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A SIMPLIFIED NUMERICAL DECISION-MAKING METHODOLOGY FOR PHYSICAL ASSET MANAGEMENT DECISIONS

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ABSTRACT

The management of physical assets has become a popular field recently, and is acknowledged in many disciplines worldwide. Physical Asset Management (PAM) is a complex subject that requires the participation of many disciplines. Maintenance management, together with accurate and effective decision–making, is vital for achieving successful PAM.

The primary objective of this research project was to identify the possibility of simplifying maintenance-related decision-making. With the focus on numerical decision-making techniques, the secondary objective was to investigate the practicality and useability of combining appropriate techniques to create an easily useable and understandable methodology to support maintenance-related decisions.

The results confirm the practicality and useability of a simplified numerical decision-making methodology. By concentrating on the core operational questions related to maintenance, and by combining the most appropriate techniques, a simplified numerical decision-making methodology can ease the decision-making process on an operational level. This can accomplish successful PAM in a proactive, preventive and simplified manner.

OPSOMMING

Die onderwerp van Fisiese Bate Bestuur (FBB) het ‘n gewilde navorsingsveld geraak oor die afgelope paar jaar. FBB is ‘n komplekse onderwerp en vereis insette van verskeie dissiplines. Effektiewe bestuur van instandhouding sowel as doeltreffende besluitneming is noodsaaklik vir suksesvolle FBB.

Die primêre doel van hierdie navorsingsprojek was om die moontlikheid van vereenvoudigde besluitneming met betrekking tot instandhouding, te ondersoek. Met die fokus op numeriese besluitnemingstegnieke was die sekondêre doel om die praktiese toepassing van ‘n gepaste tegniek-kombinasie te ondersoek om uiteindelik ‘n maklike, bruikbare en verstaanbare tegniek-kombinasie te skep wat instandhouding verwante besluite kan ondersteun.

Die resultate bevestig die bruikbaarheid van ‘n eenvoudige numeriese besluitnemings tegniek-kombinasie om die besluitnemingsproses op operasionele vlak te verlig. Deur te konsentreer op instandhouding verwante kern operasionele vrae, en deur die mees gepaste tegnieke te kombineer, kan ‘n vereenvoudige numeriese besluitnemingsmetodologie die besluitnemingsproses op operasionele vlak verlig. Dit kan FBB suksesvol op ‘n pro-aktiewe, voorkomende en vereenvoudige manier uitvoer.

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5 MULTI-CRITERIA DECISION-MAKING IN PAM

The need for maintenance in PAM is highlighted, together with the importance of decision-making, especially on an operational level. Although various mathematical decision-making techniques are available to assist the decision-making process, these techniques are not popular because time is a limited resource and they are inherently complex. In most cases, managerial decisions are based on human judgement, discussion, and previous experiences, which is not ideal.

Current decision-making techniques that are relevant to PAM decisions are mostly designed to focus only on optimising one criterion, and they neglect others. Therefore there is a need for decision-making techniques that support multiple criteria to execute PAM-related decisions effectively.

No company wants to over- or under-maintain its facilities. In either case there will be an increased production or service cost, so it is important to find an appropriate balance. It is necessary to study methods and procedures where concerns about multiple conflicting criteria can be formally incorporated into the maintenance planning process. This is required on an operational level where people can use numerical decision-making techniques without effort and without taking up too much time. Hence, the simplification of numerical decision-making techniques is emphasised. The aim is to implement simplified techniques for PAM-related decisions on an operational level.

A simplified numerical decision-making methodology for PAM-related decisions was proposed to support the decision-making process on an operational level. The purpose of this methodology is to be quick and easy to use without requiring too much effort, and it should not confuse the decision-maker. It should provide prompt and accurate results to make the use of the methodology worthwhile. Appropriate techniques for the development of this methodology are selected and combined. However, in order to select the most appropriate techniques, frequently-used decisions are identified to create a framework for the development of the methodology.

5.1 Decision selection

The questions on which the decisions selected to develop the methodology are based are:

- What assets should be maintained?
- Which asset should be maintained first?
- What failure causes the need for maintenance?
- Which failures should be treated first?
- What type of maintenance should be done?
- How urgent are the required maintenance actions?

These questions are used to formulate three objectives as a guideline to develop a simplified PAM decision-making methodology:

1. Identify assets that are critical to operations and that require immediate maintenance.
2. Prioritise the failure modes of each critical asset to address these modes in order of importance or impact.
3. Select the most appropriate maintenance tactic for each failure mode.

These objectives are organised in chronological order to create three methodology phases: *Identify, Prioritise,* and *Maintain*. These phases can be followed iteratively, and thus a continuous cycle is created, as shown in Figure 1.

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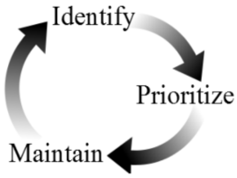

Figure 1: PAM decision-making methodology phases

The first phase, *Identify*, is the critical asset identification phase in which the critical assets of a system are identified. The reason for this is to highlight the critical focus point. These assets are analysed and prioritised to identify which should be addressed first and how urgent the responses should be. The second phase, *Prioritise*, is where the failure modes of each critical asset are further investigated and prioritised according to importance. Lastly, in the third phase, *Maintain*, the most appropriate maintenance tactic is selected for each failure mode. As the failure modes are maintained in the prioritised order, other assets in the system will become critical, and thus this cycle should be repeated continuously.

5.2 Technique selection

5.2.1 Tactical analytical hierarchal process for prioritisation (TAHPP)

TAHPP is derived from a process called analytical hierarchal process (AHP). The AHP approach was developed by Dr Thomas L. Saaty in 1980. Saaty [12] states that the development of the AHP was triggered by the lack of decision-making methodologies that are easily understood and easily implemented to enable complex decision-making. Bushan & Rai [13] mention that the effectiveness and simplicity of this approach caused it to become rapidly and globally acknowledged in multiple disciplines. Fülöp [14] explains that an AHP is used to convert subjective data of relative importance in order to define a set of overall weights. The subjective data is obtained by comparing the attribute or alternative pairs, and determining which is more important than the other, as supported by Laininen & Hämäläinen [15]. Consequently, only two alternatives are considered at a time, and they are compared according to the given criteria.

The criteria consist of quantitative rates with qualitative descriptions, and are shown in Table 1. Expert decision-makers are needed for this comparison because the alternatives should be understood.

Table 1: AHP rating scale adapted from Belvilaqua & Bragliab (2000)

Rate	Qualitative Scale	Description
1	Equal	The two attributes contribute equally to the criteria
3	Marginally strong	Experience and judgement slightly in favour of one attribute over the other
5	Strong	Experience and judgement strongly in favour of one attribute over the other
7	Very strong	An attribute is strongly favoured and its dominance demonstrated in practice.
9	Extremely strong	The evidence favouring one attribute over another is of the highest possible order of affirmation

The comparison values are presented in an $n \times n$ square matrix, with diagonal values equal to 1. Each level of the hierarchy is compared in this manner. As mentioned, this is a top-

8 CONCLUSION

Having effective and accurate maintenance management contributes to a large extent to the success of PAM. With the focus on numerical decision-making tools, it was identified that there is a tendency in practice not to use the techniques because of the great degree of complexity and the effort required. Influential decisions about maintenance management on an operational level were identified in order to find the most appropriate numerical techniques that can support the management of maintenance effectively and efficiently. The most applicable techniques were identified to create a simplified numerical decision-making methodology. The purpose of this methodology is to make effective maintenance decisions on an operational level by selecting the most appropriate maintenance tactics for different failure modes of a system or asset.

The applicability of the developed methodology was investigated theoretically to validate its applicability to an actual situation. Using a case study, the methodology was applied to an actual scenario to validate the practical value of the methodology.

Amplats provided the opportunity to apply the simplified numerical decision-making methodology in a real-world situation. Evidently the application was easy, understandable, quick, and effortless, and was referred to as a valuable tool in planning maintenance actions. This result indicates that such a tool can ease the management of maintenance decisions on an operational level, and can lead to decreased failure occurrences and down times.

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