Assessment of External Alarm System Performance and Quality Using ISO/IEC 25010 Framework

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Abstract

This study assesses the performance and quality of an external alarm system using the ISO/IEC 25010 framework. The evaluation covers eight quality characteristics: functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability. Data were collected through structured questionnaires and analyzed using Partial Least Squares–Structural Equation Modeling (PLS-SEM). The measurement model results indicate that all constructs meet the required validity and reliability criteria. Outer loadings range from 0.730 to 0.956, exceeding the recommended threshold of 0.70. The Average Variance Extracted (AVE) values are above 0.50, confirming convergent validity. Furthermore, Cronbach's Alpha and Composite Reliability values exceed 0.70 for all constructs, demonstrating strong internal consistency. These findings confirm that the external alarm system meets established software quality standards and performs reliably across multiple dimensions. The validated model provides a robust foundation for further structural analysis and quality improvement strategies.

Keywords: *ISO/IEC 25010; External Alarm System; PLS-SEM*

Abstrak

Penelitian ini bertujuan untuk menilai kinerja dan kualitas sistem alarm eksternal menggunakan kerangka kerja ISO/IEC 25010. Evaluasi mencakup delapan karakteristik kualitas, yaitu functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, dan portability. Data dikumpulkan melalui kuesioner terstruktur dan dianalisis menggunakan Partial Least Squares–Structural Equation Modeling (PLS-SEM). Hasil model pengukuran menunjukkan bahwa seluruh konstruk memenuhi kriteria validitas dan reliabilitas. Nilai outer loading berada pada rentang 0,730–0,956, melebihi batas minimum 0,70. Nilai Average Variance Extracted (AVE) berada di atas 0,50 yang menunjukkan validitas konvergen yang baik. Selain itu, nilai Cronbach's Alpha dan Composite Reliability melebihi 0,70 pada seluruh konstruk, yang mengindikasikan konsistensi internal yang kuat. Temuan ini menegaskan bahwa sistem alarm eksternal memenuhi standar kualitas perangkat lunak dan memiliki kinerja yang andal.

Kata kunci: ISO/IEC 25010; External Alarm System; PLS-SEM

1. INTRODUCTION

The rapid advancement of information and communication technologies has significantly increased the reliance on automated monitoring and alert systems in critical environments. External alarm systems play a vital role in ensuring safety, operational continuity, and rapid incident response across various sectors, including industrial facilities, public infrastructure, healthcare institutions, and security services [1]-[3]. Given their mission critical function, the performance and reliability of these systems must be systematically evaluated to prevent failures that may lead to operational disruption, financial loss, or safety hazards. Despite their importance, many external alarm systems are assessed primarily from a functional perspective, focusing on whether they operate as intended rather than how well they perform under different operational conditions [4]-[6]. Such limited evaluation approaches may overlook broader quality attributes such as usability, maintainability, security, compatibility, and portability. A comprehensive quality assessment is therefore essential to ensure that the system not only functions correctly but also meet performance efficiency standards and user expectations.

To address this need, internationally recognized standards provide structured frameworks for evaluating system and software quality. The ISO/IEC 25010 quality model offers a multidimensional perspective by defining key quality characteristics, including functional suitability, performance efficiency, reliability, usability, security, compatibility, maintainability, and portability [7]-[9]. This framework enables researchers and practitioners to systematically assess system quality using measurable indicators and standardized evaluation criteria. Applying the ISO/IEC 25010 framework to external alarm systems provides a more holistic understanding of system performance. By integrating technical performance testing with user-centered evaluation, it becomes possible to identify strengths, detect weaknesses, and quantify overall quality levels. Such an approach supports evidence-based decision making and facilitates targeted improvements aimed at enhancing system effectiveness and sustainability [10]-[12].

Therefore, this study aims to assess the performance and quality of an external alarm system using the ISO/IEC 25010 framework [13]-[15]. Through structured measurement, statistical validation, and comprehensive analysis, the research seeks to determine whether the system meets established quality standards and to provide recommendations for continuous improvement. The findings are expected to contribute both theoretically, by extending quality evaluation practices, and practically, by supporting more reliable and efficient alarm system deployment.

2. METHOD

This study adopts a structured and standards-based evaluation approach to assess the performance and overall quality of the external alarm system using the ISO/IEC 25010 software product quality model (Figure 1). Given the critical role of external alarm systems in ensuring safety, rapid response, and operational reliability, a comprehensive and systematic assessment framework is required to objectively measure their effectiveness. Rather than relying solely on functional verification, this research evaluates the system across multiple quality dimensions, including performance efficiency, reliability, usability, security, and maintainability, as defined by ISO/IEC 25010.

a. Problem Identification and Objective Setting

This initial stage aims to clearly define the performance and quality challenges associated with the external alarm system under investigation. The researcher identifies existing operational issues such as delayed alarm response, false triggering, system downtime, security vulnerabilities, or maintenance inefficiencies. Based on these identified gaps, the study formulates specific research objectives, including evaluating system quality using standardized criteria, measuring compliance levels, and proposing improvements. Clearly defining the scope ensures that the evaluation remains focused on measurable quality attributes aligned with international standards.

b. Literature Review

The literature review establishes the theoretical and technical foundation of the study. It examines prior research on external alarm systems, including their architectures, communication mechanisms, reliability concerns, and performance constraints. Additionally, the review analyzes the structure and application of the ISO/IEC 25010 software product quality model, particularly its quality characteristics and sub-characteristics. This step also investigates previous system evaluation methodologies to identify validated measurement approaches. The literature review ensures conceptual clarity and justifies the selection of the ISO/IEC 25010 framework as the evaluation basis.

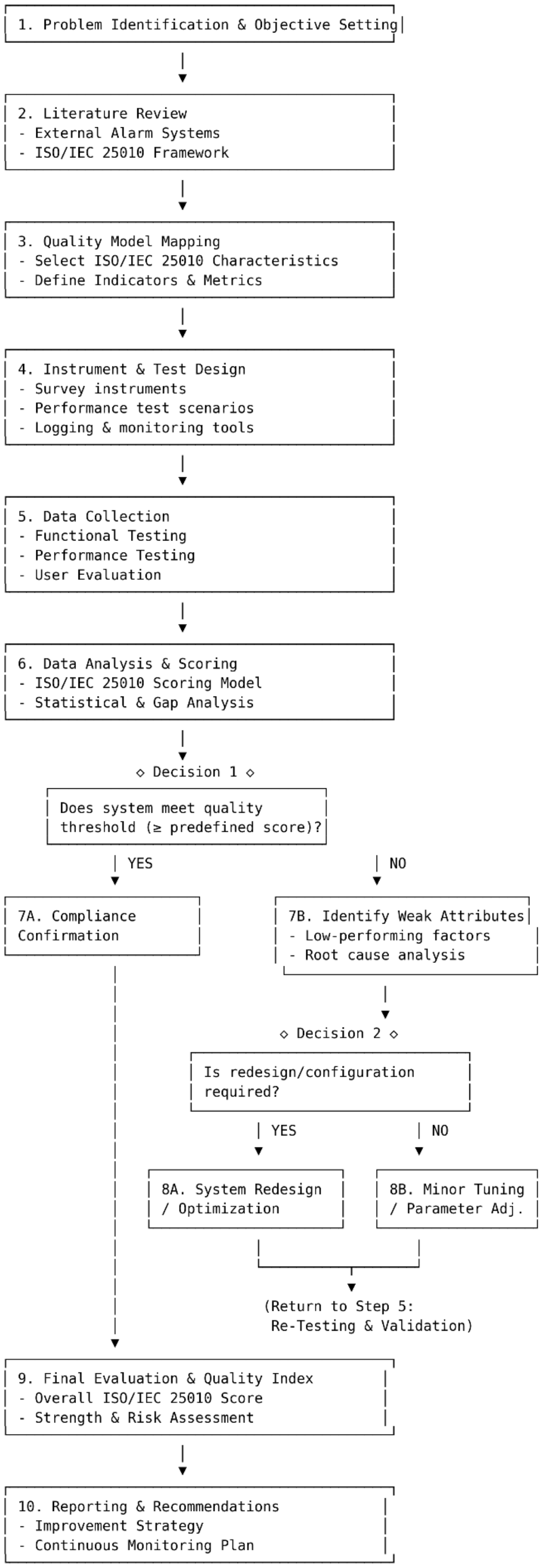

Figure 1 - Research Methodology

c. Quality Model Mapping

At this stage, relevant quality characteristics from ISO/IEC 25010 are selected and mapped to the external alarm system context. Core characteristics such as performance efficiency, reliability, usability, security, maintainability, and functional suitability are translated into operational indicators. For example, performance efficiency may be measured by response time and resource utilization, reliability by system availability and fault tolerance, and security by access control robustness. Each selected attribute is operationalized into measurable metrics to ensure objective assessment. This mapping process bridges theoretical standards and practical system evaluation.

d. Instrument and Test Design

Following the mapping process, appropriate measurement instruments are developed. These may include structured questionnaires for users, technical testing protocols for performance assessment, reliability testing procedures, and log monitoring mechanisms. Performance test scenarios are defined to simulate real-world alarm triggering conditions, including stress or load conditions. The instruments are validated to ensure reliability and consistency in measurement. This stage ensures that data collection will produce accurate and reproducible results aligned with ISO/IEC 25010 quality indicators.

e. Data Collection

Data collection involves both technical and user-centered evaluation methods. Functional testing verifies whether the alarm system performs according to specified requirements. Performance testing measures response time, processing capacity, and system throughput under normal and peak conditions. User evaluations assess usability, satisfaction, and operational clarity. Additionally, system logs are analyzed to measure reliability and fault occurrences. This multi-source data collection approach strengthens validity through triangulation.

f. Data Analysis and Scoring

The collected data are quantitatively analyzed using a scoring mechanism aligned with ISO/IEC 25010 characteristics. Statistical methods such as descriptive statistics, weighted scoring models, or normalization techniques may be applied to compute attribute level scores. Gap analysis is conducted to compare observed performance against predefined quality thresholds or industry benchmarks. This stage results in a structured quality index representing the overall system performance level. The analysis ensures objective interpretation and minimizes subjective bias.

Decision 1: Quality Threshold Evaluation

At this decision point, the computed quality scores are compared against predetermined acceptance criteria. If the system meets or exceeds the defined threshold, it is considered compliant with the expected quality standards. If it fails to meet the threshold, further diagnostic evaluation is required. This decision mechanism introduces accountability and ensures that evaluation outcomes directly inform improvement strategies.

gA. Compliance Confirmation

If the system satisfies the required quality level, the study proceeds with compliance confirmation. Strengths across evaluated attributes are documented, and the overall quality index is finalized. The system is categorized according to its compliance level (e.g., high-quality, acceptable, or excellent performance). This step validates that the external alarm system meets ISO/IEC 25010-based expectations.

gB. Identification of Weak Attributes

If the system does not meet the required threshold, low-performing attributes are identified through detailed analysis. Root cause analysis is conducted to determine whether deficiencies arise from hardware limitations, software inefficiencies, configuration errors, or user interaction problems. This diagnostic step ensures that corrective actions target the actual source of quality degradation.

Decision 2: Improvement Strategy Selection

This stage determines whether corrective action requires major system redesign or minor configuration adjustments. Structural deficiencies such as architecture limitations may require redesign, while parameter misconfigurations may only require optimization. This conditional branching enhances methodological rigor by differentiating between strategic and tactical improvements.

hA. System Redesign or Optimization

If major issues are identified, system redesign or architectural optimization is implemented. This may include upgrading communication modules, improving database performance, enhancing security protocols, or restructuring system workflows. The redesign aims to improve quality attributes that previously failed to meet standards.

hB. Minor Tuning and Parameter Adjustment

If deficiencies are minor, targeted adjustments are applied, such as recalibrating alarm thresholds, optimizing server configurations, or improving interface clarity. These changes aim to enhance performance without altering the overall system structure.

Iterative Re-Testing and Validation

After implementing corrective actions, the system undergoes re-testing using the same data collection and analysis procedures. This iterative validation ensures continuous improvement and verifies whether implemented changes successfully elevate quality scores above the threshold.

i. Final Evaluation and Quality Index Determination

Following successful validation, a final comprehensive evaluation is conducted. A consolidated quality index is computed, summarizing all ISO/IEC 25010 characteristics. Strengths, residual risks, and improvement achievements are documented. This final evaluation represents the validated performance level of the external alarm system.

j. Reporting and Recommendations

The final stage involves preparing a structured report detailing methodology, findings, compliance levels, and recommended improvements. Strategic recommendations may include technical upgrades, maintenance scheduling improvements, security enhancements, or continuous monitoring frameworks. The reporting ensures transparency, replicability, and practical applicability for stakeholders and decision-makers.

3. RESULT AND DISCUSSION

This section presents the results of the convergent validity and internal consistency reliability assessment of the measurement model. The evaluation was conducted using outer loading values, Average Variance Extracted (AVE), Cronbach's Alpha, and Composite Reliability. These criteria are widely applied in structural equation modeling (SEM), particularly in PLS-SEM analysis, to ensure that the constructs adequately measure their respective indicators and demonstrate sufficient reliability (Table 1).

Table 1 - PLS-SEM Assessment Results

Measurement Criteria	Functional Suitability	Performance Efficiency	Compatibility	Usability	Reliability	Security	Maintainability	Portability	Alarm System Performance
Outer Loadings	0.730–0.918	0.794–0.833	0.797–0.931	0.875–0.914	0.715–0.936	0.795–0.956	0.851–0.934	0.733–0.865	0.730–0.895
AVE (>0.50)	0.732	0.664	0.741	0.807	0.737	0.793	0.787	0.678	0.626
Cronbach's Alpha (>0.70)	0.812	0.751	0.824	0.880	0.817	0.868	0.865	0.759	0.848
Composite	0.827	0.765	0.839	0.883	0.856	0.892	0.881	0.760	0.856

Reliability (>0.70)									
Conclusion	Valid & Reliable	Valid & Reliable	Valid & Reliable	Valid & Reliable	Valid & Reliable	Valid & Reliable	Valid & Reliable	Valid & Reliable	Valid & Reliable

The measurement model evaluation demonstrates that all constructs satisfy the recommended criteria for convergent validity and internal consistency reliability. Based on the reported outer loading values, all indicators load strongly on their respective constructs, with values ranging from 0.715 to 0.956. Since all loadings exceed the recommended threshold of 0.70, the indicators exhibit satisfactory individual reliability. The strongest loading is observed in the Security construct (0.956), indicating that its indicators are highly representative of the latent variable. Although a few indicators show values slightly above 0.70 (e.g., 0.715 and 0.730), they remain acceptable and do not compromise measurement quality. Convergent validity is further supported by the Average Variance Extracted (AVE) values. All constructs report AVE values above the minimum threshold of 0.50, ranging from 0.626 to 0.807. The highest AVE is found in the Usability construct (0.807), suggesting that this construct explains more than 80% of the variance in its indicators, reflecting strong conceptual coherence. Even the lowest AVE value, observed in Alarm System Performance (0.626), still exceeds the recommended standard, confirming that the constructs adequately capture the variance of their associated indicators.

Internal consistency reliability is verified using Cronbach's Alpha and Composite Reliability (CR). All Cronbach's Alpha values exceed 0.70, ranging from 0.751 to 0.880, indicating satisfactory internal consistency among indicators within each construct. Composite Reliability values, which provide a more precise reliability estimate in PLS-SEM, range from 0.760 to 0.892 and similarly surpass the recommended threshold of 0.70. Notably, the Security and Usability constructs demonstrate particularly strong reliability, reinforcing the stability and consistency of these dimensions in assessing the external alarm system. Collectively, these findings confirm that the measurement model is statistically robust and suitable for subsequent structural model evaluation. The consistent fulfillment of validity and reliability criteria across all ISO/IEC 25010 quality dimensions indicates that the proposed instrument effectively measures the constructs of Functional Suitability, Performance Efficiency, Compatibility, Usability, Reliability, Security, Maintainability, Portability, and overall Alarm System Performance. Therefore, the model provides a sound empirical foundation for analyzing structural relationships and testing hypotheses regarding the determinants of alarm system performance.

4. CONCLUSION

The results of the measurement model evaluation confirm that all constructs meet the established criteria for convergent validity and internal consistency reliability. Outer loading values exceed the recommended threshold of 0.70, indicating that each indicator reliably represents its respective latent construct. The Average Variance Extracted (AVE) values are all above 0.50, demonstrating that the constructs adequately explain the variance of their indicators. Furthermore, both Cronbach's Alpha and Composite Reliability values surpass 0.70, confirming strong internal consistency across all dimensions. These findings indicate that the measurement instrument based on the ISO/IEC 25010 framework is statistically sound and appropriate for evaluating the external alarm system. Overall, the validated model provides a robust empirical foundation for further structural analysis and supports reliable interpretation of the relationships between system quality dimensions and overall alarm system performance.

REFERENCES

[1] S. Yakubu, M. Shafie-khah, and M. Elmusrati, "Cyber-physical attack and the future energy systems : A review," *Energy Reports*, vol. 12, no. July, pp. 2914–2932, 2024. doi: https://doi.org/10.1016/j.egyr.2024.08.060.

[2] A. Haleem, M. Javaid, and R. Pratap, "Green Technologies and Sustainability Encouraging Safety 4 . 0 to enhance industrial culture : An extensive study of its technologies , roles , and challenges," *Green Technol. Sustain.*, vol. 3, no. 3, p. 100158, 2025, doi: https://doi.org/10.1016/j.grets.2024.100158.

[3] B. Kidmose, "A review of smart vehicles in smart cities : Dangers , impacts , and the threat landscape," *Veh. Commun.*, vol. 51, no. July 2024, p. 100871, 2025, doi: https://doi.org/10.1016/j.vehcom.2024.100871.

[4] E. Wolf, "Quality assessment of software requirements using artificial intelligence methods : A systematic literature review," *Inf. Softw. Technol.*, vol. 191, no. November 2025, p. 107979, 2026, doi: https://doi.org/10.1016/j.infsof.2025.107979.

[5] S. Alam, K. Aminul, R. Miah, and S. Afrin, “Heliyon Key success factors of knowledge management systems for optimizing organizational performance : A PRISMA-based systematic literature review,” *Heliyon*, vol. 11, no. 16, p. e44097, 2025, doi: https://doi.org/10.1016/j.heliyon.2025.e44097.

[6] L. Sofia, M. Estrada, M. Haase, M. Baumann, and M. Cinelli, “Decision support for energy system transformation – A systematic analysis of MADM software for sustainability assessment,” *Energy Strateg. Rev.*, vol. 63, no. May 2025, p. 102016, 2026, doi: https://doi.org/10.1016/j.esr.2025.102016.

[7] A. Trendowicz *et al.*, “User experience key performance indicators for industrial IoT systems : A multivocal literature review,” *Digit. Bus.*, vol. 3, no. 1, p. 100057, 2023, doi: https://doi.org/10.1016/j.digbus.2023.100057.

[8] S. Bernardo *et al.*, “Software Quality Assurance as a Service : Encompassing the quality assessment of software and services,” *Futur. Gener. Comput. Syst.*, vol. 156, no. February, pp. 254–268, 2024, doi: https://doi.org/10.1016/j.future.2024.03.024.

[9] M. A. Saidah, H. A. Saputri, and Z. Zulfachmi, “Analisis kualitas aplikasi *Aku Pintar* dengan menggunakan framework ISO/IEC 25010,” *Jurnal Bangkit Indonesia*, vol. 12, no. 1, pp. 49–55, 2023, doi: https://doi.org/10.52771/bangkitindonesia.v12i1.229.

[10] A. Haleem, M. Javaid, and R. Pratap, “Green Technologies and Sustainability Encouraging Safety 4 . 0 to enhance industrial culture : An extensive study of its technologies , roles , and challenges,” *Green Technol. Sustain.*, vol. 3, no. 3, p. 100158, 2025, doi: https://doi.org/10.1016/j.grets.2024.100158.

[11] P. Kwan, C. Wong, W. Kit, H. Hung, J. Huang, and M. Pecht, “Results in Engineering Reliability and safety of elevators and escalators / travelators : Past , present and future,” *Results Eng.*, vol. 25, no. January, p. 104194, 2025, doi: https://doi.org/10.1016/j.rineng.2025.104194.

[12] N. Alsadi, W. Hilal, A. Mccafferty-leroux, S. A. Gadsden, and J. Yawney, “Internet of Things Smart systems : A review of theory , applications , and recent advances,” *Internet of Things*, vol. 33, p. 101667, 2025, doi: https://doi.org/10.1016/j.iot.2025.101667.

[13] X. Weng, Z. Nie, X. Xu, L. Chang, and Z. Zhou, “Hierarchical correlation modeling and evidence fusion for multivariate alarm systems in high-dimensional processes,” *Process Saf. Environ. Prot.*, vol. 203, no. PA, p. 107882, 2025, doi: https://doi.org/10.1016/j.psep.2025.107882.

[14] Y. Cao, W. Lian, J. Yang, C. Zhang, and X. Chang, “Measurement : Sensors Design of high-precision displacement safety monitoring and three-dimensional spatial alarm system for Beidou based on intelligent algorithms,” *Meas. Sensors*, vol. 33, no. February, p. 101099, 2024, doi: https://doi.org/10.1016/j.measen.2024.101099.

[15] M. Zeng and Y. Lian, “Original article A power network anomaly alarm denoising method based on a hybrid LSTM-attention model,” vol. 137, no. August 2025, pp. 76–88, 2026.