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Maintenance Process Strategic Analysis

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Abstract. The performance and competitiveness of manufacturing companies is dependent on the availability, reliability and productivity of their production facilities. Low productivity, downtime, and poor machine performance is often linked to inadequate plant maintenance, which in turn can lead to reduced production levels, increasing costs, lost market opportunities, and lower profits. These pressures have given firms worldwide the motivation to explore and embrace proactive maintenance strategies over the traditional reactive firefighting methods. The traditional view of maintenance has shifted into one of an overall view that encompasses Overall Equipment Efficiency, Stakeholders Management and Life Cycle assessment. From practical point of view it requires changes in approach to maintenance represented by managers and changes in actions performed within maintenance area. Managers have to understand that maintenance is not only about repairs and conservations of machines and devices, but also actions striving for more efficient resources management and care for safety and health of employees. The purpose of the work is to present strategic analysis based on SWOT analysis to identify the opportunities and strengths of maintenance process, to benefit from them as much as possible, as well as to identify weaknesses and threats, so that they could be eliminated or minimized.

1. Introduction

With the increasing complexity, scope, and organisational role of operational advanced manufacturing technologies, the maintenance of these technologies is becoming very critical to the ability of the organization to compete [1]. In this context, operations management, especially maintenance management is taking on a broader organizational strategic role.

The goal of the following paper is to present SWOT analysis as the tool for strategic analysis in maintenance management area. In the paper the authors introduces application of SWOT analysis to maintenance system diagnosis and identification of directions of company's strategic actions within maintenance area. This paper is structured as follows: in the next chapter the term and idea of strategic analysis is defined and completed with characteristics of classic SWOT approach. The third chapter introduces the theme of maintenance management and maintenance concepts. The fourth chapter is dedicated to a case study of the SWOT analysis of the maintenance management in the plastic industry. The fifth chapter is a summary of the analysis and discussion presented.

2. Strategic management

2.1. Strategic analysis – definition, scope and methods

The strategic management process is a theoretical approach that incorporates human capital, skill and technical structures in an institution to boost efficiency, effectiveness, and customer fulfilment, while

enhancing employees' satisfaction, adding value to the services and increasing business income [2]. It's a holistic application and handling of the employees, technology, information so as to achieve the preferred results and includes a series of decisions and management actions in order to achieve the defined long-term goals of the company [3]. Strategic management enables an organization to recognize the existing environmental opportunities and threats, and also to understand or estimate the organization's resources capabilities considering the strengths and weaknesses of its resources so as to align itself and to battle with the environmental challenges. Strategic management can be regarded as built from three main components: strategy analysis, which seeks to understand the strategic position of an organisation; strategic choice, which is all about listing the possible scenarios for action, evaluating them, and choosing amongst alternatives; and strategy implementation, which focuses on planning the manner by which strategy is put into action, and managing the changes required. A strategic analysis for a business is one of the most basic and useful tools for strategic business planning. There are many definitions of strategic analysis, for example, strategic analysis is:

- "... a theoretically informed understanding of the environment in which an organisation is operating, together with an understanding of the organisation's interaction with its environment in order to improve organisational efficiency and effectiveness by increasing the organisation' s capacity to deploy and redeploy its resources intelligently" [4],
- "the application of techniques in order to analyze the pressures within an organization's external business environment and the level of internal organizational capability to respond to these pressures" [5].

Definitions of strategic analysis often differ, but the following attributes are commonly associated with it [6]: (1) Identification and evaluation of data relevant to strategy formulation [7]; (2) Definition of the external and internal environment to be analysed; (3) A range of analytical methods that can be employed in the analysis.

Business organizations today deal with unprecedented challenges, opportunities and threats in carrying out their mission. The contemporary market and its tendency to continuous change and growing demands of the relevant stakeholders of organizations, force the search for solutions that ensure achievement of success in the long-term. Short-term thinking about the results of the organization does not guarantee success, and moreover is not sufficient to provide competitive advantage over the world-class companies [8]. Managers always look for comprehensive picture of present condition of the organization and analyze of its future situation considering internal and external environment [9]. In their research and analysis they benefit from analytical methods used in strategic analysis such as: SWOT analysis, PEST analysis, Porter's five forces analysis, four corner's analysis.

2.2. SWOT analysis

In this strategic management process a number of tools and techniques are used, among which analysis of Strengths, Weaknesses, Opportunities and Threats - (SWOT) has a special role. The methodology originally comes from the business management literature and it was developed by the researchers at Stanford Research Institute. The background to SWOT analysis stemmed from the need to find out why corporate planning failed [10, 11]. According to the advocates of SWOT, strengths refer to inherent abilities to compete and grow strong. Weaknesses are the inherent deficiencies that cripple growth and survival. Strengths and weakness are mostly internal. Opportunities are the good chances and openings available for growth. Threats are externally wielded challenges, which might suppress inherent strengths, accelerate weakness and stifle opportunities from being exploded (figure 1).

Figure 1. Classification of factors in the SWOT analysis.

To succeed in any field, weaknesses must be overcome through strengths and threats must be transferred into opportunities. The best way to overcome the weaknesses is to benefit from opportunities and the way to transfer threats into opportunities is through the strengths identified. Hence, egzogenic (external) and endogenic (internal) perspectives are interrelated and influence each other.

The TOWS (Threat, Opportunity, Weakness, Strength) Matrix developed by Weihrich [12] is a commonly cited tool for structuring strategy generation. The TOWS analysis is a conceptual strategic planning model, which allows for flexible formulation of the organization's strategic directions by taking into account future opportunities and threats and seeking to optimize the use of the organization's strengths in order to minimize its weaknesses. The TOWS analysis is carried out by developing four types of strategic directions built by combining the following elements:

- Strengths and opportunities – strategic directions of this type allow for the best use of an organization's achievements by taking into account the opening opportunities for action in the external environment. These strategic directions enable optimal use of an organization's achievements.
- Weaknesses and opportunities – strategic directions of this type focus on various weaknesses that an organization should overcome. Weaknesses may also be overcome by using external opportunities.
- Strengths and threats – strategic directions of this type allow seeing how to use best the main strengths of an organization in order to overcome and minimize threats emerging in the external environment.
- Weaknesses and threats – strategic directions of this type encourage thinking on how an organization should best solve its internal problems in order to avoid the destructive impact of external threats.

Thus, the TOWS analysis empowers an organisation to formulate and evaluate strategic directions comprehensively from different perspectives.

SWOT involves systematic thinking and comprehensive diagnosis of factors relating to a new product, technology, management, or planning. Despite its wide applications, the SWOT method has also a number of problems. According to Ghazinoory et.al [13] the most important are as follows:

- Usually only qualitative examination of environmental factors is considered;
- It considers no priority for various factors and strategies;
- If the number of factors are more, the number of adopted strategies will be increased exponentially;
- It does not consider the vagueness of the factors.

Although up to now, efforts have been made to solve out the SWOT problems, the usual approach is the use of prioritization methods. In particular, the Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP) have been implemented for this case [14, 15, 16]. In the literature on the subject there are also numerous examples of benefiting from fuzzy sets to support interpretation of SWOT analysis. Sevkli et.al [17] proposed *SWOT fuzzy ANP* methodology. The method they

developed was implemented and tested in the Turkish airline industry. Kuo-liang and Lin Shu-chen [18] applied a fuzzy SWOT method to evaluate the competitive environment of different transshipment locations as international distribution centers in the Pacific-Asian region.

3. Maintenance management

3.1. Maintenance scope and definition

Maintenance in its narrow meaning includes all activities related to maintaining a certain level of availability and reliability of the system and its components and its ability to perform a standard level of quality [19]. Maintenance also includes engineering decisions and associated actions that are necessary for the optimization of specified equipment capability, where capability is the ability to perform a specified function within a range of performance levels that may relate to capacity, rate, quality, safety and responsiveness [20, 21]. In European Standards EN 13306:2010 [22] maintenance is defined as the combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function (function or a combination of functions of an item which are considered necessary to provide a given service).

The primary objective of maintenance is to take care of equipment, respond to its needs, and keep it in good operating condition. However, in a business context, maintenance is not the goal [23]. The expectation of an equipment-intensive business is to have reliable equipment performing functions that lead to its business goals. Today, maintenance has become a management issue, with its function as a contributor towards profit. This indicates the need for the maintenance operation to align with the business objectives and increase value for the enterprise. Hence, it is necessary to implement strategic approach and apply methods of strategic management. Murthy et al. [24] define the two key elements of the strategic maintenance management approach: "(1) maintenance management is a vital core business activity crucial for business survival and success, and as such it must be managed strategically. (2) Effective maintenance management needs to be based on quantitative business models that integrate maintenance with other decisions such as production, etc.". They also note that maintenance is understood as a multidisciplinary activity in the strategic maintenance management approach. It involves "(1) scientific understanding of degradation mechanisms and linking it with data collection and analysis to assess the state of equipment; (2) building quantitative models to predict the impact of different actions (maintenance and operations) on equipment degradation; and (3) managing maintenance from a strategic perspective" [24]. As illustrated in figure 2, Marquez and Gupta [25] note that maintenance management must align with business activities at the strategic, tactical, and operational levels. Actions at the strategic level will transform business priorities into maintenance priorities. To meet these priorities, this process will help craft mid-to-long-term strategies to address current and/or potential gaps in equipment maintenance performance. Actions at the tactical level would determine the correct assignment of maintenance resources (skills, materials, test equipment, etc.) to fulfill the maintenance plan. As a result, a detailed program would materialize with all tasks specified and resources assigned. Actions at the operational level would ensure that the maintenance tasks are carried out by skilled technicians, in the time scheduled, following the correct procedures, and using the proper tools.

Maintenance should be considered in long time horizon of strategic planning. Strategic approach to shaping maintenance system should include internal and external conditionings of a company, business strategy of the company and projection of how future changes in maintenance system will influence efficiency of company's functioning. Therefore knowledge and awareness of maintenance context, including maintenance external and internal conditionings, is necessary for contemporary managers.

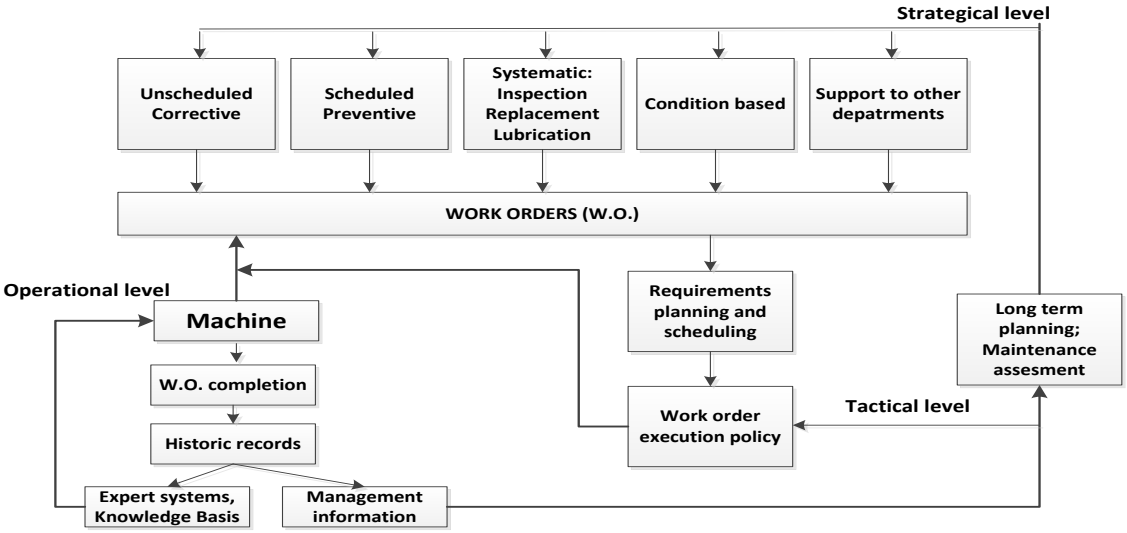

Figure 2. Maintenance process, course of action and feedback operating at the three levels of business activities [25]

3.2. Maintenance context

Usually, maintenance is perceived as a supporting process for main processes performed in a company and working for one customer only – production. However, apart from being a support function, maintenance has a role in gaining and maintaining competitive advantages. Therefore, it is very important for all relevant stakeholders to be aware of the role of maintenance in achieving sustainable and competitive business environment. Usually, stakeholders are groups of people who are the most important for overall success of maintenance. They have the ability to influence realization of maintenance operations and either win or lose depending on results of actions taken. Maintenance system acquires resources from both external and internal sources. The ability to acquire resources from the environment and process them according to a system's own needs and needs of environment is a basic task of constructive actions and development of the system. Considering the fact that stakeholders requirements change continuously, it is necessary to develop and improve of the system maintenance – stakeholders. The higher the pace of changes of conditions of maintenance functioning the more foresighted, flexible and able to create reserves for maintenance it needs to be. The goal is to build capabilities of counteracting unpredictable hazards in advance. Hence, it is necessary to continuously monitor the effects of maintenance work and the environment, relations between maintenance and stakeholders and to develop the long-term strategy of maintenance development [26]. This approach is supported by contemporary maintenance concept such as Total Productive Maintenance (TPM) and Reliability-centered maintenance (RCM).

3.3. Maintenance management concepts

In pursuit of continuous improvement, two complementary methodologies that reflect various focuses are available (uptime) of physical assets, these methodologies are [27]: Total Productive Maintenance – a people-centred methodology and Reliability-centred maintenance – an asset-centred methodology. TPM has been developed from the original PM (preventive maintenance or productive maintenance) concept and methodology introduced from the USA [28]. It has been further developed and implemented in many Japanese companies, and is now rapidly becoming a method applied worldwide. TPM brings maintenance into focus as a necessary and vitally important part of the business [29]. The TPM initiative is targeted to enhance competitiveness of organizations and it encompasses a powerful structured approach to change the mind-set of employees thereby making a visible change in the work culture of an organization. TPM seeks to engage all levels and functions in an organization to

maximize the overall effectiveness of production equipment. This method further tunes up existing processes and equipment by reducing mistakes and accidents. The principle activities of TPM are exercised under its various pillars [30]. Different researchers have presented different pillars but, most accepted model is model of eight pillars (figure 3): (1) Focused Improvement, (2) Autonomous Maintenance, (3) Planned Maintenance, (4) Training and Education, (5) Early Equipment Management, (6) Quality Maintenance, (7) Office TPM, (8) Safety, Health and Environment.

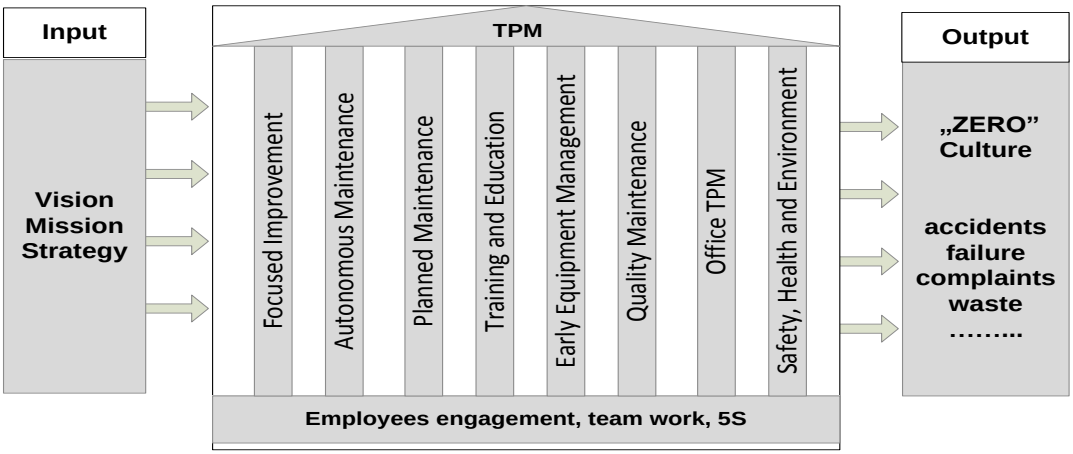

Figure 3. Total Productive Maintenance model.

The implementation and efficiency of application of TPM activities requires firstly the commitment and support of both Production and Maintenance. Each plays a role in ensuring the TPM activities are followed through, thereby improving the reliability, maintainability and availability of equipment, as well as reducing costs as a result of these improvements. Secondly, it requires application of strategic point of view, and considering long-time perspective. A good maintenance leader always sees this aspect in two ways, both the short term and the long term plan**.**

Reliability-Centred Maintenance is one of the well-established systematic methods for selecting applicable and suitable maintenance operation types. It originated in the civil aircraft industry in the 1960s with the introduction of the Boeing 747 series, and the need to lower PM costs in attaining a certain level of reliability. Reliability-centred maintenance (RCM) is a process to ensure that assets continue to do what their users require in their present operating context [31]. It is generally used to achieve improvements in fields such as the establishment of safe minimum levels of maintenance, changes to operating procedures and strategies and the establishment of capital maintenance regimes and plans. Its successful implementation lead to increase in cost effectiveness, machine uptime, and a greater understanding of the level of risk that the organization is presently managing. Technical standard IEC 60300-3-11:2009 sets out the minimum criteria that any process should meet before it can be called RCM [32]. This starts with the 7 questions: (1) what the item is supposed to do and its associated performance standards, (2) in what ways it can fail to provide the required functions, (3) what events can cause each failure, (4) what happens when each failure occurs, (5) in what way each failure matter, systematic task that can be performed proactively to prevent, or to diminish to a satisfactory degree, (6) the consequences of the failure, and, (7) what must be done if a suitable preventive task cannot be found. The example of the process of RCM implementation is introduced in the figure below (figure 4).

In many enterprises RCM methodology is an element of TPM approach realization [34]. TPM is a holistic approach building technical culture, based on team work and common goals. Simultaneous application of TPM and RCM contributes to synergy effect within maintenance area. The effect is possible thanks to combination of knowledge of maintenance engineers (RCM) and machines operators (TPM) – participation in striving for a common goals.

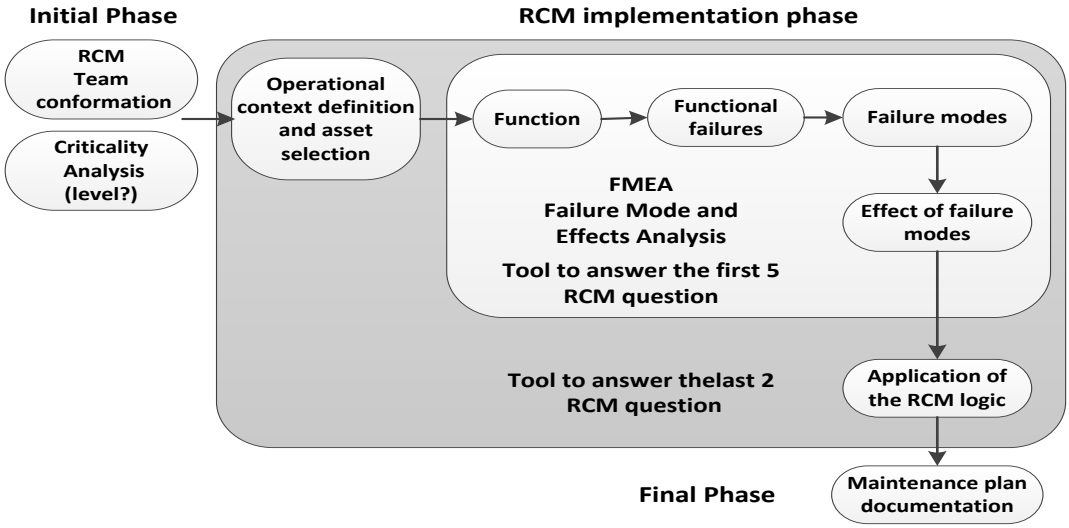

Figure 4. RCM implementation process [33].

4. Case study

4.1. Characteristics of the company

The company subjected to analysis operates in plastics processing industry. It specializes in manufacturing of various advertisement materials, as well as products for personalization and visual identification. It is also a manufacturer of devices for laboratory use.

The company employs about 90 people. It operates in three shifts system. Its organizational structure includes maintenance department that is supervised directly by The CEO of the company. The maintenance department employs 9 people, and that includes two mechanics, six adjusters and a manager of the department. During the first and the second shift, the maintenance staff available is one mechanic and two adjusters, while at the third shift there are only two adjusters available. None of the maintenance employees graduated from technical college or university, but the manager, mechanics and two of the adjusters are the technicians mechanics, and the other employees graduated from technical vocational schools.

The SWOT analysis was chosen as the analysis method in this study because of its straightforward approach, flexibility, and practical/useful output. The SWOT matrix was used to assist the company in focusing their maintenance planned strategy improvement**.**

4.2. SWOT analysis and its results

The Maintenance mission was defined by management as: "Increase the availability of the machines and installations with adequate costs". The Critical Success Factor defined by the team seek to: (1) reduce, eliminate and prevent breakdowns; (2) implement a planned maintenance system; (3) control and reduce the maintenance cost.

At the beginning of the project, a project group was established from employees of two departments: production (production department manager) and maintenance (maintenance department manager, maintenance operator). The CEO was also the member of the working group.

The SWOT analysis was conducted through a few rounds of brainstorming (figure 5).

Before the first round of brainstorming session the team members were given the set of five questions, so that they could prepare themselves for the discussion and the meeting. The questions were as follows:

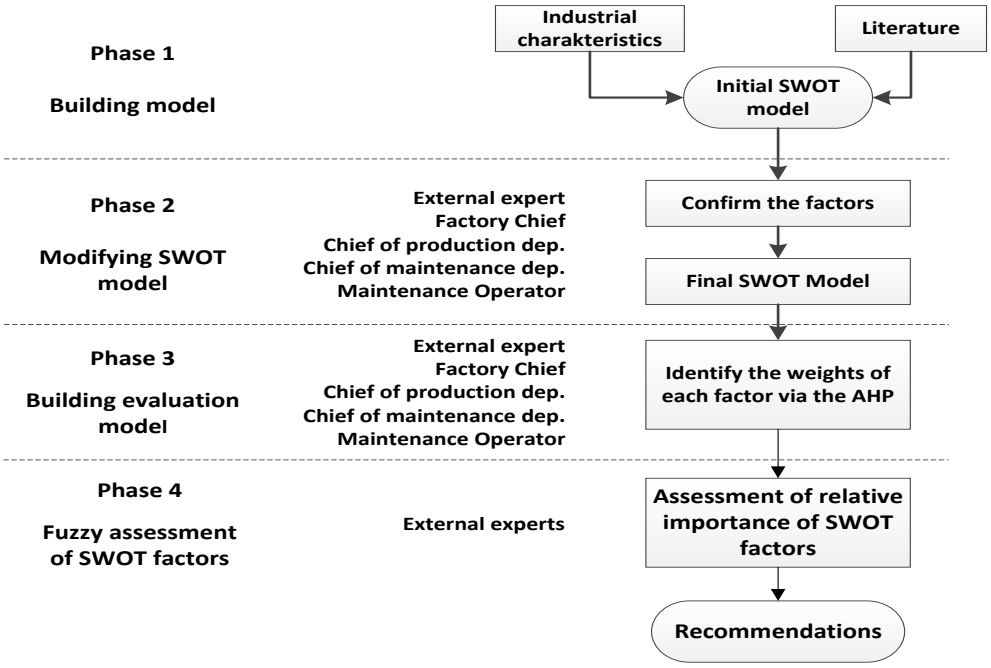

Figure 5. SWOT analysis phases.

- What are the particular strengths and weaknesses of the current maintenance practices? Explain.
- Have you experienced or witnessed any particularly effective maintenance practices? Explain.
- Have you experienced or witnessed an particularly ineffective maintenance practices? Explain.
- In your opinion, should the current maintenance be changed? Explain.
- What can or should be done to improve maintenance effectiveness?

Table 1. Identification of SWOT factors

Strenghts	Weaknesses
S1 – Good cooperation between maintenance and production managers S2 – Well defined tasks and responsibilities of maintenance staff S3 – partnership with companies providing outsourced maintenance services S4 – extensive professional experience of maintenance staff and adjusters S5 – attractive remuneration for new employees	W1 – lack of system for performance measurement W2- technical knowledge of mechanics and adjusters results from their experience W3 – lack of team work W4 – lack of knowledge on contemporary maintenance concepts W5 – lack of systematic records of performed technical services and failure W6 – breakdowns are not analyzed W7 – poor workshop equipment
Opportunities	Threats
O1 – purchasing software to support planning and analysis of maintenance data O2 – purchasing specialist diagnostic equipment O3 – specialist technical training for maintenance department O4 – trainings on problem solving	T1 – strong dependence on companies providing outsourced maintenance services T2 – aging machines

The team analyzed the current effects of actions, cooperation with suppliers of spare parts and service providers, enterprise activities implemented within the quality management approach. The purpose of these analyzes was to identify internal strengths and weaknesses of the maintenance and the external opportunities and constraints. The obtained results are shown in table 1.

Based on the results of the SWOT analysis which define the current state of the Maintenance department, by comparing the SWOT factors: strengths, weaknesses, opportunities and threats, as well as sub-factors within each factor, the possible future development strategies of the Maintenance department were defined until the next 5 year. The structure of the decision model, which was used in this study, is shown in figure 6.

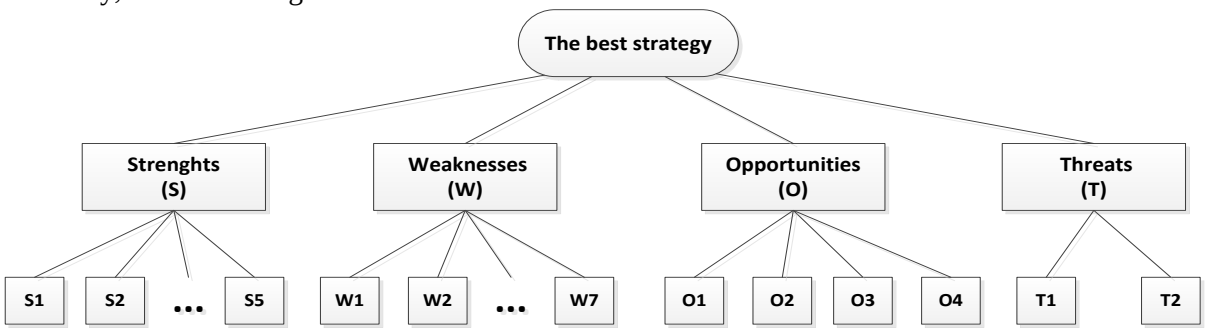

Figure 6. AHP model for the selection of the best strategy **.**

By combining the SWOT, factors and sub-factors within each factor, possible alternative SO, WO, ST and WT strategies were defined, which derive from the adopted mission „ Increase the availability of the machines and installations with adequate costs".

Based on the rankings of the team the importance of each SWOT factor (criteria) in the model is determined. The scale used for relative importance assessment is presented in the table 2.

Table 2. Scale for pairwise comparisons.

Importance measure	Definition
1	Equally important
2	Equally to moderately more important
3	Moderately more important
4	Moderate to strongly more important
5	Strongly more important
6	Strong to very strongly more important
7	Very strongly more important
8	Very to extremely strongly more important
9	Extremely more important

The resulting importance of each SWOT factor is shown in table 3 where it can be seen that the greatest importance, based on scores of the expert team, has the SWOT factor Opportunities (42% importance). Analysis of the data presented in the table proves that the maintenance strategy for the company analyzed should be based on benefiting from the opportunities and counteracting the threats. Strengths are perceived more important than weaknesses. The further analysis is based on these general assumptions, thus opportunities and strengths are analyzed and referred to weaknesses, as their elimination, together with strengthening the company supports the strategy by minimizing the risk of threats.

Table 3. Relative importance of SWOT categories

	S	W	T	O	
S	1	2	1/3	1/2	0,168
W	1/2	1	1/2	1/3	0,123
O	3	2	1	2	0,420
T	2	3	1/2	1	0,289

In this step, the local importance of SWOT sub-criteria is determined by the team, while the ranks of comparative pairs of the SWOT sub-criteria, defined in table 1, are given in table 4.

Table 4. Relative importance of SWOT factors.

Strengths						Weaknesses							
	S1	S2	S3	S4	S5		W1	W2	W3	W4	W5	W6	W7
S1	1	3	1/5	1/3	5	W1	1	1/7	1/3	1/3	1/5	1/7	1/9
S2	1/3	1	1/3	1/4	5	W2	7	1	5	7	4	2	2
S3	5	3	1	1/5	7	W3	3	1/5	1	1/4	3	1/3	1/3
S4	3	5	4	1	5	W4	3	1/7	4	1	1/5	1/5	1/5
S5	1/5	1/5	1/7	1/5	1	W5	5	1/4	1/3	5	1	4	5
						W6	7	1/2	3	5	1/4	1	5
						W7	9	1/2	3	5	1/5	1/5	1

Opportunities					Threats		
	O1	O2	O3	O4		T1	T2
O1	1	5	1/5	4	T1	1	3
O2	1/5	1	1/5	1/5	T2	1/3	1
O3	5	5	1	5			
O4	1/4	5	1/5	1			

The procedure of fuzzy-SWOT analysis is based on translating the pair-wise comparison of importance of SWOT factors into fuzzy numbers. The procedure is based on the scale presented in the table below (table 5).

Table 5. Membership functions of the fuzzy numbers.

Crisp judgment of the pairwise matrix	TFN
1	(1, 1, 2)
2	(x – 1, x, x + 1) for x = 2, 3, …, 8
9	(8, 9, 9)
1/1	(1/2, 1, 1)
1/x	(1/(x + 1), 1/x, 1/(x – 1)) for x = 2, 3, …, 8
1/9	(1/9, 1/9, 1/8)
When an enabler ‘i’ is compared with itself, although the crisp judgement is 1, the TFN corresponding to this judgement will be (1, 1, 1)	

The results of the fuzzification procedure are presented below. The table 6 refers to opportunities and presents the pair-wise comparison with fuzzy logic.

Table 6. Fuzzified pairwise comparison for opportunities

	O1	O2	O3	O4
O1	(1;1;1)	(4;5;6)	(0,17;0,2;0,25)	(3;4;5)
O2	(0,17;0,2;0,25)	(1;1;1)	(0,17;0,2;0,25)	(0,17;0,2;0,25)
O3	(4;5;6)	(4;5;6)	(1;1;1)	(4;5;6)
O4	(0,2;0,25;0,33)	(4;5;6)	(0,17;0,2;0,25)	(1;1;1)

The formula for calculation of aggregated assessment of importance is presented below:

$$R_i = \frac{\sum_{t=1}^{s} R_{it}}{s} \forall i = 1, 2, \cdots, n$$

where: R is the rating given by the assessment team
s is the number of aspects compared and assessed
n refers to SWOT areas

The results are given in the table 7, which enables ranking of the opportunities and identification of the most important ones to focus the strategy.

Table 7. Aggregated importance assessment for opportunities

Factor	Aggregated importance	Defuzzification
O1	(2,04;2,55;3,06)	moderately more important
O2	(0,38;0,4;0,44)	moderately less important
O3	(3,25;4;4,75)	moderately to strongly more important
O4	(1,34;1,61;1,90)	equally to moderately more important

The ranking of opportunities is presented below:

- O3 moderately to strongly more important
- O4 equally to moderately more important
- O1 moderately more important
- O2 moderately less important

which proves that the most important aspect for the team is training, including both technical and soft (problem solving) factors, and suggesting that the most important asset are people.

The analysis of the Streghts was performed with the same procedure, hence it includes fuzzification of the assessment, presented in the table 8.

Table 8. Fuzzified pairwise comparison for strengths

	S1	S2	S3	S4	S5
S1	(1,1,1)	(2,3,4)	(0,17;0,2;0,25)	(0,25;0,33;0,5)	(4,5,6)
S2	(0,25;0,33;0,4)	(1,1,1)	(0,25;0,33;0,4)	(0,2;0,25;0,33)	(4,5,6)
S3	(4,5,6)	(2,3,4)	(1,1,1)	(0,17;0,2;0,25)	(6,7,8)
S4	(2,3,4)	(4,5,6)	(3,4,5)	(1,1,1)	(4,5,6)
S5	(0,17;0,2;0,25)	(0,17;0,2;0,25)	(0,125;0,14;0,17)	(0,17;0,2;0,25)	(1,1,1)

Calculation of their relative importance leads to the following results (table 9)

Table 9. Aggregated importance assessment for strengths

Factor	Aggregated importance	Defuzzification
S1	(1.484;1.906; 2.35)	equally to moderately more important
S2	(1.14;1.38;1.62)	equally to moderately more important
S3	(2.63;3.24;3.85)	moderately more important
S4	(2.8;3.6;4.4)	moderately more important
S5	(0.326;0.348;0.384)	moderately less important

which enables ranking of the strengths and identification of the most important ones to focus the strategy. The ranking is presented below:

- S4 moderately more important
- S3 moderately more important
- S1 equally to moderately more important
- S2 equally to moderately more important
- S5 moderately less important

The results of the analysis prove that the most important asset are people as the most important strengths refer to experience and skills of the staff and communication and cooperation between them, however importance of external cooperation is also stressed and outsourcing idea appreciated.

To complete the analysis the weaknesses were analyzed as well. The purpose of this part of the strategy was to identify potential sources of problems and eliminate them or minimize their influence. The weaknesses analysis followed under the same procedure as the previously presented (table 10).

Table 10. An aggregated importance assessment for weaknesses

	W1	W2	W3	W4	W5	W6	W7
W1	(1,1,1)	(0,125;0,14;0,17)	(0,25;0,33;0,5)	(0,25;0,33;0,5)	(0,17;0,2;0,25)	(0,125;0,14;0,17)	(8,9,9)
W2	(6,7,8)	(1,1,1)	(4,5,6)	(6,7,8)	(3,4,5)	(1,2,3)	(1,2,3)
W3	(2,3,4)	(0,17;0,2;0,25)	(1,1,1)	(0,2;0,25;0,33)	(2,3,4)	(0,25;0,33;0,5)	(0,25;0,33;0,5)
W4	(2,3,4)	(0,125;0,14;0,17)	(3,4,5)	(1,1,1)	(0,17;0,2;0,25)	(0,17;0,2;0,25)	(0,17;0,2;0,25)
W5	(4,5,6)	(0,2;0,25;0,33)	(0,25;0,33;0,5)	(4,5,6)	(1,1,1)	(3,4,5)	(4,5,6)
W6	(6,7,8)	(0,33;0,5;1)	(2,3,4)	(4,5,6)	(0,2;0,25;0,33)	(1,1,1)	(4,5,6)
W7	9	(0,33;0,5;1)	(2,3,4)	(4,5,6)	(0,17;0,2;0,25)	(0,17;0,2;0,25)	(1,1,1)

Calculation of the weaknesses relative importance leads to the following results (table 11).

Table 11. Aggregated importance assessment for strengths

Factor	Aggregated importance	Defuzzification
W1	(1,42;1,45;1,66)	Equally important
W2	(3,14;4;4,86)	Moderate to strongly more important
W3	(0,84;1,15;1,51)	Equally important
W4	(0,95;1,25;1,56)	Equally important
W5	(2,35;2,94;3,55)	Moderately more important
W6	(2,50;3,11;3,75)	Moderately more important
W7	(2,24;2,7;3,07)	Equally to moderately more important

hence, the weaknesses ranking is as follows:

- W2 Moderate to strongly more important

- W6 Moderately more important
- W5 Moderately more important
- W7 Equally to moderately more important
- W1 Equally important
- W4 Equally important
- W3 Equally important

The threat referring to lack of learned (coming from education process) knowledge identified can be easily overcome by trainings that are defined as the most important opportunities. The other threats important are the result of lack of recording procedures, hence application of such should be recommended.

5. Conclusions

Fredriksson and Larsson [35] points out that "maintenance strategy should be aligned with manufacturing and business strategies". Consequently, the relevance of a specified maintenance strategy may be influenced by the manufacturing and business requirements. Moreover, an effective maintenance strategy should be suitable for the requirements of an organization.

Unlike other functions like manufacturing and business, the strategic literature on maintenance is meagre. Many tools and techniques have been developed and applied in other fields. However, the applicability of those tools to maintenance function is rarely and quite generally discussed in the literature.

SWOT analysis is one of the most commonly used tools of strategic management. It gives opportunity to analyze internal aspects, such as its strong and weak sides, as well as provides external perspective by referring to opportunities and threats. Moreover, it links these aspects and combines them, to benefit from holistic interpretation. The conclusion obtained with SWOT analysis are solid base for development of corporate strategy, or when the scope of analysis is limited, for functional strategy.

Application of fuzzy sets for interpretation of SWOT analysis results is the solution providing numerous benefits, including natural representation and reflection of experts assessment.

In the research conducted fuzzy sets were employed for presentation of assessment of relative importance of SWOT factors, and used for calculation of aggregated relative assessment for each factor. As the result, the SWOT factors predefined for the research purpose were ranked, enabling definition of recommendations for strategic maintenance management development. According to the results obtained, the maintenance strategy dedicated for the company analyzed should be focused on benefiting from opportunities, specifically the ones connected with employees' skills and knowledge, through organization of trainings (technical and problem-solving focused) for the department staff. The present level of skills and experience was appreciated and presented as the most important asset, proving the necessity of its development.

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