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Design of Operational Vehicle Maintenance Programme Based on Life Cycle Cost and Reliability Centred Maintenance

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Abstract:

This contribution deals with one possible approach to the determination of the on-going vehicle maintenance programme. This approach is based on life cycle costs and a method called "Reliability centred maintenance". The objective of this method is to maintain system functions within required safety limits, maintain an inherent level of safety and reliability, optimise availability, and perform these objectives with minimal total life cycle costs. The design of the on-going vehicle maintenance programme was based on quantitative, qualitative and economic analyses.

Keywords:

Operational (on-going) maintenance programme, vehicle life cycle costs, reliability centred maintenance, vehicle durability time.

1. Introduction

A maintenance programme generally consists of an initial programme and continuously developing operational (on-going) programme. As an example of a possible solution, this contribution includes a design of an operational maintenance programme.

The operational maintenance programme is elaborated using an initial maintenance programme. Thus it is necessary for the user to commence collecting operation data as soon as possible after a vehicle was put to operation.

To elaborate an effective on-going maintenance programme it is necessary to define:

- maintenance programme objectives,
- a method enabling the maintenance programme elaboration,
- content of the maintenance programme[8].

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For the description of the on-going maintenance programme, the following progressive logic diagram was proposed (see Fig. 1). This progressive logic diagram is divided into three main parts – quantitative analysis, qualitative analysis based on RCM (Reliability Centred Maintenance), and economic analysis. These analyses are described further in this Chapter.

In the initial part of the on-going maintenance programme design, the following acts must be performed:

1. Collecting information

In the initial part it is necessary to collect credible data about vehicle operation, forming the basis for the evaluation and then proposal of various measures. The data are collected prior to the analysis commencement. To ensure completeness and to prevent from duplicity, an appropriate and logic division of items is necessary.

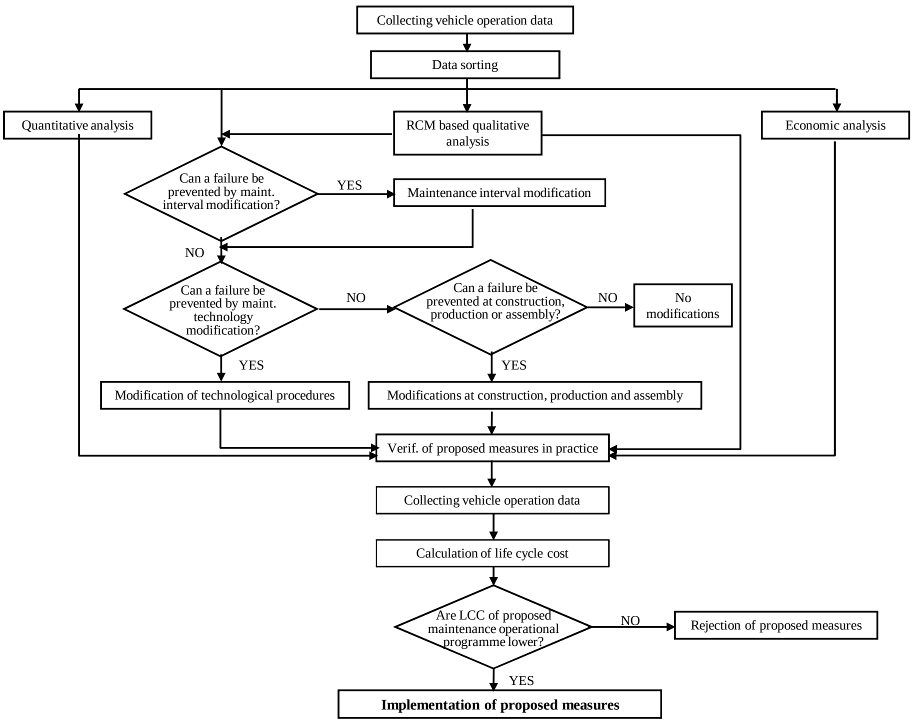

Fig. 1 Proposed progressive logic diagram for determining an operational maintenance programme

2. Data sorting

Vehicles are divided into the following groups: engine, transmission mechanism, brakes, driving, wiring system, body and frame. This division is based on functionally significant items. Concerning road traffic safety, it is important to divide brakes and driving to two separate groups and pay them increased attention to them.

It is appropriate to divide the data according to the classification of failure consequences [6]:

- minor failure consequences,
- major failure consequences,

- critical failure consequences,
- catastrophic failure consequences.

Failures may be also classified according to other criteria:

- classification according to origination rate,
- classification according to extent,
- classification according to criteria combination,
- classification according to causality.

In the article, classification according to failure consequences is applied since each failure has a different effect to the safety, availability, and costs on corrective maintenance of the vehicle.

3. *Performing individual analyses*

After data are sorted, individual analyses are performed:

- quantitative analysis,
- RCM based qualitative analysis,
- economic analysis.

4. *Asking question "Can a failure be prevented from by modification of the maintenance interval?"*

If the answer is YES, the service maintenance interval shall be modified upon the quantitative analysis. If the answer is NO, the existing service maintenance interval shall be retained.

5. *Asking question "Can a failure be prevented from by modification of the maintenance technology?"*

If the answer is YES, individual technological acts of maintenance shall be modified. If the answer is NO, the existing maintenance technology shall be retained.

6. *Asking question "Can a failure be prevented from at the construction, production or assembly stages?"*

If the answer is YES, detected modification at the vehicle construction, production or assembly stages shall be performed. If the answer is NO, the existing documentation and technology of vehicle production shall be left without modifications.

7. *Evaluation of individual analyses and adoption of specific measures.*

Upon the quantitative analysis results, the service maintenance interval shall be modified or the existing interval retained. Upon the RCM based qualitative analysis results, individual maintenance acts, performed within the service maintenance of a vehicle, shall be modified. Upon the economic analysis results and the failure intensity calculation, the vehicle durability time shall be specified as compared to the initial proposal.

8. *Verification of proposed measures in practice.*

Upon the proposal of the stated modifications in the whole design of the on-going maintenance programme, another data collection and an economic analysis shall be performed, aimed at the calculation of vehicle life cycle costs (LCC). Upon LCC, point 9 shall be dealt with.

9. *Asking question "Is the system proposal optimal?"*

If the answer is YES, integrated modifications in the on-going vehicle maintenance programme shall be accepted. If the answer is NO, the previous preventive maintenance system and vehicle durability shall be retained, or partial modifications, which are considered rational, shall be performed. Consequently, re-verification in practice with evaluation of vehicle monitoring results shall be performed.

2. Quantitative Analysis for the Service Maintenance Programme Elaboration

The following section presents a quantitative analysis progressive logic diagram, which is part of the design of an on-going vehicle maintenance programme.

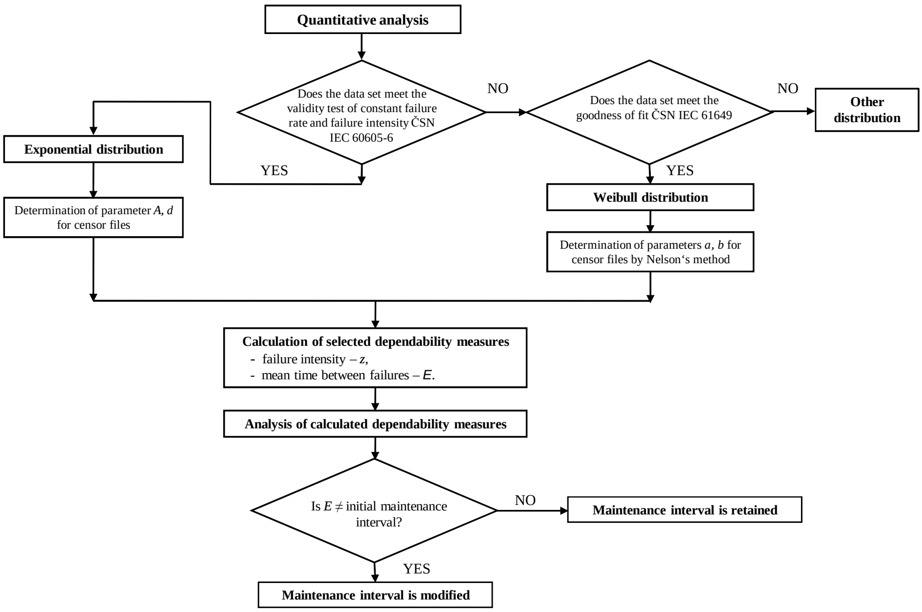

Fig. 2: Progressive logic diagram of quantitative analysis

2.1. Determination of a Continuous Distribution Type

For the determination of a continuous distribution type, the "constant rate validity test" [1], "failure intensity validity test" [1], and "test of goodness of fit for data with the Weibull distribution" [2] methods were used. Results of the given calculations shall form the basis for the selection of a suitable type of continuous distribution, and consequently for the calculation of mean time between failures.

In order to determine the values, it is necessary to lay down a continuous distribution type that will describe vehicle properties best. Verification of the failure rate behaviour for irreparable items or of the failure intensity for repairable items shall be performed [1].

2.1.1 Constant Rate Validity Test

The test was performed in order to determine the validity of the assumption of constant failure rate for irreparable items. It was assumed that a vehicle shall behave as irreparable, meaning it shall be withdrawn from monitoring after the first failure. A test specified in this way is meant for testing whether times to item failures are exponentially distributed, i.e. whether the failure rate is constant.

For the procedure to be valid, at least ten times to failure must be available. Further, according to the number of n sample selections, either a numerical procedure or graphic method for a small number of samples is used. A condition of the same operating environment for all test samples must be met. Not all samples must have failure at the end of the testing period. At the time given, the total of *r* recorded valid times to failure will exist. The times to failure shall be arranged in the ascending order of values and the arranged selection shall be marked $t_1, t_2, \ldots, t_r$.

The cumulative time to "*i*" failure shall be calculated as [1]:

$$T_i = \sum_{k=1}^{i} t_k . \qquad (1)$$

Procedure for a selection range greater than 40.

1. Time interval between zero and the total cumulative time of T^* test shall be divided into *m* identical intervals with the length *w*. An expected number of failures in each interval is:

   $$E = w\frac{d}{T^*}, \qquad (2)$$

   d parameter related to the number of valid failures; *m* must be selected in such a way that *E* is equal to or greater than 5.
2. Test statistics is calculated:

   $$c^2 = \sum_{i=1}^{m} \frac{(O_i - E)^2}{E} \qquad (3)$$

   O_i is observed number of failures in the time interval *i*.
   The calculated value c^2 shall be compared to the theoretical value $\chi^2(n)$ given in Tab. A1 [1] for $n = m - 1$.
3. One-sided test shall be performed within 10% significance level using Tab. A1 [1], as follows:
   - If $c^2 > \chi^2_{0.90}(\nu)$, then the assumption of failure rate constancy is refused.
   - In this procedure it is not possible to assess whether the failure rate is increasing or decreasing.
   - Otherwise the assumption of failure rate constancy is refused, i.e. exponential distribution may not be considered.

2.1.2. Test of failure intensity constancy

This test is used for repairable items, which applies fully to vehicles. Only one vehicle shall be selected for testing and failure occurrence and seriousness are monitored. It is recommended to select a vehicle with the highest durability (the highest kilometrage) and the highest failure occurrence.

Testing failure intensity constancy means that times between successive failures show neither increasing nor decreasing trend. If this is this case, the sample may be considered an item repaired after every failure. For the calculation it is necessary to meet this condition: at least six successive failures recorded during the testing period must exist.

This procedure may be used either at the time of the last failure T_r, or at any other later time T^* during which the test sample continues performing its function [1].

Step 1

For each cumulative valid failure time T_i value *U* shall be calculated:

If $T^* > T_r$ then:

$$U = \frac{\sum_{i=1}^{r} T_i - r\frac{T^*}{2}}{T^*\sqrt{\frac{r-1}{12}}}. \tag{4}$$

If $T^* = T_r$ then:

$$U = \frac{\sum_{i=1}^{r-1} T_i - (r-1)\frac{T_r}{2}}{T_r\sqrt{\frac{r-1}{12}}}. \tag{5}$$

Step 2
Permissible risk α of an incorrect refusal of the failure intensity constancy assumption shall be specified, although in fact it is constant. Recommended values α are given in [1].
Step 3
If the absolute value U is higher than a critical value given in Table [1], the assumption of failure intensity constancy shall be refused. Otherwise this assumption shall not be refused.

A) Goodness of fit tests for data with the Weibull distribution
Step 1
All r times to failure shall be arranged in the ascending order and natural logarithm of these times shall be calculated: $\ln(t_1) = x_1$, $\ln(t_2) = x_2$, …, $\ln(t_r) = x_r$.

$$\text{It is true that: } x_1 \le x_2 \le \ldots \le x_r. \tag{6}$$

Step 2
The following values shall be calculated l_i for $i = 1$ up to $r - 1$

$$l_i = \frac{x_{i+1} - x_i}{\ln\left\{\ln\left[\frac{4(n-i+1)+3}{4n+1}\right] \Big/ \ln\left[\frac{4(n-i)+3}{4n+1}\right]\right\}}. \tag{7}$$

Step 3
H shall be calculated using values calculated in step 2

$$H = \frac{\sum_{i=\lfloor r/2 \rfloor+1}^{r-1} \frac{l_i}{\lfloor (r-1)/2 \rfloor}}{\sum_{i=1}^{\lfloor r/2 \rfloor} \frac{l_i}{\lfloor r/2 \rfloor}}, \tag{8}$$

where: $\lfloor x \rfloor$ is used for indicating the greatest integer less than or equal to x.
Step 4
If $H \ge F_\gamma\left(2\lfloor (r-1)/2 \rfloor, 2\lfloor r/2 \rfloor\right)$, then the hypothesis saying that data follow the Weibull distribution shall be refused within γ.100% significance level, and the analysis shall not continue. Otherwise no evidence for refusing the hypothesis that times to failure have the Weibull distribution has been found and the analysis may be continued [2].

2.2. Weibull Distribution –Determination of α, β Parameters

This section contains formulas for calculating the point estimation of the most important measures according to the Weibull distribution of a random variable valid for repairable as well as irreparable cases. A number of machine parts and other equipment, to which exponential distribution cannot be apply, have durability time (operating time between failures) of the Weibull distribution, especially those machine parts showing mechanical wear and material fatigue. Also mechanical properties of materials, e.g. strength, have the Weibull distribution.

The a and b parameters are presumed not to be negative. Parameter a is so called scale parameter, parameter b is so called shape parameter.

If the threshold value is zero ($c = 0$), W distribution (a, b) has only two parameters and the following expressions may be used [3, 4].

The basic theoretical characteristics of the Weibull distribution have the following form [4]:

a) Mean value of $E(t)$ function

$$E(\tau) = \alpha K_{\beta} = \alpha\Gamma(1+1/b). \tag{9}$$

b) Dispersion $D^2(t)$

$$D^2(t) = \alpha^2 g_b^2 = \alpha^2\left[\Gamma(1+2/b) - \Gamma^2(1+1/b)\right]. \tag{10}$$

Symbol Γ denotes gamma function the form of which is expressed as follows:

$$\Gamma(y) = \int_0^{\infty} x^{y-1} e^{-x} dx. \tag{11}$$

These values K_β and g_β are tabulated in [3].

2.2.1. Determination of Parameters a, b for the Weibull Distribution by Nelson's Method

This is one of methods suitable for processing generally censored samples [5, 6].

Problem formulation

During a longer monitoring of a group of items, generally a situation may occur for individual items in which the total monitored interval of operating time $t \in \langle 0, T_S \rangle$ will break into two characteristic interval types I & II.

Type I represents intervals of operating time limited on both ends by failures of the item monitored. According to the definition, they are time to failure intervals (time between failures for repaired items). Hereinafter these intervals are called "*closed*".

Type II represents intervals of operating time limited on one end by an item failure, and on the other by a variously determined moment at which monitoring (test) is terminated upon reaching T_S^*, without failure occurrence. Hereinafter these intervals are called "*unclosed"*.

The estimation of parameters is based on the linearization of a relation for cumulative failure rate $H(x)$. This solution applies to the *Weibull distribution.*

Distribution function of two-parameter W-distribution is given by the following relation [5, 6]:

$$F_x(x) = 1 - \exp\left[-H(x)\right], \tag{12}$$

where $H(x)$ is cumulative failure rate given for W-2 distribution by the following relation:

$$H(x) = \int_0^x \lambda(t)\,\mathrm{d}t = \int_0^x \frac{b}{\theta}\left(\frac{t}{\theta}\right)^{b-1} \mathrm{d}t, \tag{13}$$

$$H(x) = \left(\frac{x}{\theta}\right)^{b}. \tag{14}$$

Application of logarithm on (13) will result in the following equation, linear between parameters:

$$\ln H(x) = b \ln x - b \ln \theta. \tag{15}$$

The equation is already linear between parameters and may be solved in various ways:

a) Graphically on an appropriate logarithmic paper,

b) Numerically (e.g. by least squares method) [5].

2.2.2. Determination of Confidence Interval for Parameter *a* with Known Parameters *b* and *g*.

Two-sided confidence interval $\langle a_D, a_H \rangle$ for parameter a with known parameters b, g with confidence coefficient $1 - a$ shall be determined from relation [3]:

$$a_D = \left[\frac{2\sum_{i=1}^{n}(x_i - \gamma)^b}{\chi^2_{1-a/2}(2n)}\right]^{1/b}, \tag{16}$$

$$a_H = \left[\frac{2\sum_{i=1}^{n}(x_i - \gamma)^b}{\chi^2_{a/2}(2n)}\right]^{1/b}. \tag{17}$$

where $\chi^2_q(n)$ is the value of quantile (fractile) of χ^2-distribution with n degrees of freedom which is to be found in [3], Tab. 6. One-sided confidence intervals with confidence coefficient $1 - a$ shall be determined from the relation for a_D, with a instead of $a/2$ used in the quantile values.

2.3. Calculation of Selected Dependability Measures

2.3.1. Failure intensity

Failure intensity $z(t)$ is the limit of a ratio – if it exists – of the mean failure number of a repaired item within $(t, t + \Delta t)$ time interval to the length of this interval Δt, if the length of the time interval is approaching zero [9].

$$z(t) = \lim_{\Delta t \to 0+} \frac{E[N(t+\Delta t) - N(t)]}{\Delta t}, \tag{18}$$

where: $N(t)$ - number of failures within $(0, t)$ time interval,
E - expected value,
$t + \Delta t$ - time interval.

Using the given expression, it is possible to calculate failure intensity for the whole vehicle or for individual groups of the vehicles.

2.3.2. Mean Time between Failures Calculated with the Weibull Distribution

The calculation of mean time between failures for a vehicle (or groups) may be performed in longer intervals (e.g. 50 000 km). After determining values in these intervals, curve regression with function expression may be carried out. In this way the values of mean time between failures in the interval from production to disposal may be calculated.

The calculation shall be done in each interval using the following procedure:

1. Failures according to consequences are selected and divided to intervals; calculation includes also unclosed set values when a failure did not occur.
2. Using Nelson's method, cumulative rate $H(x)$ values are calculated.
3. Using the Weibull diagram, cumulative values $H(x)$ are plotted depending on the kilometrage.
4. Values a and b are read from the Weibull diagram.
5. Mean time between failures is calculated using the Weibull distribution and calculated values a and b.
6. Resulting values are plotted in the diagram and regression curve with function expression is calculated. Upon theoretical as well as practical knowledge it is recommended to employ regression analysis. In this analysis, special non-linearizable models shall be used with exponential trend. The most appropriate particular regression curve has the following general form:

$$y = b_1 e^{-b_1 x} + b_2 e^{-b_2 x}, \tag{19}$$

where: y - mean time between failures in kilometres,
x - operating time in kilometres,
b_1, b_2 - estimations of parameters,
β_1, β_2 - estimations of parameters.

7. Mean time between failures in defined maximum durability time of a vehicle is calculated from the given equation.
8. Confidence interval for parameter a with known parameter b is determined.

2.4. Analysis of Calculated Dependability Measures

2.4.1. Analysis of Failure Intensity

The calculation of failure intensity is recommended to be employed for the determination of the vehicle durability time. This is a possible criterion used for the durability time determination.

From the failure intensity-kilometrage relation, failure occurrence at a certain kilometrage may be determined. During the analysis, the curve development is monitored and the point in which a sudden increase of failure intensity occurs is looked for. However, this trend must be of a permanent character, not only a sudden increase followed by decrease of failure intensity values.

2.4.2. Analysis of Mean Time between Failures Calculated with the Weibull Distribution

The calculation of mean time between failures is recommended to be employed for the determination of interval between preventive maintenances, i.e. so-called service interval. As generally assumed, a vehicle is a piece of equipment for which the interval between failures shortens with increasing kilometrage.

The analysis is based on the determination of the vehicle durability time. Mean time between failures is calculated in the given point and then the confidence interval lower limit is calculated with known parameter β. Upon the calculated value, a maintenance interval is determined, rounded down to thousands. When modifying this interval, motor oil durability time must not be omitted. Engine or transmission oil change shall comply with the maintenance interval multiple.

2.5. Decision on the Optimal Interval for Service Maintenance

Upon the analysis of mean time between failures calculated with the Weibull distribution, a decision on the determined interval optimality shall be made. There are two possibilities: to refuse the interval modification, because the calculated interval is the same as the interval recommended by the manufacturer, or to accept the interval modification, because it seems to be optimal. It means that if preventive maintenance costs decrease within the vehicle durability time, at the same time corrective maintenance costs should not increase. Another possibility is that the service maintenance interval will shorten and at the same time preventive maintenance costs will increase, with expected decrease of corrective maintenance costs. For the verification of stated hypotheses it is necessary to continue monitoring failure occurrence for the newly proposed interval in order to draw final conclusion.

3. Qualitative Analysis Based on Reliability Centred Maintenance

This qualitative analysis is based on principles of reliability centred maintenance (RCM). The following section contains an example of determining failure effects and optimal acts which are necessary to be performed within the vehicle preventive maintenance.

In the first part of the decision logic tree, categorisation of failure effects is performed. Questions such as "Is functional failure occurrence during a usual check obvious to the operator?" are asked here. Answers are "yes" or "no", with assigning categories of failure effects such as apparent failure, latent failure etc.

In the second part, maintenance tasks selection is proposed resulting from the RCM based decision logic tree, which is the result of the decision logic tree. Questions such as "Is functional failure occurrence during a usual check obvious to the operator?" are asked here. Answers are "yes" or "no", with assigning categories of failure effects such as apparent failure, latent failure etc. Further, maintenance tasks selection is proposed resulting from the RCM based decision logic tree, which is the result of the decision logic tree.

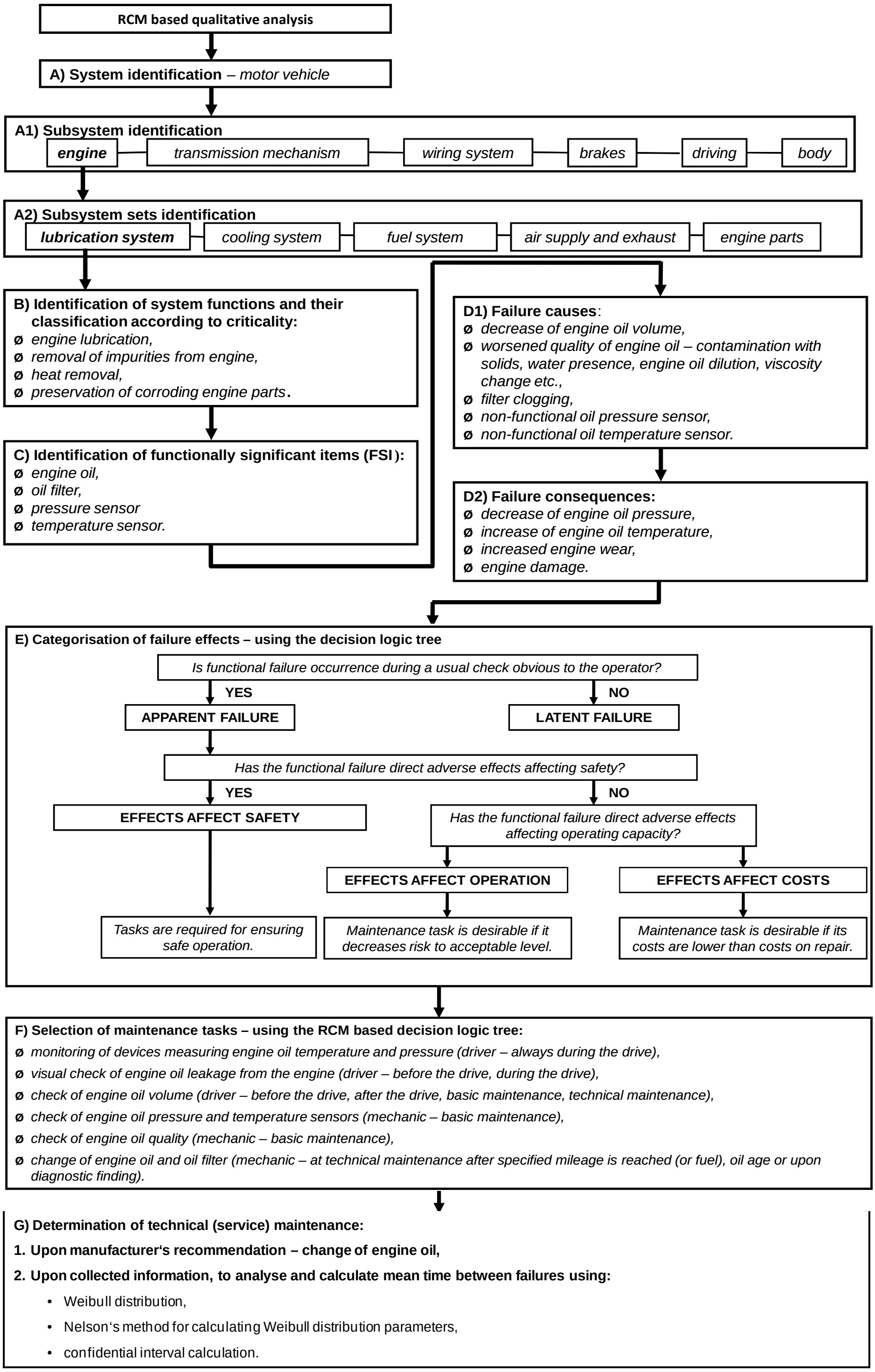

Fig. 3 Example of the engine qualitative analysis based on RCM

4. Economic Analysis Based on Life Cycle Costs

The life cycle costs analysis is an economic analysis process for assessing the total costs on purchase, possessing, and disposal of an item. The analysis may be used within the whole life cycle of the item, or in some parts, or in combinations of various periods of the life cycle [7].

There are five periods of the vehicle life cycle:

1.	Period of concept and requirements determination	- purchase costs (periods 1–3)
2.	Design and development period	
3.	Manufacture period	
4.	Operation and maintenance period	- possession costs
5.	Disposal period	- disposal costs

4.1. Calculation of Selected Life Cycle Costs

$$C_{PAM} = C_{PA} + C_{OMC} + C_{OMP}, \tag{20}$$

where: C_{PAM} - life cycle costs,
C_{PA} - costs on vehicle purchase and amortisation,
C_{OMC} - corrective maintenance costs,
C_{OMP} - preventive maintenance costs,

4.1.1. Costs on Vehicle Purchase and Amortisation

The actual value of a vehicle during its operation shall be calculated from costs on vehicle purchase reduced by its amortisation. Costs on amortisation include the vehicle age and kilometrage.

a) Costs on vehicle purchase

Vehicle purchase costs may be expressed as:

$$C_P = C_{CD} + C_{DD} + C_M + C_S + C_G, \tag{21}$$

where: C_{CD} - costs on the period of concept and requirements determination,
C_{DD} - costs on the design and development period,
C_M - costs on the manufacture period,
C_S - costs on the vehicle sale period,
C_G - costs on ensuring repairs during a guarantee period.

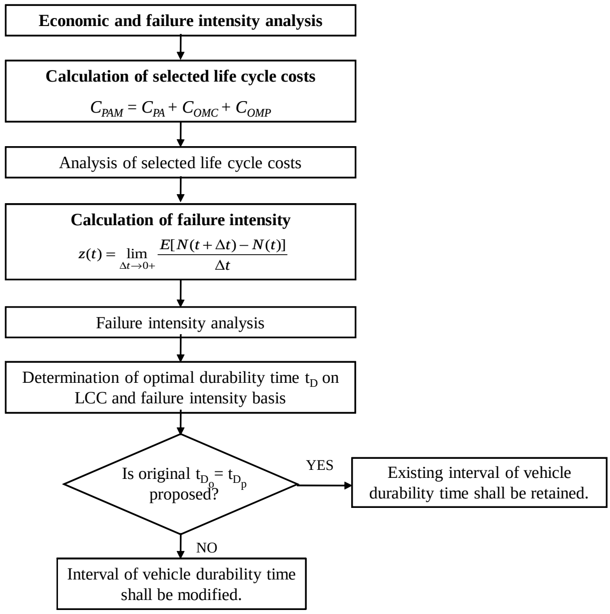

Fig 4: Progressive logic diagram of economic analysis and failure intensity

b) Calculation of vehicle residual value (amortisation)

The value of amortised vehicle shall be determined upon the vehicle operating time (age) and mileage. For a certain vehicle type, the price shall be calculated from amortisation scales [10], in which a basic percentage deduction for the operating time and a basic percentage deduction for mileage are determined. The vehicle value shall then be calculated as an arithmetic average of the following values:

$$C_{PA} = (C_{AT} + C_{AO})/2, \tag{22}$$

where: C_{PA} - costs on vehicle purchase and amortisation,
C_{AT} - amortisation value of the vehicle depending on the operating time,
C_{AO} - amortisation value of the vehicle depending on its mileage.

4.1.2. Costs on Vehicle Maintenance

a) Corrective maintenance costs

The total costs which are required for ensuring repairs during the vehicle operating time depend on the number of failures which occur in the vehicle during its operation, and on costs necessary for removing these failures. Corrective maintenance costs may be calculated as follows:

$$C_{OMC_{(j)}} = \sum_{n=1}^{n=j} z_{(n)} i c_R, \tag{23}$$

$$f_{C_{OMC}} = c_R \int_{t_0}^{t_n} \frac{t}{E_t} \mathrm{d}t, \tag{24}$$

$$C_{OMC} = \frac{c_R}{f} t. \tag{25}$$

where: C_{OMC} - corrective maintenance costs during operating time t,
t - operating time in kilometres,
i - determined value of the interval in kilometres,
j - number of determined intervals i,
$z_{(n)}$ - failure intensity in interval n,
$E_{(t)}$ - mean time between failures depending on mileage t, calculated with Weibull distribution,
Φ - mean time between failures,
c_R - average cost on one failure repair, consisting of costs on material and costs on work.

b) Preventive Maintenance Costs

These include costs on scheduled preventive maintenance performed in compliance with a specified maintenance schedule for a given vehicle.

For costs on ensuring preventive maintenance, the following generally applies:

$$C_{OMP} = t\hat{c}_M , \tag{26}$$

where: C_{OMP} - costs on ensuring preventive maintenance during operating time t,
t - operating time in kilometres,
$\hat{c}_M$ - average cost on ensuring preventive maintenance, consisting of costs on material and costs on work relating to an operation time unit.

c) Total costs on vehicle maintenance

The total costs on vehicle maintenance consist of costs on preventive maintenance and on corrective maintenance.

$$C_{OM} = C_{OMC} + C_{OMP}. \tag{27}$$

4.2. Determination of Optimal Vehicle Durability Time

Optimal durability time of a vehicle is recommended to be determined upon selected components of vehicle life cycle costs (costs on vehicle purchase and amortisation, maintenance cost), and upon the failure intensity analysis.

4.2.1. Determination of Vehicle Durability Time upon Selected Life Cycle Costs

This is one of possible methods employed for the determination of the vehicle life cycle.

The determination of vehicle durability time based on LCC may be performed in two ways:

a) By deducing optimal life cycle costs directly from the graph.

b) By determining optimal life cycle costs using points of the elaborated graph through which a suitable regression curve shall be laid. This curve is expressed by an equation of function $f(x)$. For expressing the function equation, Matlab software may be used, or any other that meets required conditions. Calculation procedure:

- Finding a local extreme of the function within $[0, T_D]$ domain, where T_D is vehicle durability time. The calculation is performed with the first derivative of function $f'(x)$ where the following applies:

$$f'(x_0) = 0. \tag{28}$$

The result is a local extreme within interval [0, T_D].

- Finding a strong local minimum of the function within [0, T_D] domain:

$$f''(x_0) > 0, \tag{29}$$

After the function minimum within the searched interval [0, T_D] is determined, it is necessary to determine the value of vehicle durability time. It is recommended to determine optimal mileage interval which is 5 to 10 % higher than the calculated value of the minimal costs, see Fig. 5.

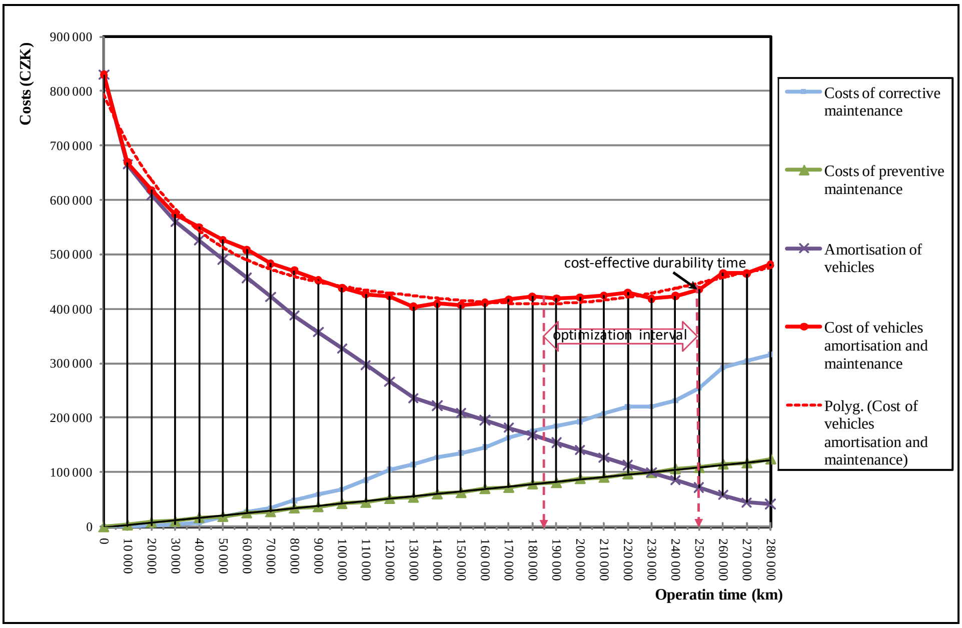

Fig. 5: Example determination of optimal durability time depending on costs for vehicle Land Rover Defender

4.2.2. Determination of Vehicle Durability Time upon Failure Intensity

The second method of determining optimal vehicle durability time is based on the calculation of failure intensity formula (18). Using the given expression, it is possible to calculate failure intensity for the whole vehicle or for individual groups of the vehicle.

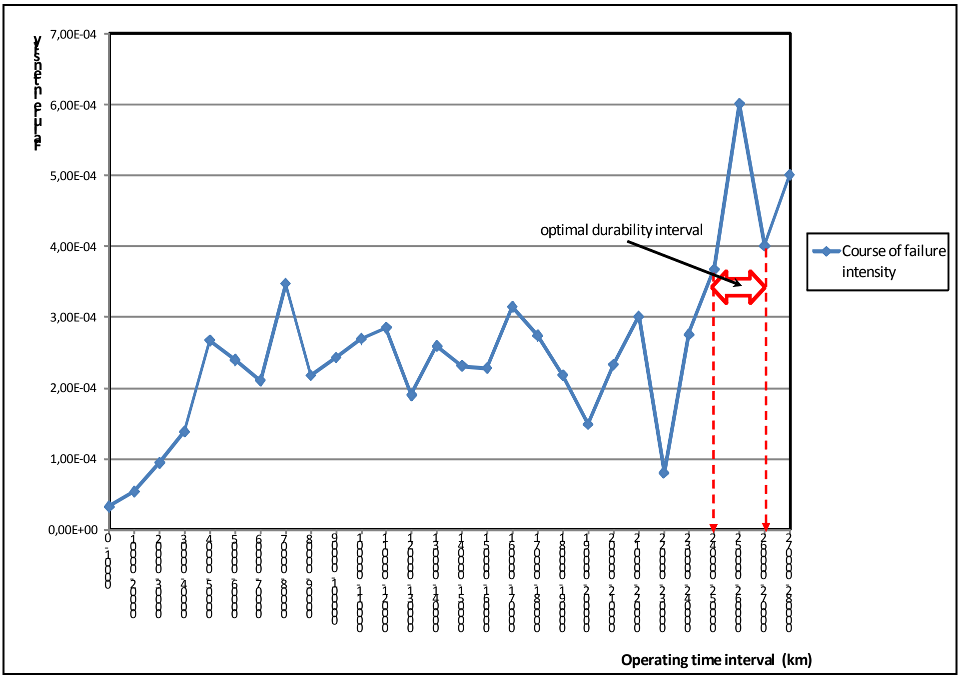

Fig. 6 Example expression of failure intensity-kilometrage dependency for vehicle Land Rover Defender

5. Conclusion

Upon the analysis of life cycle costs and failure intensity, the optimal durability time of the vehicle shall be determined. Both optimisation intervals are used as the basis. If the optimisation intervals overlap the value shall be determined from the optimisation interval rounded to tens of thousands of kilometres. If the optimisation intervals do not overlap it shall be necessary to perform a detailed analysis of both criteria and then determine so-called optimal durability time of the vehicle.

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