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Transport and Telecommunication Institute, Lomonosova 1, LV-1019, Riga, Latvia

EVALUATING THE OPERATIONAL RELIABILITY OF ROAD VEHICLES

Marta Knutelska

Faculty of Operation and Economics of Transport and Communications
University of Zilina, Univerzitna 1, 011 26 Žilina, Slovakia
E-mail: marta.knutelska@fpedas.uniza.sk

Operational reliability takes into account operational conditions. It can be specified by evaluating the operational data gained during the operation of the object. In the area of the operation of road vehicles, it is possible to evaluate records of failures, repairs, maintenance, operation costs, etc. These are stored in an information system or in another digital evidence system and are usable for operation reliability evaluation. The operational data can be also used to prognosticate the development of some reliability parameters. Most SMEs in the area of transport do not use special software for monitoring and evaluating the operational reliability of road vehicles. This article refers to the possibility of acquiring some variables in operational reliability from a commonly used Information System and to the possibility of creating a simple programming tool for decision-making and management support in the area of maintenance and replacement of road vehicles, by means of commonly used office software.

Keywords: *evaluation, operational reliability, road vehicles, software, Excel*

1. Operational Reliability of Road Vehicles

The management of the operational reliability of a vehicle fleet is one of the most important tasks of technical operation. It is important to know, and to be able to quantify necessary variables of operational reliability, as it is an inseparable part of quality.

Reliability variables may be classified into three groups.

- technical variables, i.e. those characterizing service life, such as non-fault rate, the duration of service life, the duration of operation, malfunction probability, malfunction intensity etc.
- time variables, i.e. those characterizing time operation parameters, e.g. maintenance duration, repair duration, down time duration etc.
- costs variables, i.e. those characterizing vehicle operation reliability cost parameters, e.g. average costs of replacement per unit of drive output etc.

Cost items related to the technical state of the respective object, or more precisely to the changes in the technical state of the respective object, which can be continuously observed while the respective object (road vehicle) is used, may be exploited as cost parameters. Changes in the technical state provoke changes in selected kinds of operation costs.

There are three significant forms of cost parameters related to the operation of road vehicles: cumulative costs, average costs and immediate costs [1].

Cumulative costs represent a function of operational duration; at a given time t they reflect the total sum of costs from the beginning of the operation until the given time t. They inform about the total sum expended on the operation over time.

Average unit costs express the average sum spent per unit of operation duration since the beginning of the observation.

Immediate unit costs express elementary increases in costs for elementary increases in operation duration. These are those most closely connected with changes in the technical state of a vehicle.

Cost parameters are characteristic not only of their dependence on changes in technology, but on the current price level as well. This can be perceived as a disadvantage as well as an advantage, as it is the price level that influences the weight or the importance of any kind of intervention in the area of maintenance and reconditioning in given operational conditions in a given time [1].

2. Operational Reliability in Maintenance and Reconditioning Management

Observation and evaluation of the operational reliability of road vehicles, as well as the acquisition and evaluation of other parameters that could be helpful in decision-making and managing the technological maintenance and reconditioning of road vehicles, can be integrated as a part of an Information System.

Even if there are special information systems for maintenance management, these are usually too expensive for smaller enterprises.

Currently, most enterprises use centralized information systems, which are usually modularly formed. Their only module is sometimes equivalent to a maintenance management module. However, IS are usually oriented towards economics and logistics (accountancy, HR, storage, invoices, etc.) and they offer minimal benefit for maintenance management (if they are used for that purpose at all).

Available net applications aimed at maintenance management are suitable for this purpose because of their utility characteristics which meet the needs of management maintenance systems. However, their price is often not acceptable for SMEs. Therefore, many small enterprises prefer to order bespoke software of a lesser scope. The analysis and designing phase of an appropriate model of an IS, as well as the creation of a database (i.e. supplying the input parameters phase) is lengthy, and there are many potential pitfalls for both partners (the enterprise and the programmers). If the designed system is too large-scale and relatively complex, its creation and initiation takes too long (not less than two years), and costs are too high for a small enterprise. Therefore, it is very common for an enterprise to use a commercial system for accountancy, wages, logistics etc. Then, its maintenance workers often use smaller-scale software, whose creation and initiation they have supported themselves.

Even in the absence of software for management maintenance, it is possible to acquire data which can be used, for example, for the evaluation of operational reliability or for the prognosis of the development of some observed parameters from a 'classical' Information System. There is an appropriate and much used programming tool: common office software such as a database or spreadsheet calculator.

Owing to the nature of transport activities, questions of maintenance, repairs, reliability monitoring etc. are handled together with logistics and transport services. In reality, the monitoring and evaluating of reliability is often of secondary importance, or there is no computer support for reliability monitoring at all. On the other hand, it may be expected that there is evidence of failures in transport activities and repairs in some form in any company. Moreover, it may also be expected that any company uses a spreadsheet calculator, usually MS Excel. Among the more advanced tools in MS Excel are pivot tables and charts that can be successfully used to create outputs, overviews and calculations in the form of tables and charts regarding the maintenance, repairs, failure rate, reliability etc. The software presented is based on the same pivot tables, which are simple and of great information value.

The system is based on a register, kept continuously in a database, of spare parts used and work done on maintenance and repairs on road vehicles. Consequently, it offers an overview of some reliability variables displayed as tables or charts, and it enables trends in the logistics development for any component group or for the vehicles as a whole to be checked [2].

The software consists of a package of templates and books in MS Excel, named Evidence, Time, Cost and Replacement and a special program in Visual Basic named Prognosis.

This was generated by using the tools of the spreadsheet calculator MS Excel, especially pivot tables, charts and macro programming in Visual Basic for Applications.

The following pictures illustrate the whole software and the Evidence file. This serves also to run the Time, Costs and Replacement modules [3].

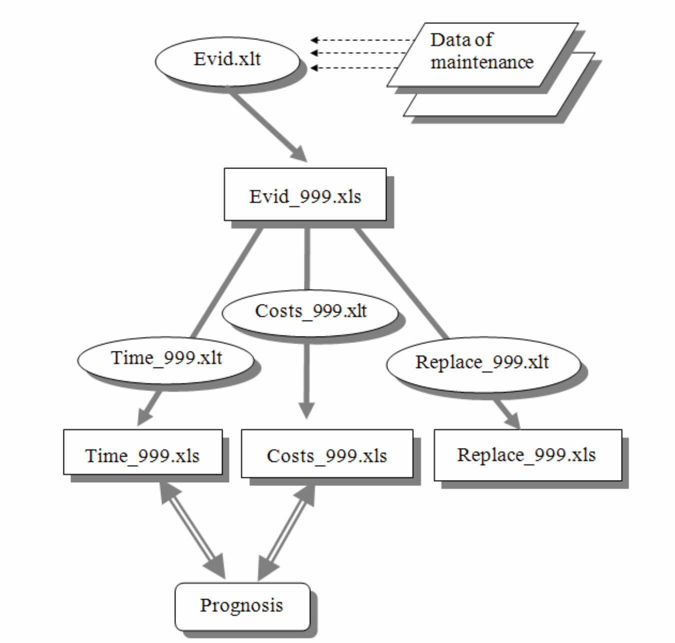
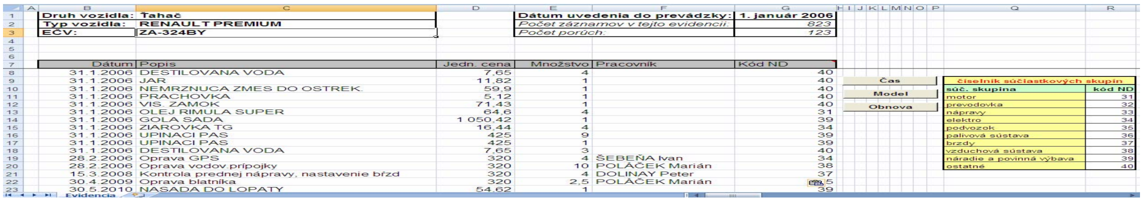


Figure 1. Scheme of the software

The Evidence file (Evid_999.xls) represents the basis of the whole process. This book has a single sheet containing the evidence of individual spare parts, additional material used and work done in repairs of a specific road vehicle in the course of its service.

There are identification data for the vehicle, the date of the start of its service, the number of records in a given time and the number of registered failures. (Cells G1 to G3).



Druh vozidla:	Ťahač
Typ vozidla:	RENAULT PREMIUM
EČV:	ZA-324BY
Dátum uvedenia do prevádzky:	1. január 2006
Počet záznamov v tejto evidencii:	823
Počet porúch:	123

Dátum	Popis	Jedn. cena	Množstvo	Pracovník	Kód ND
31.1.2006	DESTILOVANA VODA	7,65	4		40
31.1.2006	JAR	11,82	1		40
31.1.2006	NEMRZNUCA ZMES DO OSTREK.	59,9	1		40
31.1.2006	PRACHOVKA	5,12	1		40
31.1.2006	VIS. ZAMOK	71,43	1		40
31.1.2006	OLEJ RIMULA SUPER	64,6	4		31
31.1.2006	GOLA SADA	1 050,42	1		39
31.1.2006	ZIAROVKA TG	16,44	4		34
31.1.2006	UPINACI PAS	425	9		39
31.1.2006	UPINACI PAS	425	1		39
31.1.2006	DESTILOVANA VODA	7,65	3		40
28.2.2006	Oprava GPS	320	4	ŠEBEŇA Ivan	34
28.2.2006	Oprava vodov.prípojky	320	10	POLÁČEK Marián	38
15.3.2008	Kontrola prednej nápravy, nastavenie bŕzd	320	4	DOLINAY Peter	37
30.4.2009	Oprava blatníka	320	2,5	POLÁČEK Marián	5
30.5.2010	NASADA DO LOPATY	54,62	1		39

Čas

Model

Obnova

číselník súčiastkových skupín	
súč. skupina	kód ND
motor	31
prevodovka	32
nápravy	33
elektro	34
podvozok	35
palivová sústava	36
brzdy	37
vzduchová sústava	38
náradie a povinná výbava	39
ostatné	40

Evidencia

Figure 2. Example of data in the Evidence sheet

The specific records consist of the following data: Date, Description, Unit price, Amount, Worker, ND Code (Cells B7 to G7). These records are created gradually in the course of the service of the road vehicle and are ranged according to date. The 'Worker' data contain the name of the worker in the case of work done in repairing the vehicle. In the case of spare parts used, the column remains empty. An example of input data can be seen in Picture 2.

The evidence file serves as the source of data for consecutive processing of the Costs, Time and Replacement books, which are activated by macro buttons (Čas, Model, Obnova), as seen in Picture 2. The data in the Evidence can be obtained also by exporting and adjusting the data from the business information system into an Excel table if the system used contains such data but does not monitor reliability. The ND code is assigned to the records according to the encoding contained in Table 1.

Table 1. Encoding

Spare parts group encoding	
Spare parts group	**Code**
motor	31
gear	32
axles	33
electronics	34
chassis	35
fuel system	36
brakes	37
air system	38
tools and compulsory equipment	39
other	40

To enable a successful use of this book, continuous evidence, including the correct ND codes, is required. In addition, the data from the book are to be used as the single common data source for the Costs.xls (button "Model"), Time.xls (button "Čas"), and Replacement.xls (button "Obnova") books.

The Costs.xls and Time.xls books allow various overviews and values concerning the reliability indexes by using the pivot tables and charts to be obtained. These books can be created by running macro directly from the Evidence book. The macro copies the evidence records into the Costs.xlt and Time.xlt templates, and so the prepared pivot tables, pivot charts and calculations of reliability indexes are updated.

A program to search for the Logistic Curve ("Logkrivka" button) variables can be run on some sheets. This allow forecasting of the future development of monitored indicators [3].

A pivot table with the rate of occurrence of failures of spare parts group 37-brakes for a specific road vehicle, complemented by output from the module Logistic curve is shown (picture 3). This module computes the values of logistic function on the basis of data from the pivot table, and forecasts the trend.

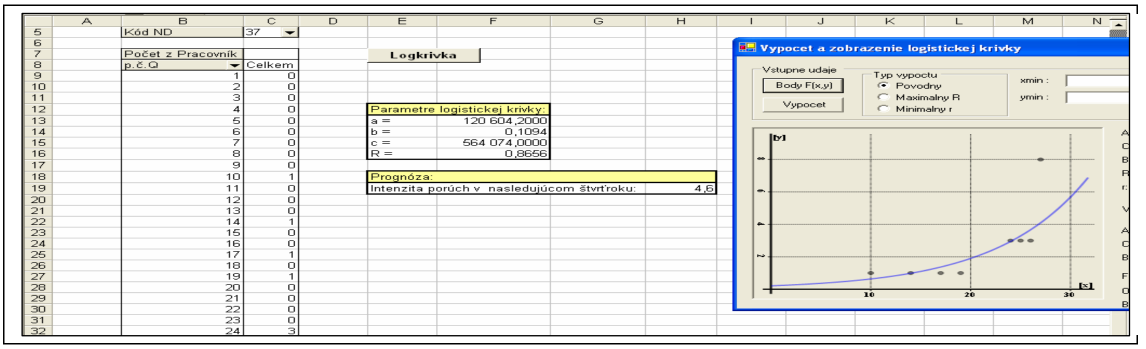


Figure 3. Rate of occurrence of failure complemented by logistic curve and prognosis

Time indicators are contained in the Time.xls book. The pivot table and pivot chart offering information on the gradually decreasing time between failures of spare parts group 37-brakes are seen in Figures 4 and 5.

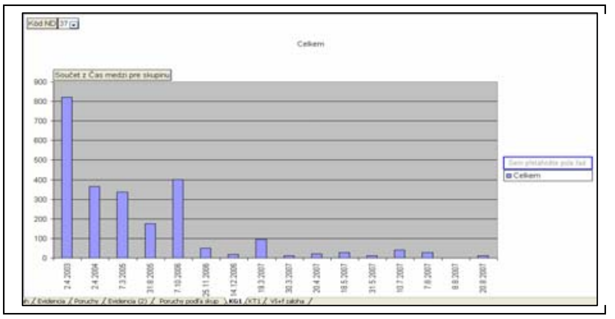


Figure 4. Pivot chart - decreasing time between failures

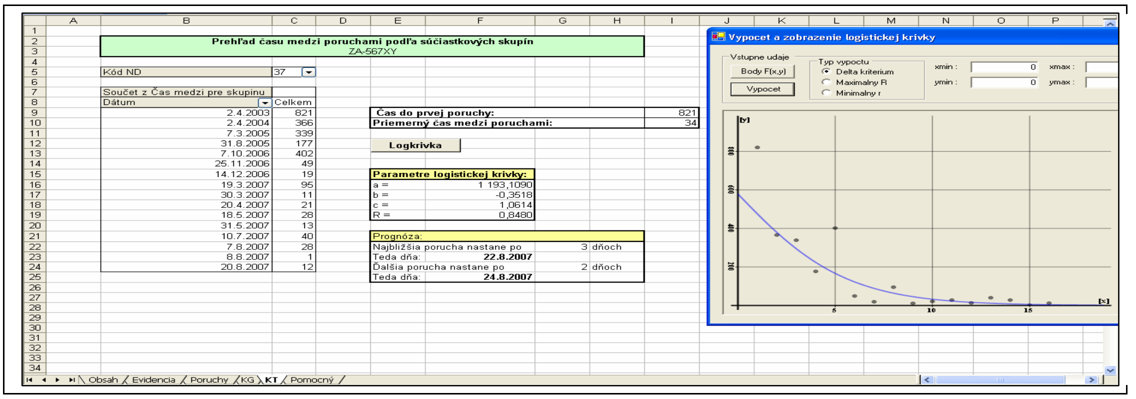


Figure 5. Output of the Time book with prognosis of the next failure

The macro run from the Evidence book can also activate the Replacement template and create the Replacement book, aimed to calculate the time for the optimal replacement of the object by using the function of immediate costs of replacement with the help of the Excel function to add a trendline to the chart and to obtain the corresponding equation of regression function. While applying the regression function for a few periods ahead, we obtain a prognosis for the development of the observed variable. If the analytical expression of regression function is known, its derivation gives us the function of immediate unit costs, which may be used; for example, to specify the optimum reconditioning time for the vehicle.

A situation can occur, when none of the trendlines offered by the spreadsheet (MS EXCEL in our case) for the chart design is appropriate for the regression of development. Then it is possible to use its complementary part Solver or to create a simple application; for example by searching for a regression function using the smallest squares method. Of course, many activities may be automated even in Excel by using macros.

3. Conclusion

As the processing is automatic and supported by various macros, this software product can be also operated by relatively unskilled MS Excel users. This tool has the potential to be used in the information systems dealing with the operational reliability of road vehicles in order to manage the technological processes of maintenance and repairs. After a little adjustment, this software support for monitoring and evaluating reliability can be also used for other objects of maintenance (not just road vehicles).

A similar approach is appropriate if there is an SME not using any special Information System for its maintenance management. This would offer suitable grounds for decision-making and managing the technological processes of the maintenance and reconditioning of road vehicles.

The software is simple and user-friendly, with low hardware requirements and is easily compatible with other business information systems platforms or maintenance management systems. Thanks to these qualities, as well as its low cost, it is especially suitable for SMEs in the transport sector that could find the purchase of a complex information system with integrated support for the operation, maintenance and repairs of road vehicles beyond their needs and means.

The given example can provide a basis for specially created software, which, if being developed with knowledge of a given enterprise, and not expected to be grand and universal, can provide higher quality in the process of maintenance management, while keeping costs low and the design period short. This can profoundly influence the operational reliability of the enterprise's vehicle fleet, lower the costs of reconditioning, and lower the inventory level in the spare parts warehouse. In this way, total costs can be lowered and profits increased.

The author graduated in mathematics from the Comenius University in Bratislava and was awarded RNDr. in Informatics. She received her PhD. in Transport and Communications technology. She currently works as a lecturer at the Univesity of Zilina, where she teaches Informatics in the Road Transport study programme. In her research, she focuses on reliability in road transport.

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