MEANS OF TRANSPORT MAINTENANCE PROCESSES PERFORMANCE. DECISION SUPPORT SYSTEM.

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Abstract

The target of this paper is to develop a decision support system for means of transport maintenance processes performance. As a result, there is presented the decision support system conception which is investigated in the research area. Later, the implementation of chosen expert system is discussed.

Keywords:
passenger transportation, maintenance strategy, decision support system, delay time.

1. INTRODUCTION

The main problem, which occurs during the exploitation process performance of technical objects (including means of transport), is connected with a present or future main maintenance strategy definition. The proper decision demands a dependability state of a system or adequate maintenance performance determination. The decision effectiveness strictly depends on their accuracy and dedicated decision time.

The decision making process includes three steps, information gathering and analysis, available decisions definition, and optimal solution choice [20]. In the area of transportation means’ maintenance performance, the main decision process elements are presented e.g. in [3].

Improvement of decision making process can be achieved with the use of decision support systems. Such systems can support chosen or every step of manager’s decision making process, such as: data gathering, problem definition, problem classification, information model designing, model solution, or optimization process performance [7].

The concept of a decision support system (DSS) is extremely broad and its definitions may vary depending on the author’s point of view and the way of its use [5]. According to DSSResources.com, a DSS is defined as an interactive computer-based system or subsystem intended to help decision makers use communications technologies, data, documents, knowledge, and/or models to identify and solve the problems, complete decision process tasks, and make decisions [19]. Thus, the systemic framework should be used as an organizing concept when designing an effective and reliable DSS [1]. For more information, we recommend reading e.g. [5, 7, 15, 19].

The computerized information systems used to support exploitation processes performance can be found e.g. in [9], where authors focused on Belt Conveyor Editor performance. There are described the system structure and operation, including operational information and its availability analysis. Another research works, in which the problem of decision support system development and implementation is analysed are e.g. [2, 10, 11, 12, 13, 21]. Moreover, in work [17], the expert system for technical objects’ reliability prediction was developed. The solution was based on EXSYS Professional system implementation. In the area of passenger transportation processes performance, DSS problems are analysed e.g. in [4, 8, 14, 18].

Following this introduction, the conception of DSS in the area of means of transportation maintenance processes performance is developed. Thus, the paper is organized as follows: First, there is briefly literature overview in the research area discussed. Later, the expert system for means of transport maintenance
processes performance is also investigated. The research area encompass formulation of methods and algorithms of right maintenance strategy (traditional/Delay Time Approach) for system elements selection. The solution is based on decision rules implementation. The examples of expert system implementation are given. The work ends up with summary and directions for further research.

2. DECISION SUPPORT SYSTEM IN TRANSPORTATION MEANS’ MAINTENANCE PROCESSES PERFORMANCE – CONCEPTION

The expert system is prepared as a computer program which enables easier and faster conclusion acquirement. The solution is based on EXSYS Professional system implementation. The general decision support program's structure is given in the Fig. 1. Moreover, the example of decision rules edition process is given in [17] and the introduction to the presented problem is given in [3, 16]. The purpose of the DSS performance is connected with possible maintenance strategy for technical object definition based on chosen maintenance and dependability indicators' values.

![Fig. 1. The structure of DSS for means of transport maintenance process performance [16]](image)

The main assumptions taken during the DSS development encompass [3]:

- performance of a multi-component (or complex), repairable transportation system investigation,
- investigation of maintenance strategies for systems with and without components dependence,
- corrective maintenance strategy omission,
- condition-based maintenance models omission – because of the different approach to maintenance performance than PM models,
- maintenance information management models omission – because of focusing on proper organization of maintenance information management processes necessary to effective performance of a system,
- cannibalization maintenance models omission – because of focusing on such issues as inventory planning problem, spares allocation problem, or supply cannibalization issues.

Following this, the main input data which are necessary to be used in a DSS performance can be classified into three groups [3]:

- general data, which describe transportation system performance,
• data which describe the actual state of transportation system,
• data which describe the maintenance costs of transportation system performance.

More information can be found in [3].

Based on the gathered information in the system, the main conclusions in a DSS may be defined [3]. The exemplary ones are given below:

• MAINTENANCE ACCORDING TO SERVICE MANUAL (t0) – indicate, that mean of transport maintenance should be made according to the given service directions included in object’s documentation. Such a conclusion is stated when there is no operational information available in a system,

• MAINTENANCE ACCORDING TO CHOSEN STRATEGY – indicate, that there should be implemented maintenance strategy in a system,

• MAINTENANCE ACCORDING TO DTA IMPLEMENTATION – suggests implementation of maintenance strategy based on Delay Time approach (DTA).

The final conclusions which end the chosen branch of a decision tree are indexed according to $t_i$, were $i$ – defines $i$-th final conclusion in the DSS, $i = 0, 1, 2, \ldots$

Taking into account the analysed DDS, the decisions are made based on the information about the state of a system, maintenance costs and data accessibility. These input data being defined more precisely and quantified are used to develop decision rules, which are the simple logical sentences [16]. Moreover, the presented below decision rules can be used only in the situation when all the prerequisites connected with input data availability are defined. Decision rules are of both types, indirect and direct ones [3].

First decision rule defines if there is a possibility to use one of the maintenance strategies. The condition regards to data accessibility ($I$):

IF $(I = 1)$ THEN MAINTENANCE ACCORDING TO SERVICE MANUAL
ELSE MAINTENANCE ACCORDING TO CHOSEN STRATEGY

When data are available, second problem is connected with the system components which are to be maintained. The first condition regards to components’ dependency ($L$):

IF $(L = 0)$ THEN MAINTENANCE STRATEGY FOR INDEPENDENT SYSTEM COMPONENTS
ELSE MAINTENANCE STRATEGY FOR DEPENDENT SYSTEM COMPONENTS

When there is known expected delay time $E[h]$, and its relation to the length of time between maintenance actions performance $T_{cw}$ is greater than a specified value $x$ (subjectively estimated by experts), then we can choose one of the inspection strategies based on Delay Time approach (DTA) implementation:

IF $(E[h] = 0$ AND $E[h]/T_{cw} \geq x)$ THEN MAINTENANCE ACCORDING TO DTA IMPLEMENTATION
ELSE MAINTENANCE ACCORDING TO PM STRATEGY

Later, if the DSS recommends DTA implementation, we can choose maintenance policy for complex systems or multi-unit systems:

IF $(N_p = 2)$ THEN DTA MAINTENANCE MODEL FOR COMPLEX SYSTEMS
ELSE DTA MAINTENANCE MODEL FOR MULTI-UNIT SYSTEMS

If the DTA model for complex systems is recommended, manager should decide whether repair time (RT) is negligible or not:

IF $(RT = 0)$ THEN DTA MAINTENANCE MODEL $t_{25}$
ELSE DTA MAINTENANCE MODEL FOR COMPLEX SYSTEMS WITH NEGLIGIBLE RT

The example of decision tree part, which illustrates the presented decision rules, is given in a Fig. 2.
3. EXPERT SYSTEM IMPLEMENTATION

The described DSS was implemented into Exsys Corvid „Shell“ computer system. Exsys Corvid, is a development environment suitable for any type of knowledge automation system project – anywhere expert advice and answers need to be distributed or accessed [6].

The first step of building a new system is the variables creation. We have 3 types of defined variables (see Fig. 3):

- names of maintenance strategies to be chosen with confidence factor,
- parameters of branch point in the tree of static list type,
- parameters of branch point in the tree of numeric type.

Static list variable is a variable that has a specific list of possible values. These are typical multiple choice list. The possible values always remain the same to each user of the system.

Numeric variable is a variable that is assigned a numeric value. The value may be asked of the end user, calculated from other rule or obtained from an external source.

Confidence variable is a variable that will be assigned a value that reflects a degree of certainty in a specific result or recommendation. Like a numeric variable, the value is a number, but in this case it is a measure of how likely it is that the variable applies to a particular situation. Confidence variables are used most effectively in systems where there are multiple possible recommendations based on how likely they are.
The second step of the system building is to create a Logic Block that matches the tree diagram. (see Fig. 4) The Logic Blocks are groups of rules that can be defined by tree diagrams or stated as individual rules. Each block may contain many rules, many trees or only a single rule. Usually, the block of rules all relate to a specific aspect of the decision-making task, though how blocks are used in a particular system is up to the developer. The discussed exemplary DSS have only a single Logic Block. In addition to the tree view shown in the Logic Block, individual rules can also be examined in the Rule View Window.

The system was added by Command Block which contains the procedural commands that tell the Inference Engine how to use the rules. It was determined that the rules will be run in forward chaining. The validation test shows that the system works correctly – the system helps to choose one of the given maintenance strategies with confidence factor $cf=1$.

4. SUMMARY

The presented issue is a continuation of research work connected with developing a decision support system for transportation means’ maintenance processes performance. The system should give decision makers a hint which one from the defined maintenance strategies is the most advisable to implement in a defined circumstances. Thus, the main decision support process’ backgrounds include present technical state of an object, maintenance standards, and input data availability. As a result, the main problems which are necessary to be solved regard to e.g. dependability characteristics definition, decision variables definition and evaluation (e.g. time resource).
LITERATURE


