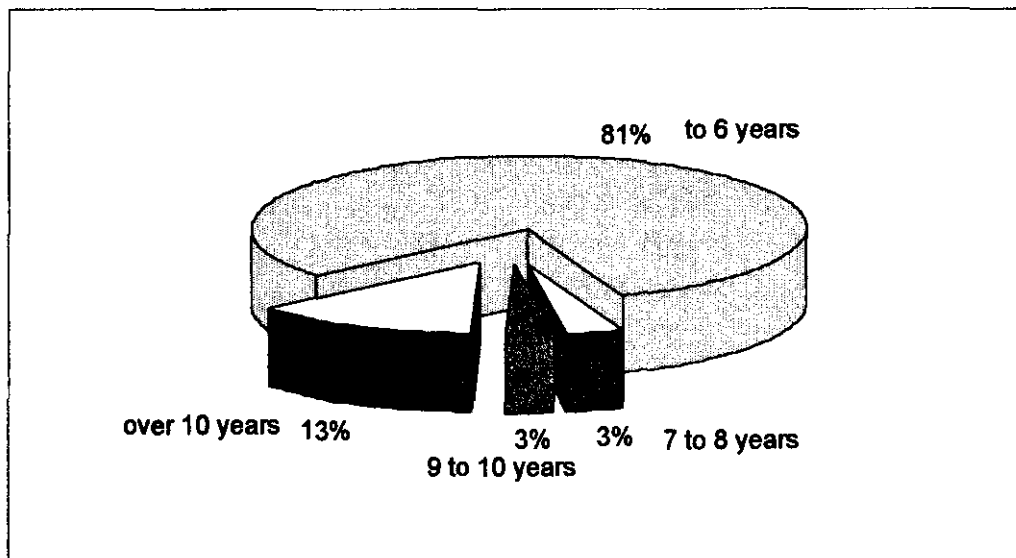


Fig. 3 Expected Age Structure of the Fleet in 2005

Using this model in practice, more favourable parameters would be achieved in 2005 compared with the year 2000. The point is mainly an average age of vehicle fleet and number of vehicles forming depreciation.

Providing that vehicle fleet will be replaced by lower number of vehicles than those considered in the simple model of renovation, its average age will grow and age structure will continue to be unfavourable from the point of view of depreciation.

Fleet emergency and transport services will be possible to reach only at the expense of increased maintenance and overhaul costs, or considering another overhaul after the period shorter than 8 years.

5. Conclusion

Public mass passenger transport has an irreplaceable place in the society. To be able to fulfil its function it needs, however, sufficient technical equipment. The question is first of all the fleet and its satisfactory condition. Reaching this condition requires systematic replacement of vehicles.

At present the replacement of vehicles is random as it depends largely on the state budget possibilities. However, it is inevitable to find finances for systematic replacement because the present inconvenient condition and the development trend head for worsening the situation in SAD companies, which may cause collapse in the mass passenger traffic in the near future.

Realisation of the fleet renovation in practice by means of this model is no doubt financially demanding, but the vehicle age structure would be remarkably improved by 2005 and number of vehicles forming depreciation would be increased every year as well as the source of finances for simple reproduction of the vehicle fleet.

Resumé

Paper deals with renovation of the bus fleet of SAD, the State Enterprise. The designed renovation model results from the analysis of actual condition of the vehicle fleet in the selected SAD company, as well as from data on renovation of the bus fleet in the Slovak Republic. Judgement of the applied system of maintenance, repairs and operation reliability of selected type of buses, as well as data on operation of buses and evaluated data on the vehicle fleet management are the part of the analysis. Based on the above mentioned data the conditions of renovation were described. The simple model, which the whole complexity of the process is briefly shown on, is one of the outcomes of the work. Analysis of the economic aspect of the process of renovation is also an important outcome of the work. The model provides contribution to the renovation problem solution under the given economic and operation conditions by application of which the actual inconvenient condition could be resolved in the near future.

Abbreviations:

GO	Overhaul
SAD	Slovak Bus Service
SR	Slovak Republic

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