JURTEKSI (Jurnal Teknologi dan Sistem Informasi) ISSN 2407-1811 (Print)
Vol. XI No 3, Juni 2025, hlm. 397 – 404 ISSN 2550-0201 (Online)
DOI: http://dx.doi.org/10.33330/jurteksi.v11i3.3698
Available online at http://jurnal.stmikroyal.ac.id/index.php/jurteksi

AHP-TOPSIS AND ANOVA METHOD APPROACH IN SOFTWARE DEVELOPMENT CRITERIA SELECTION ACCORDING TO ISO 12207:2017

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Abstract: The rapid development of information technology has increased the demand for high-quality software, necessitating a structured development process. ISO/IEC/IEEE 12207:2017 serves as an international standard encompassing organizational, technical, and project support processes, differing from ISO 9001, which focuses more generally on quality management. This study employs a Multi-Criteria Decision Making (MCDM) approach by integrating the Analytic Hierarchy Process (AHP) and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). AHP determines the weight of ISO 12207:2017 criteria through pairwise comparisons, while TOPSIS ranks software development activities based on these weights. To validate the results, Analysis of Variance (ANOVA) is applied. The findings indicate that the Software Requirements Definition Process has the highest priority weight (0.169), followed by Implementation (0.101) and Operation (0.095). Software Configuration Management is identified as the most critical activity with the highest TOPSIS score (0.221). ANOVA confirms the reliability of expert evaluations, showing no significant differences. This study provides a structured decision-making framework based on ISO 12207:2017, helping optimize software project management while ensuring alignment with international standards and industry best practices.

Keywords: AHP; TOPSIS; ANOVA; ISO 12207:2017

Abstrak: Perkembangan teknologi informasi meningkatkan permintaan perangkat lunak berkualitas tinggi, sehingga diperlukan proses terstruktur dalam pengembangannya. ISO/IEC/IEEE 12207:2017 menjadi standar internasional yang mencakup proses organisasi, teknis, dan pendukung proyek, berbeda dengan ISO 9001 yang lebih umum pada manajemen kualitas. Penelitian ini menggunakan *Multi-Criteria Decision Making* (MCDM) dengan mengintegrasikan *Analytic Hierarchy Process* (AHP) dan *Technique for Order of Preference by Similarity to Ideal Solution* (TOPSIS). AHP menentukan bobot kriteria ISO 12207:2017 melalui perbandingan berpasangan, sementara TOPSIS memeringkat aktivitas pengembangan berdasarkan bobot tersebut. Untuk validasi, *Analysis of Variance* (ANOVA) diterapkan. Hasil penelitian menunjukkan bahwa Proses Definisi Kebutuhan Perangkat Lunak memiliki bobot tertinggi (0,169), diikuti Implementasi (0,101), dan Operasi (0,095). Manajemen Konfigurasi Perangkat Lunak menjadi aktivitas paling kritis dengan skor TOPSIS tertinggi (0,221). ANOVA mengonfirmasi keandalan penilaian para ahli tanpa perbedaan signifikan. Penelitian ini memberikan kerangka kerja pengambilan keputusan berbasis ISO 12207:2017, membantu optimalisasi manajemen proyek perangkat lunak, serta memastikan keselarasan dengan standar internasional dan praktek terbaik industri.

Kata kunci: AHP; TOPSIS; ANOVA; ISO 12207:2017

INTRODUCTION

The development of information technology has created a significant demand for high-quality software across various industrial sectors [1]. Software is no longer just a computational tool but has evolved into an integrative solution that supports business processes, automation, and innovation in various industrial domains. This phenomenon emphasizes the importance of structured and standards-based software develop ment to ensure the quality, efficiency, and sustainability of the resulting systems [2]. In software development, the Software Development Life Cycle (SDLC) encompasses various critical activities that need to be optimally managed. Some key activities in mana ging high-quality software include Software Project Tracking and Control, Risk Management, Software Quality Assurance, Technical Reviews, Measu rement, Software Configuration Manage ment, Reusability Management, and Work Product Preparation and Produc tion [3].

ISO/IEC/IEEE 12207:2017 is a comprehensive international standard for managing the software life cycle. Unlike ISO 9001, which focuses on general quality management systems and process capability improvement, ISO/IEC/IEEE 12207:2017 offers a more holistic approach by covering organizational project-enabling processes, technical management processes, and technical processes [4]. The broad scope of this standard enables a more systematic and structured implementation of guidelines in software development management. However, to effectively apply ISO/ IEC/IEEE 12207:2017, it is necessary to select and prioritize the most influential criteria affecting software development quality and effectiveness [5].

The Multi-Criteria Decision Making (MCDM) approach can be used to systematically evaluate these criteria. Various MCDM techniques have been applied in previous research, such as Analytic Hierarchy Process (AHP), Best-Worst Method (BWM), and ranking methods like TOPSIS, MOORA, VIKOR, and PROMETHEE [6]. The AHP-TOPSIS approach is used as a superior MCDM method. AHP is utilized to determine the weight of each criterion through pairwise comparisons, while TOPSIS is used for ranking alternatives based on their relative proximity to the ideal solution. To ensure the reliability of results and minimize unwanted variability, this study also integrates Analysis of Variance (ANOVA) as a methodological validation mechanism. The combination of AHP-TOPSIS with ANOVA validation offers significant comparative advantages. AHP facilitates the decomposition of problems into a hierarchical structure and ensures respondent consistency in determining criterion weights. TOPSIS allows for objective ranking of alternatives by considering both the ideal and anti-ideal solutions while maintaining flexibility in handling heterogeneous data scales [7]. ANOVA is used to analyze the statistical significance of differences in weights or ranking criteria, thereby enhancing result credibility and reducing potential perceptual biases [8].

The MCDM implementation in the context of software development has been proven effective through various studies. [9] used a combination of Fuzzy AHP and Fuzzy TOPSIS to identify efficient Parameter-Influencing Testing (PIT) in software testing processes. [10] applied the AHP method to evaluate software quality based on ISO 9126 criteria. [11] developed an MCDM-based framework that compares various techniques such as AHP, TOPSIS, and DEMATEL, concluding that hybrid approaches yield more optimal results. [12] combined GIS and AHP methods with validation using ANOVA to improve decision-making accuracy. However, the implementation of MCDM is not without methodological challenges. AHP requires an exponentially increasing number of pairwise comparisons, which can lead to subjective bias. TOPSIS is sensitive to data normalization and does not consider interrelationships between criteria. ANOVA requires the fulfillment of statistical assumptions such as normality and homoscedasticity and has limitations in evaluating direct causality.

Based on literature analysis and the need for a systematic decision-making framework in software develo pment, this study proposes a hybrid AHP-TOPSIS approach with ANOVA validation. This methodology is expected to contribute to developing a more structured and validated framework while enhancing the effectiveness of ISO/IEC/IEEE 12207:2017 implementa tion in software development manage ment.

METHOD

This study employs a quantitative approach with an evaluative method to assess the effectiveness of implementing activities in the Software Development Life Cycle (SDLC) based on the ISO 12207:2017 standard. The Analytical Hierarchy Process (AHP) technique is used to determine the weight of ISO 12207:2017 criteria based on expert evaluations. The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method is applied to rank alternatives based on the ISO 12207:2017 criteria weights from AHP, combined with the ISO 12207:2017 criteria matrix and SDLC activities. Subsequently, the obtained results will be validated using two-way ANOVA with replication to analyze significant differences in respondent evaluations.

In this study, the research framework consists of three main stages:

Determining Criteria Weights

1. Using the AHP method to determine the weight of each ISO 12207:2017 criterion based on expert evaluations through pairwise comparisons.
2. Applying the Saaty scale in pairwise comparisons.
3. Involving more respondents (four) to improve result validity.

Determining Alternative Rankings

1. Applying the TOPSIS method to analyze the combination of ISO 12207:2017 criteria with SDLC activities.
2. The alternatives considered include Software Project Tracking and Control, Risk Management, Software Quality Assurance, Technical Reviews, Measurement, Software Configuration Management, Reusability Management, and Work Product Preparation and Production.

Validating Results

1. Using two-way ANOVA with replication to analyze significant differences in respondent evaluati ons.
2. Ensuring that the results from AHP and TOPSIS calculations are not affected by respondent variability.

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Table 1 presents the calculation results of the ISO 12207:2017 criteria weights based on AHP.

Table 1. Results of the ISO 12207:2017 Criteria weights Based on AHP

Criteria	Bobot
Software Requirements Definition Process	0.169
Operation	0.095
Implementation	0.101
Maintenance	0.063
Stakeholder Needs	0.081
Project Planning	0.051
Measurement	0.055
Decision	0.062
Project Assessment and Control	0.095
Risk Management	0.087
Infrastructure	0.089
Life Cycle Model	0.078

On table 1 presents the weight of each criterion based on the Analytical Hierarchy Process (AHP) method in the context of the ISO 12207:2017 standard for software development processes. These weights reflect the importance of each criterion in the decision-making process.

The next step, in the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method, the positive distance represents the Euclidean distance of each activity from the ideal best solution. The steps for calculating the positive distance are as follows:

1. The ideal best solution is derived by selecting the maximum value for beneficial criteria and the minimum value for non-beneficial criteria.
2. The positive distance for each activity is obtained using the formula:

$$D_i^+ = \sqrt{\sum_{j=1}^{m}(x_{ij} - A_j^*)^2} \quad (1)$$

Table 2 the TOPSIS Positive Distance Calculations

Activities	Positive Distance
Software project tracking and control	0.01756
Risk Management	0.01376
Software Quality Assurance	0.00932
Technical Reviews	0.01128
Measurement	0.01711
Software Configuration Management	0.02028
Reusability Management	0.01387
Work Product Preparation and Production	0.01072

On table 2 presents the positive distance calculations in the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method. Positive distance measures how far an activity is from the ideal best solution.

1. The activity Software Configuration Management has the highest positive distance (0.02028), indicating that it is the farthest from the ideal solution.
2. Conversely, the Software Quality Assurance activity has the lowest positive distance (0.00932), meaning it is closer to the ideal solution compared to other activities.

The next step, in the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method, the negative distance represents the

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Euclidean distance of each activity from the ideal best solution. The steps for calculating the positive distance are as follows:

1. The ideal best solution is derived by selecting the maximum value for beneficial criteria and the minimum value for non-beneficial criteria.
2. The negative distance for each activity is obtained using the formula:

$$D_i^- = \sqrt{\sum_{j=1}^{m}(x_{ij} - A_j^-)^2} \quad (2)$$

Table 3. Result The TOPSIS Negative Distance Calculations

Activities	Negative distance
Software project tracking and control	0.01341
Risk Management	0.01543
Software Quality Assurance	0.01739
Technical Reviews	0.01696
Measurement	0.00974
Software Configuration Management	0.00576
Reusability Management	0.01269
Work Product Preparation and Production	0.01964

On table 3 presents the negative distance calculations in the TOPSIS method. Negative distance measures how close an activity is to the worst possible solution.

By comparing Table 2 and Table 3, we can determine the ranking of activities based on the TOPSIS preference value, calculated using the formula:

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad (3)$$

In this study, the number of respondents was increased to four experts in software development to enhance the validity of the results. The weights used in this study are based on the Saaty scale, applied in pairwise comparisons to determine the relative importance of criteria/sub-criteria in evaluating ISO 12207:2017 for software development.

RESULT AND DISCUSSION

This chapter presents the results of the priority determination analysis in software development activities using an integrated approach that combines the Analytical Hierarchy Process (AHP) and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). These results are validated through Analysis of Variance (ANOVA) to ensure objectivity and reliability in software development decision-making. The ISO 12207:2017 framework serves as the foundation, providing an international standard for activities and tasks throughout the software lifecycle.

This study involves four experts with substantial expertise in various aspects of software development, ensuring a multi-dimensional perspective on the issues examined. Based on ISO 12207:2017, this study identifies and analyzes twelve sub-criteria as evaluation parameters. The Software Requirements Definition Process serves as the foundational phase, encompassing a comprehensive definition of system requirements. Operation and Implementation provide practical perspectives, while Maintenance ensures system sustainability. Stakeholder Needs

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and Project Planning establish the strategic framework, supported by Measurement and Decision Making for evaluation and decision-making. Project Assessment and Control, Risk Manage ment, Infrastructure Management, and the Life Cycle Model ensure effective lifecycle management.

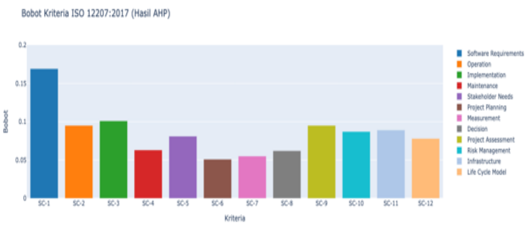

Image 1. Result Weighting AHP ISO 12207:2017

The AHP method assigns priority weights to various software development activities. The Software Requirements Definition Process receives the highest weight (0.169), followed by Impleme ntation (0.101), Operation (0.095), and Project Assessment and Control (0.095). These results highlight the critical role of requirements definition and systematic implementation in software development. Infrastructure (0.089) and Risk Management (0.087) also hold significant weights. Project Planning (0.051) has the lowest weight, indicating a relatively lower priority in this analysis. The AHP weighting results show a Consistency Ratio (CR) of 0.000, indicating consistent results.

TOPSIS analysis ranks software development activities based on prefe rence scores. Software Configuration Management (SCM) emerges as the highest-priority activity with a score of 0.221, highlighting its crucial role in managing software artifacts. Measure ment ranks second with a score of 0.363, emphasizing the importance of metric data in objective decision-making.

To evaluate the consistency of expert assessments in the AHP-TOPSIS method, an ANOVA (Analysis of Variance) test was conducted. This analysis examines the average ratings provided by four expert respondents (R1-R4) for eight alternative software development activities (A1-A8).

On Table 4, Variance Among Experts: The F-calculated value of 7.87 is significantly higher than the F-table value of 3.07 at a 0.05 significance level, indicating substantial differences in assessment patterns among experts.

Variance Among Activities: The F-calculated value of 0.63 is lower than the F-table value of 2.49, indicating no significant differences in ratings among software development activity alternatives. This consistency validates the ranking results obtained through the AHP-TOPSIS method, suggesting that the variations among alternatives reflect stable and reliable assessments.

Tabel 4. Result Anova

Source of Variance	Degrees of Freedom	Sum of Squares	Vari-ance	F Comp.	F Table
Block	3	2.82	0.94	7.87	3.07
Among Columns (Activities)	7	0.52	0.07	0.63	2.49
Residual	21	2.51	0.12		
Total	31	5.86			

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CONCLUSION

The integrated AHP-TOPSIS approach successfully prioritizes software development activities based on ISO 12207:2017, with Software Configuration Management and Measurement emerging as the top-ranked activities. ANOVA validation confirms that the method is statistically reliable, with no significant discrepancies in alternative rankings. These insights provide a structured, data-driven approach for optimizing software project management decisions. This study contributes to the refinement of software development prioritization strategies, ensuring alignment with international standards and industry best practices.

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