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# STRATEGY OF MAINTENANCE SYSTEM IN INDUSTRIAL COMPANY

# STRATEGIA SYSTEMU UTRZYMANIA RUCHU W ZAKŁADACH PRZEMYSŁOWYCH

A b s t r a c t

This paper introduces the main conclusions of the doctoral thesis "Strategy of maintenance system in industrial company", which focuses on improving of economic efficiency of the maintenance system by selecting the appropriate maintenance strategy for production machines. In the paper I characterise outputs of the survey, which focuses on characterization of maintenance management level, maintenance cost control and allocation level and range of modern maintenance management tools (Computerized Maintenance Management Systems = CMMS) utilization in industrial enterprises in Czech Republic. This article also deals with proposed methodology for selecting the appropriate maintenance strategy and with the brief characteristic of the model MAM (Maintenance Analytical Module), which was developed as a decision support tool for maintenance managers.

*Keywords*: *maintenance*, *maintenance strategy*, *maintenance management*, *maintenance planning*, *CMMS*, *Computerised Maintenance Management Systems*

S t r e s z c z e n i e

Artykuł prezentuje główne wnioski z pracy doktorskiej „Strategia systemu utrzymania ruchu w zakładzie przemysłowym", która skoncentrowała się na ulepszeniu ekonomicznej wydajności systemu utrzymania ruchu poprzez wybór właściwej strategii konserwacji maszyn produkcyjnych. W artykule została zaprezentowana charakterystyka przeglądów, które skupiają się na charakterystyce poziomu zarządzania obsługą, kontrolą kosztów utrzymania i poziomu alokacji, zakresu wykorzystania nowoczesnych narzędzi do zarządzania remontami w zakładach przemysłowych w Czechach. W artykule opisano proponowaną metodę wyboru właściwej strategii zarządzania remontami, scharakteryzowano model MAM (Maintenance Analytical Module), który pełni rolę narzędzia wspomagającego decyzję personelu zarządzającego konserwację.

*Słowa kluczowe*: *konserwacja*, *strategia konserwacji utrzymanie ruchu*, *CMMS*

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## Abbreviations

CMMS – Computerised Maintenance Management Systems
ERP – Enterprise Resource Planning
HCT – Hourly Cost Tariff [EUR/hour]
MAM – Maintenance Analytical Module = decision support model

## 1. Main objectives of the thesis

Maintenance is an integral part of any production system, plays an important role in ensuring the operability of the company and significantly influences its productivity. Appropriately chosen maintenance strategy contributes to the fact that customers receive their products in the required time and required quality, which is involved in maintaining business competitiveness. It is therefore obvious that the level of maintenance management can significantly influence the success of business. For this reason I chose maintenance as a target area for my doctoral thesis Strategy of maintenance system in industrial company, which focuses on improving of maintenance system economic effectiveness.

The main task of the thesis is to provide maintenance managers with the information necessary for selecting the appropriate maintenance strategy in the enterprise. This strategy should ensure that the resources allocated to maintenance are used effectively. For fulfilling this task, the following objectives were identified:

**A. Des cription of current state in the field of maintenance management and planning**
Using research of information sources and survey among target companies I described current state in this field and identified requirements of target industrial enterprises, weaknesses in their maintenance management systems and potential areas for future development.

**B. Proposal of the methodology for selecting the appropriate maintenance strategy**
I proposed and characterised steps of the methodology for selecting appropriate maintenance strategy which effectively uses allocated resources.

**C. Design of the decision support model for selecting of the appropriate maintenance strategy**
I designed the decision support model MAM (Maintenance Analytical Module) as a key tool integrated in the proposed methodology. This model provides managers with important information for the selection of maintenance strategy.

**D. Characteristics of the links between the model and other information systems and sources**
Because the methodology and the MAM model are demanding on input data an essential part of the thesis represents description of the links and information flows between information systems and other information sources.

**E. Evaluation of the maintenance efficiency**
As the last step of the methodology I proposed a system of evaluation indicators that helps maintenance managers to verify if the appropriate maintenance strategy was chosen.

In the following parts of article I will deal with a brief description of the three main outputs of the dissertation: survey of the maintenance management level in industrial enterprises in Czech Republic, methodology for selecting of appropriate maintenance strategy and decision support model MAM.

## 2. Survey of the maintenance management level in industrial enterprises in Czech Republic

Determining the level of maintenance management in Czech engineering enterprises was the main objective of the survey. I chose an electronic questionnaire in combination with structural interviews to meet this objective. The questionnaire consists of five main parts, which represent key characterization areas of maintenance management level.

**A. Definition of the role of maintenance in the enterprise**
Respondent defines the scope of maintenance and characterizes the importance of maintenance to ensure the operability of the company.

**B. Maintenance strategy**
Respondent defines which approaches and strategies are applied in the management and maintenance planning in the company.

**C. Causes of failure**
Respondent characterizes the typical causes of failure (if they are monitored and set by the company).

**D. Use of IT tools in the management and maintenance planning**
Respondent defines what tools and IT support uses for planning and managing maintenance. When the company uses Computerized Maintenance Management Systems, in which way this system is used, which are the main benefits of the implemented systems.

**E. Costs associated with maintenance**
Respondent characterizes the amount of the cost of maintenance and explains what kinds of cost are monitored in the company and to what level they are allocated. This part of questionnaire should be answered by maintenance manager or in consultation with controlling manager.

Brief characteristic of the survey is in the Table 1.

### 2.1. Results of the survey

Most of the respondents define their maintenance strategy as a combination of reactive and preventive approach. They differ only in the ratio between these parts. Average share of machines on which preventive maintenance is performed is approximately 75%. This share is lower for companies with smaller number of machines and younger machines.

Results show that a large portion of failures can be directly influenced by maintenance (normal wear, lack of lubrication or cleaning, poorly performed maintenance).

Only 25% of respondents have implemented specialized CMMS systems. The wider application of these modern tools can be seen as a potential way for improving maintenance management level in target enterprises.

Mostly only direct maintenance costs are closely monitored and calculated, allocation level of costs is insufficient for proper choice of maintenance strategy.

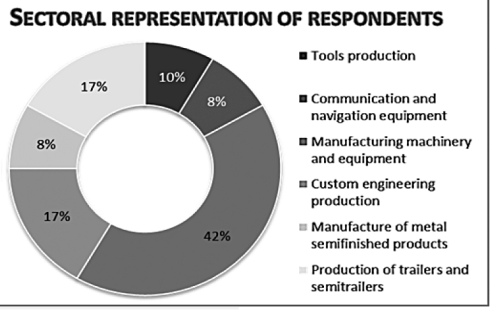
Maintenance management level in target companies cannot be considered as low, but maintenance managers often have not enough information for choosing appropriate maintenance strategy.

More detailed information about the survey was published in articles [1, 2].

Table 1

**Survey characteristic**

| Survey characteristic |
|---|
| **Goal** |
| Characterization of the maintenance management level, maintenance cost control and allocation level and range of modern maintenance management tools (Computerized Maintenance Management Systems=CMMS) utilization in industrial enterprises in Czech Republic. |
| **Method of data collection** |
| Questionnaires created in Adobe Acrobat Professional in combination with structured interviews |
| **Target person** |
| Head of Maintenance Department, the last part of the survey focused on costs is determined by staff responsible for monitoring and analysing costs (e.g. staff of controlling or economic department) |
| **Target respondents** |
| ▫ **Midsized and larger engineering enterprises with mostly small-lot production:** These companies already have such a number of machines, which requires a systematic approach to maintenance management. On the other hand, sophisticated maintenance management systems are often not implemented and maintenance processes are not precisely defined as it could be seen in automated mass production.<br>▫ **Number of complete questionnaires - 12 pcs**<br>▫ **Return rate of questionnaires - 15%** |




## 3. Methodology for selecting the appropriate maintenance strategy

This part of the paper deals with a brief description of the methodology for selecting of the appropriate maintenance strategy for defined system of machines. The methodology focuses primarily on the economic benefits of implemented strategies and is primarily based on the Reliability Centred Maintenance (RCM) approach [3–5].

The main goal of the methodology is to prepare and provide information needed for the selection of the maintenance strategy for individual system element (machine), which effectively uses resources allocated to the maintenance and has maximum benefits for the whole system. The final decision about maintenance strategy makes maintenance manager. However, he can rely not only on his experience, but also on relevant information obtained through the proposed methodology and by using the developed MAM decision support model.

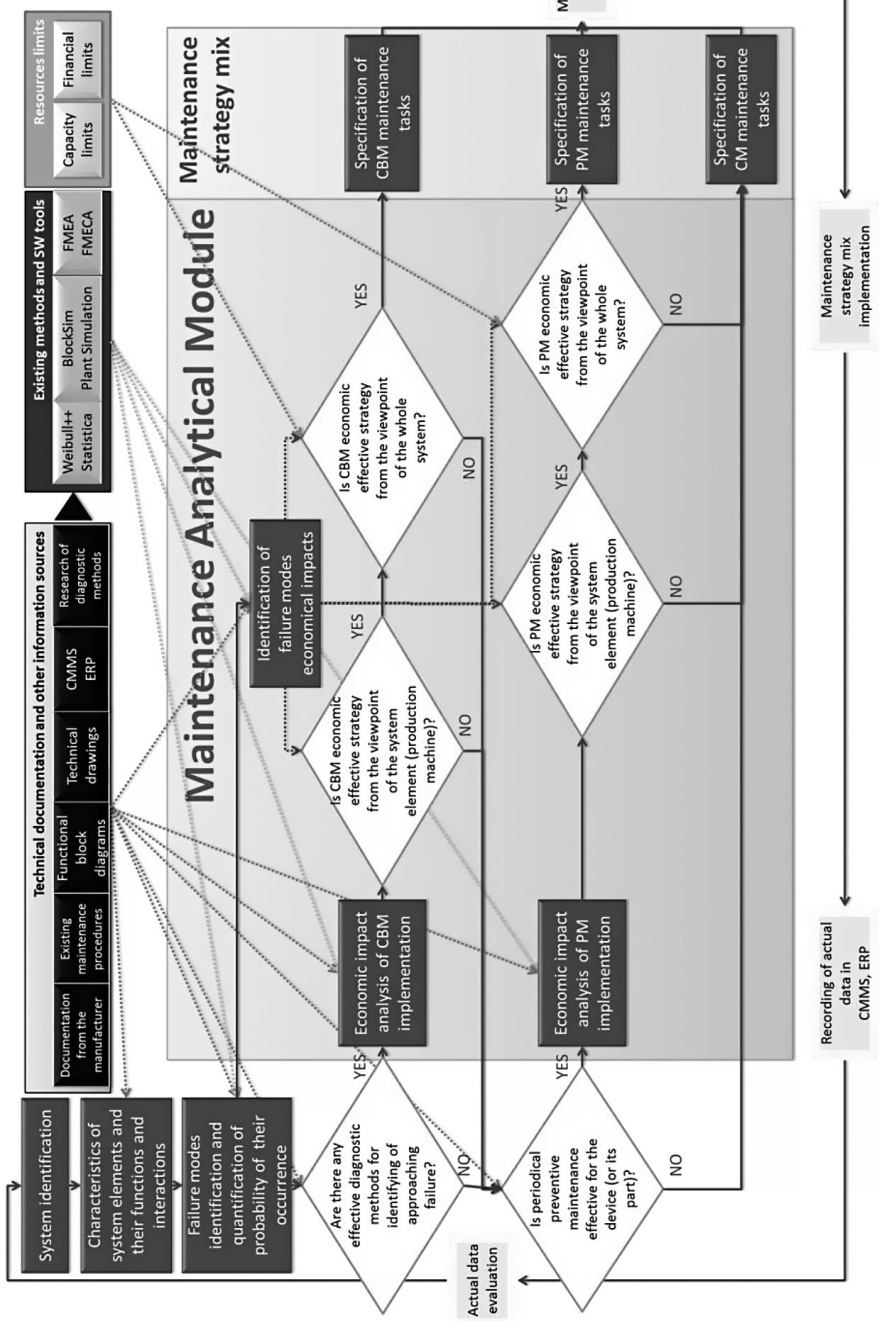



Fig. 1. Process map of the methodology for selecting appropriate maintenance strategy

Rys. 1. Mapa procesu metodyki wyboru właściwej strategii remontu

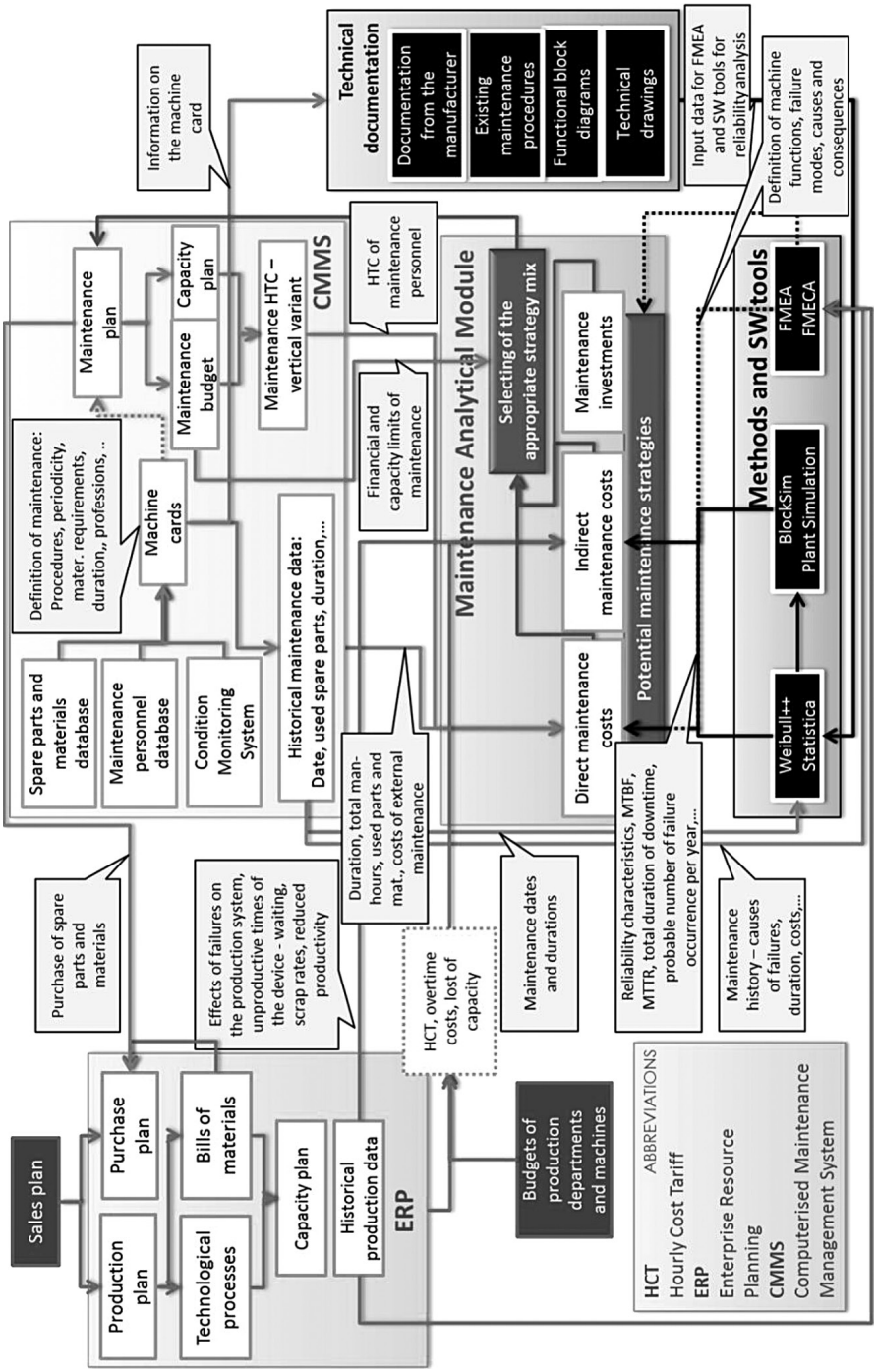



Fig. 2. Information flows between information systems used within proposed methodology

Rys. 2. Przepływ informacji pomiędzy systemami wykorzystanymi w proponowanej metodyce

Individual steps of the methodology are shown in the Figure 1. Information flows and links between information systems and sources within the methodology are shown in the Figure 2.

Because the methodology is very demanding on input data the possibility of its application without using advanced software tools (CMMS, SW for reliability data analysis) is very limited. It is also very important to ensure the linkages between information systems, as shown in Figure 2.

## 4. Decision support model MAM (Maintenance Analytical Module)

Model MAM was developed as an integral part of the methodology (the field of application of the model within the methodology is marked in the Fig. 1 and 2). It is decision support model (not optimization model), which represents specialized module for complex analysis of the maintenance system. Model uses big amount of input data from different information sources for generating outputs needed for decision making on maintenance strategies (see Fig. 2).

The main objective of the model MAM is an information support for maintenance managers in choosing the appropriate maintenance strategy. With this main objective are connected these benefits of the model:

- Simplifies the quantification of the direct and indirect maintenance costs
- Organizes the data about individual system elements (machines) as well as the entire system and thus provides decision support for maintenance managers at three different levels:
  - Mutual comparison of different maintenance strategies on one machine,
  - Mutual comparison of system elements (machines) within the whole system,
  - Mutual comparison of the strategic mixes,
- Provides sensitivity analysis and simulations of the impact of changes in various inputs on the overall costs of maintenance, production capacity and other characteristics (e.g. in case of lack of empirical data),
- Provides financial arguments to maintenance managers for negotiations with top management on investments in the maintenance system development.

Model MAM represents prototype of the information system programmed in MS Excel, which is used for presentation of basic structure, verification of the model functionality and illustration of the links between individual model parts. For demonstration of the model functionality the case study for system of ten machines was defined.

The model structure is hierarchical and is shown in the Fig. 3.

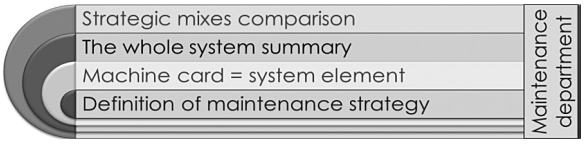



Fig. 3. Structure of the MAM model

Rys. 3. Struktura modelu MAM

Model MAM provides output characteristics, which can be used by maintenance managers for selecting of maintenance strategy mix suitable for individual system element (machines). This strategy mix brings maximal benefits for the whole system. Selected outputs characteristics provided by the MAM model are shown in the Table 2.

Table 2

| Output characteristics for different maintenance strategies provided by the MAM model | | |
|---|---|---|
| ✓ Purchasing price of the machine | ✓ Total maintenance costs (direct and indirect) | ✓ Work hours of the maintenance department |
| ✓ Age of the machine /planned durability | ✓ Savings in the implementation of the chosen maintenance strategy | ✓ Increase of the real production capacity of the machine |
| ✓ Hourly costs of overtime and lost production capacity | ✓ CAPEX associated with maintenance strategy, ROI, payback period | ✓ Downtime/Uptime rate |

## 5. Conclusions

This article deals with brief description of three main outputs of the doctoral thesis Strategy of maintenance system in industrial company. At first it describes survey of the maintenance management level in industrial enterprises that was used for definition of current state, needs of target companies and together with research of information sources for identification of potential ways of development in field of maintenance management. Second part of the article describes methodology for selecting appropriate maintenance and developed SW tool – MAM decision support model. Dissertation as a whole is beneficial mostly for maintenance managers, whom provides information and methodological support.

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