Design and Development of a Competency Certificate Surveillance System for Electrical Technical Personnel using a Disruptive RSM Design Approach

Rika Mulyati [a,1,*], Muharman Lubis [a,2], Sinung Suakanto [a,3], A. Taupik Rahman [b,4]

[a] Universitas Telkom, Jl. Telekomunikasi No.1, Bandung 40257, Indonesia
[b] Artristik Studio, Jl. Puspa Cemp. Barat I No.19 Blok A4, Bandung 40559, Indonesia
[1] rikamulyati@student.telkomuniversity.ac.id*; [2] muharmanlubis@telkomuniversity.ac.id; [3] sinung@telkomuniversity.ac.id; [4] a.taupik.r@gmail.com
* corresponding author

ARTICLE INFO

Article history
Received
Revised
Accepted

Keywords
Certificate
Surveillance
RSM
Disruptive

ABSTRACT

The competency certificate for electrical technical personnel serves as formal evidence that an individual is qualified to work in the electricity sector and has a validity period of three years, requiring periodic surveillance to ensure regulatory compliance. In practice, the surveillance process is still largely conducted manually by Competency Certification Bodies (LSK), resulting in administrative inefficiencies, delays in certificate renewal, fragmented documentation, and limited traceability of surveillance records. These challenges not only burden certification bodies and certificate holders but also affect regulatory supervision performance. This study aims to design and develop a competency certificate surveillance information system for electrical technical personnel using a disruptive Recognise–Scrutinize–Materialize (RSM) design approach. Data were collected through observations, semi-structured interviews, and document analysis to identify existing problems and system requirements. The RSM method was applied to systematically align stakeholder needs with national regulations and international standards, including ISO, IEEE, and NIST guidelines. The results of this research produce a regulation-based surveillance system design in the form of a structured mock-up that integrates automated reminders, digital document validation, standardized surveillance workflows, and real-time monitoring dashboards. The proposed system is expected to improve efficiency, data accuracy, transparency, and regulatory compliance in the surveillance and renewal process of competency certificates. This research contributes novel insights into the digitalization of competency certificate surveillance, a topic that has received limited attention in previous studies, particularly within the electricity sector.

1. Introduction

A competency certificate is a supporting document that proves an individual possesses expertise in their field [1]. Based on Law Number 30 of 2009 concerning Electricity, Article 44 paragraph 6 states that every technical personnel in the electricity business is required to hold a competency certificate [2], [3]. The competency certificate is an essential instrument that ensures each personnel has technical capabilities, understanding of electrical safety, and appropriate qualifications to perform work on electrical power installations [4]. As the complexity of electrical power systems increases, along with digital technology penetration, renewable energy integration, and operational needs demanding high reliability, the presence of competent technical personnel becomes increasingly crucial. In this regard, the Ministry of Energy and Mineral Resources (ESDM), through Decree of the Directorate General of Electricity (DJK) Number 217 of 2018, requires all Competency Certification Bodies (LSK) in the electricity sector to comply with the established Electricity Competency Certification Methodology (MSKK).

Fig. 1. Legal Basis for Competency Certification of Electrical Technical Personnel
(Source: Directorate General of Electricity)

Competency certificates for electrical technical personnel have a validity period of 3 (three) years, requiring a renewal process. Based on Ministerial Regulation Number 12 of 2021 concerning Classification, Qualification, Accreditation, and Certification of Electrical Power Supporting Service Businesses, it is explained that every LSK in implementing competency certification (new tests and renewals) must be supported by an information system integrated with the DJK system [5], [6]. DJK serves as the supervisor and overseer of certification implementation to support the achievement of Electrical Safety (K2), which in 2023 had not yet met performance targets. The supervision and oversight activities carried out focus on the certification process, both new tests and certificate renewals.

Program Objectives	Performance Indicators	Performance Target	Performance Realization
Enhancing National Electricity Independence and Resilience	National Electricity Indeicity Index (Scale 100)	70,78	73,88
	National Electricity Resiliencce Index	89,22	88,80*
	Electricity Infrastructure Readiness Indev to Support Economic Developmentid Basic Public Services (Scale 1	100	83,19
Optimization of the Contribution of Accountable and Sustainable Electricity Subsector	Percentage of Realized Investment in the Electricity Subsector	100%	89,47
Development, Supervision, and Control of an Effective Electricity Subsector	Effectiveness Index of Development and Supervision of the Electricity Subsector (Scale 100)	85,77	83,14*
Formulation of Policies and Regulations for the Electricity Subsector	Number of Policy Improvements on Electricity Governance (Regulations/ Recommendations)	3	3

Fig. 2.DJK Performance Achievement
(Source: DJK Performance Report, 2023)

The unachieved DJK performance targets can be analyzed from the renewal implementation targets compared to new test implementations three years earlier. The phenomenon of certificates being unable to be renewed frequently occurs, creating obstacles for company business processes and affecting DJK performance. This phenomenon can be observed from data obtained from one of the best LSKs in Indonesia.

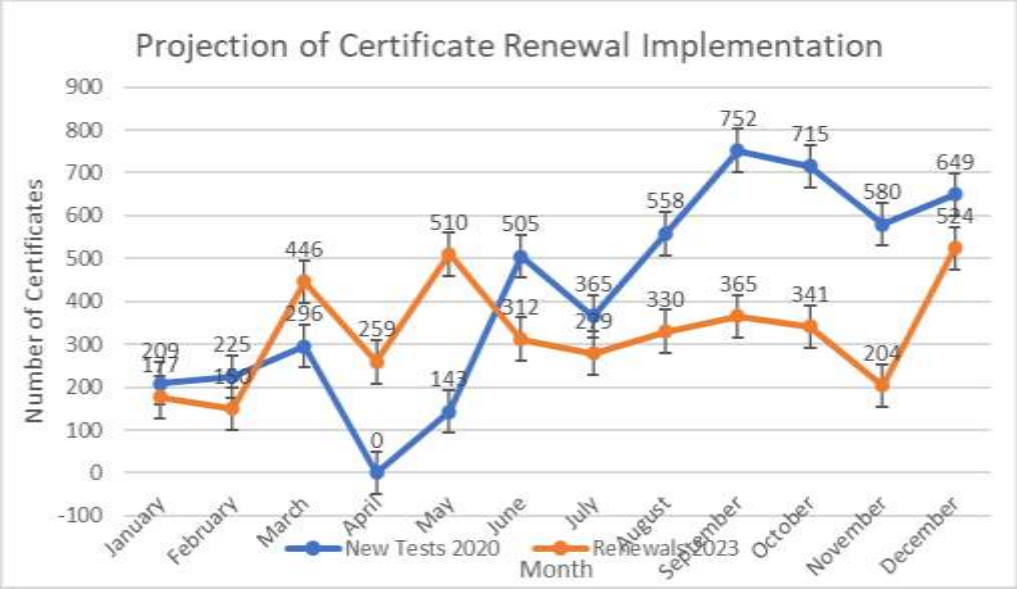

Fig. 3. Implementation of New Tests in 2020 and Renewals in 2023

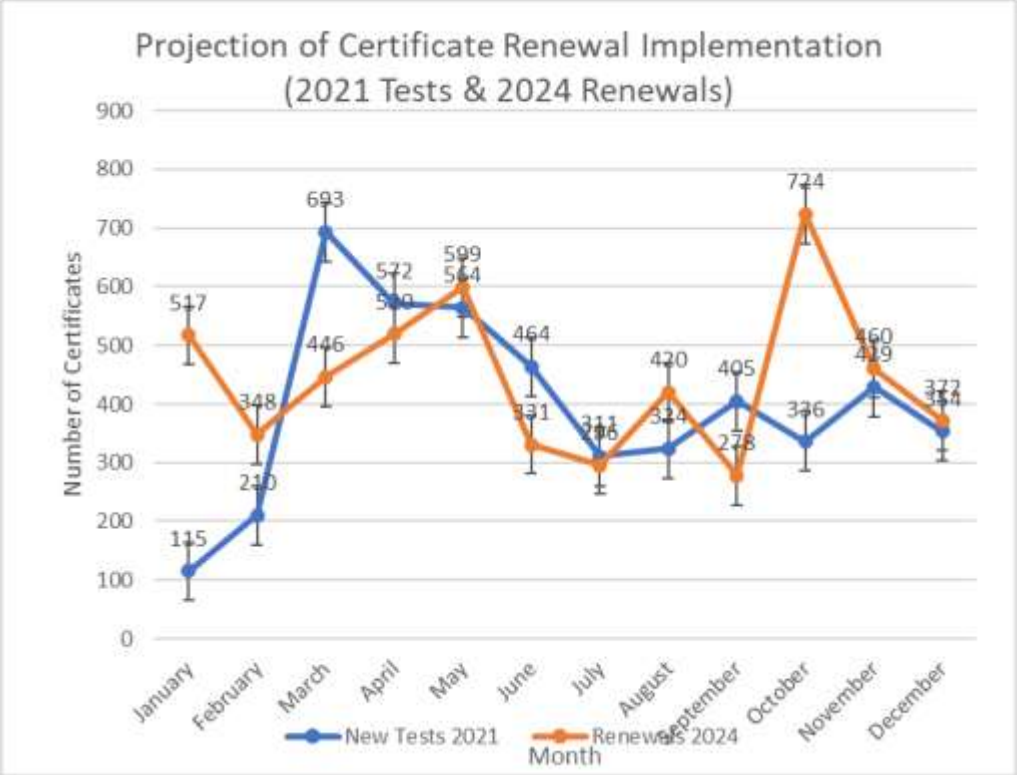

Fig. 4. Implementation of New Tests in 2021 and Renewals in 2024

The requirements for certificate renewal according to Director General Decree No. 217 of 2018 include documented evidence of surveillance implementation by the LSK. The need for surveillance implementation becomes closely related to LSK business processes and must accommodate the needs of technical personnel for both new certification services and certificate renewal. The surveillance mechanism consists of a series of processes including supervision, data collection, verification of practice activity evidence, examination of renewal requirement fulfillment, tracing of competency records, and confirmation that technical personnel remain active in relevant work areas, as well as reporting for monitoring compliance or specific behaviors [7]. The surveillance process for competency certificates must be carried out not only for the needs of certificate holders but also in relation to compliance with applicable regulations [8].

Failure to meet these requirements can result in the suspension of certificate validity, ultimately impacting the productivity of technical personnel and LSK compliance with regulations [9]. Although surveillance is a critical part of the certification cycle, in practice LSKs often face challenges in implementing surveillance because regulations allow technical personnel to renew their certificates with any LSK, resulting in complex bureaucracy, certificate documentation transfers, limited resources, and lack of involvement from related parties. These problems not only hinder the efficiency and effectiveness of LSK business but also affect trust in certification bodies. Therefore, this surveillance process can automatically influence the sustainability of LSK business.

Fig. 5. Business Sustainability and Surveillance

Currently, the surveillance process conducted at LSK is still performed manually using forms, unstructured messages, scattered digital documents, and non-integrated spreadsheets. This manual approach creates various operational challenges, such as delays in surveillance implementation, inaccurate data on evidence fulfillment, archives that are not consistently documented, and difficulties in tracing the surveillance activity history of each certificate holder [10], [11].

To identify previous research related to certificate surveillance, the researchers used bibliometric analysis of 996 articles published in the period 2019-2024 from Google Scholar and 2,216 articles published by Scopus. The results of bibliometric analysis on research regarding surveillance and certification develop in different domains. Articles containing the keyword "surveillance" are dominated by studies related to epidemiology, disease monitoring systems, biological security, and surveillance in public health contexts. Meanwhile, articles containing the words "certificate" or "certification" generally relate to health personnel certification, professional training schemes, occupational safety, and competency evaluation. Literature analysis results from Scopus produced 14 articles that simultaneously discuss "surveillance" and "certificate," but none relate to competency certificates for electrical technical personnel.

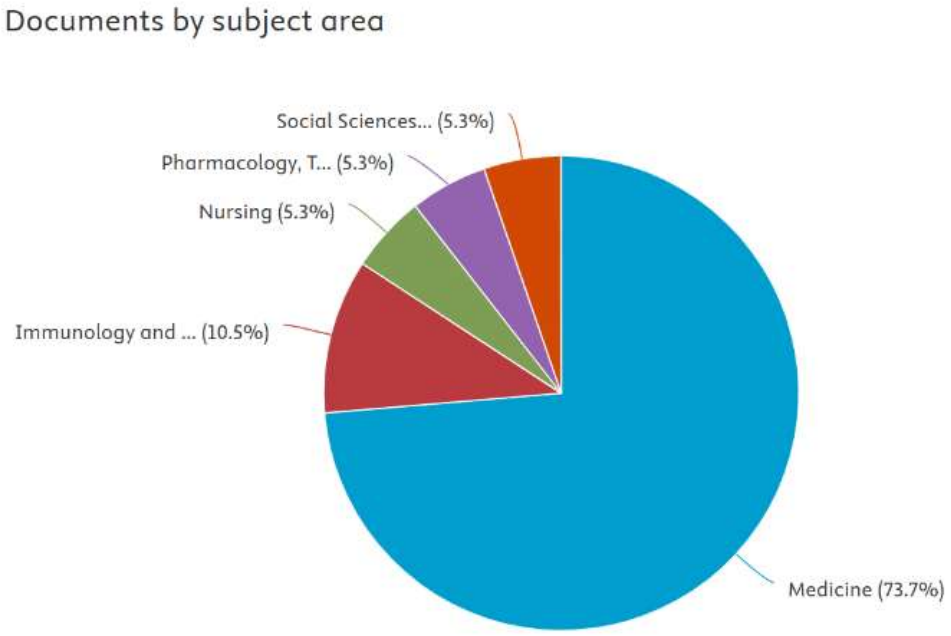

Fig. 6. Articles by Subject Area Surveillance from Scopus

Specifically, no research was found that addresses surveillance of competency certificates in the context of professional certification bodies or electricity regulations. This fact indicates that although competency certification is an important instrument for ensuring the quality of technical personnel, the aspect of periodic surveillance of certificate holders has not yet become a focus of academic research. The absence of studies combining surveillance and competency certification aspects indicates a significant research gap, especially in the electrical engineering domain where regulatory compliance is crucial for the safety and reliability of electrical installations.

Table 1. Bibliometric Recapitulation Based on Main Keywords (2019-2024)

No	Search Keyword Category	Number of Articles	Percentage	Notes
1	Articles containing the word "Surveillance"	312	31,3%	Research related to epidemiology, public health, infectious diseases
2	Articles containing the words "certificate/certification/competency"	178	17,9%	Majority about medical personnel certification, training standards, and safety
3	Articles containing both words "surveillance" and "certificate" simultaneously	1	0,1%	Only one article touches on both topics, and not in the electricity sector
4	Articles discussing surveillance of competency certificates in the electricity sector	0	0%	No research at all

The results of bibliometric analysis using VOSviewer with the keyword filter "surveillance competency" show that research on this theme is dominated by the health field, particularly related to infection control, epidemiology, and the validation process of health personnel competency. Keywords such as infection control, validation, and epidemiology become nodes with the strongest connections. Conversely, keywords such as certificate, certification, or competency appear in different clusters without strong direct connections to "surveillance competency." This condition indicates that the integration of surveillance concepts with competency certification has not been extensively studied.

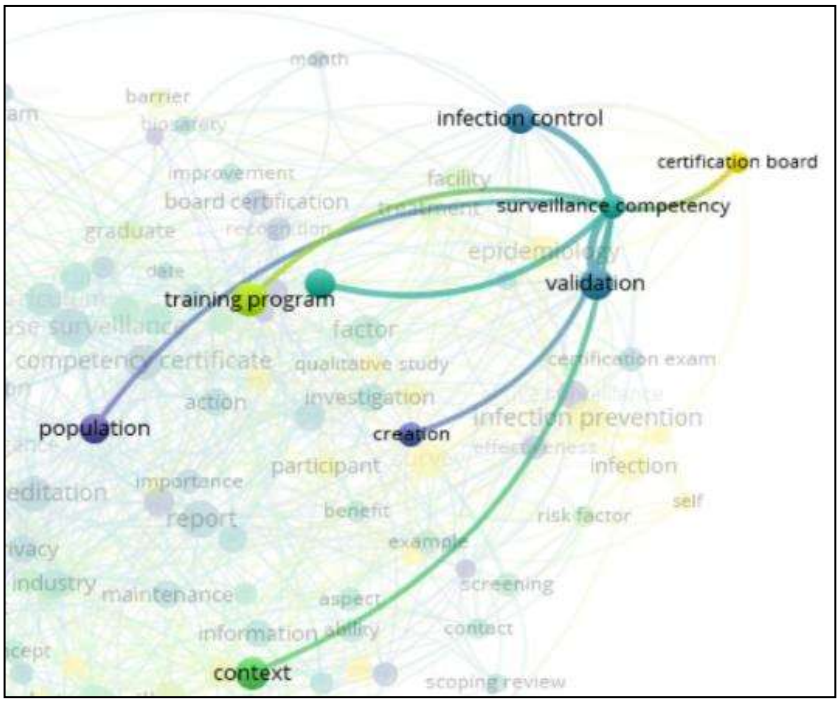

Fig. 7. Visualization of Keyword Co-occurrence VOSviewer "Surveillance Competency"

Previous research shows that manual processes in regulatory compliance management tend to increase the risk of non-compliance, hinder examination processes, and reduce data reliability levels [12]. Digital transformation in recent years has brought significant changes to how organizations manage business processes, including in the field of competency certification and regulatory compliance management [13], [14]. Current literature shows that digitalization of the certification process can improve data accuracy, process transparency, and administrative efficiency [15]. However, research on the digitalization of competency certificate surveillance, especially in the electricity field, is still very limited. Most previous research focuses on developing computer-based examination systems, competency learning platforms, or digitalization of initial assessments [15], [16], [17], [18], [19]. Studies on information systems for long-term surveillance of competency certificates have not been extensively conducted, so this mechanism is often overlooked in digital certification system development. However, without a good surveillance system, certification bodies

potentially face difficulties in ensuring regulatory compliance and the quality of certified technical personnel.

The results of VOSviewer visualization analysis with the keyword filter "surveillance technology" show that this topic is primarily connected with themes of governance, education, competency model, and enforcement. This indicates that surveillance technology is extensively discussed in the context of governance, learning processes, and general competency modeling [20]. However, the visualization shows no direct connection between "surveillance technology" and certification concepts or competency certificate maintenance. Nodes such as certificate or certification do not appear in the same cluster, and there are no connecting lines showing significant co-occurrence.

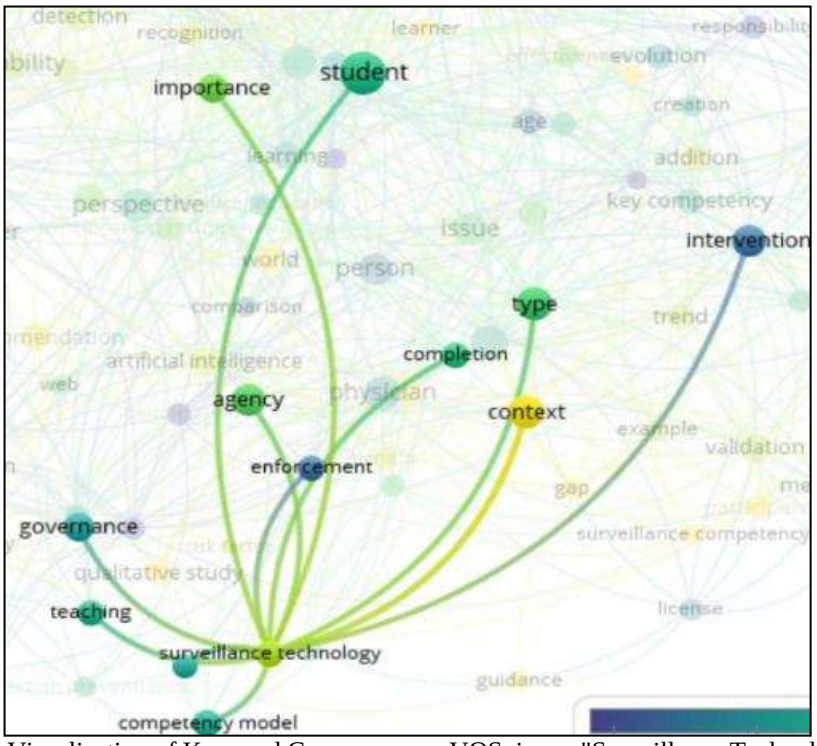

Fig. 8. Visualization of Keyword Co-occurrence VOSviewer "Surveillance Technology"

To address these challenges, literature in the field of information systems recommends various digitalization strategies, including process automation, integrated workflow design, implementation of rule-based compliance checking, and development of standards-based information systems [14]. Regulation-based information systems have been proven to improve process implementation consistency, facilitate examination processes, and ensure compliance with applicable provisions [21]. However, most of these solutions were developed for other domains such as medical certification, educational accreditation, or environmental audits. There has been no research applying a similar approach to competency certification for electrical technical personnel, especially in surveillance mechanisms, which have unique characteristics such as specific technical requirements, the need for field practice evidence, and provisions for personnel involvement in high-risk work environments.

A number of previous studies also highlight the importance of integrating international standards in information system development, such as ISO 17024, ISO 9001, ISO 56001 for quality management, IEEE Standard 1233 for software requirements specifications, and NIST 800-30 guidelines for information technology risk management [22], [23]. This standards-based approach enables system designers to ensure that every developed process has a strong regulatory foundation, is auditable, and aligns with international best practices. In the context of competency certificate surveillance, the existence of these standards can help translate regulatory clauses into system requirements, both functional and non-functional requirements. Other research also shows that this approach supports process transparency and facilitates integration between certification bodies and other stakeholders [24]. Nevertheless, no research has implemented the integration of these multiple standards in technical personnel competency surveillance systems.

Bibliometric analysis of competency certification research in recent years found that the main research focus remains on initial competency assessment, improvement of technical training quality, and evaluation of certification scheme effectiveness [19]. There are no studies that deeply examine the long-term surveillance process and how this process can be supported by standardized information systems. This research gap demonstrates the need for a new approach that integrates national regulations, including DJK provisions, with international standards such as ISO, IEEE, and NIST to produce system designs capable of meeting certification body needs in the digital era.

Thus, there is a significant research gap in the form of limited research on competency certificate surveillance in the electricity field, opening opportunities for new relevant and original research. This condition strengthens the research gap that the integration of surveillance technology in the context of technical competency certification systems, particularly in the electricity field, remains very limited and has academic urgency and clear novelty contribution while offering solutions to regulatory needs demanding periodic supervision of competency certificates.

All standard paper components have been specified for three reasons: (1) ease of use when formatting individual papers, (2) automatic compliance to electronic requirements that facilitate the concurrent or later production of electronic products, and (3) conformity of style throughout a IJAIR template. Margins, column widths, line spacing, and type styles are built-in; examples of the type styles are provided throughout this document and are identified in italic type, within parentheses, following the example. Some components, such as multi-leveled equations, graphics, and tables are not prescribed, although the various table text styles are provided. The formatter will need to create these components, incorporating the applicable criteria that follow.

2. Method

The researchers designed a regulation-based information system using a prominent approach, namely the Recognise-Scrutinize-Materialize (RSM) method developed by Lubis et al. (2018), which offers a three-stage structure: recognizing core problems, scrutinizing needs based on literature and regulatory evidence, and materializing solutions in the form of mock-ups or prototypes. This approach has been used in several studies in the fields of digital government, public service systems, and organizational system development requiring regulatory compliance [25]. The main strength of RSM is its ability to align system design with stakeholder needs and standard provisions from the initial stage, making it suitable for designing complex, legally-based surveillance systems.

A systematic review of the literature shows that no research has specifically designed an information system for certificate surveillance. Based on this context, this research aims to design and develop a surveillance information system for competency certificates of electrical technical personnel using the RSM Design Approach. The main research objectives are to identify system requirements based on regulations and standards, design process flows that support timely and accurate surveillance implementation, build a system mock-up, and evaluate the design results from the aspects of regulatory compliance and implementation feasibility. The novelty of this research lies in the systematic integration between national regulations and various international standards in the system design process, something that has never been done in previous research.

This research is expected not only to contribute to the development of theory and methodology for regulation-based information system design but also to provide practical benefits for LSKs in improving the effectiveness, transparency, and compliance of the surveillance process for competency certificates of electrical technical personnel.

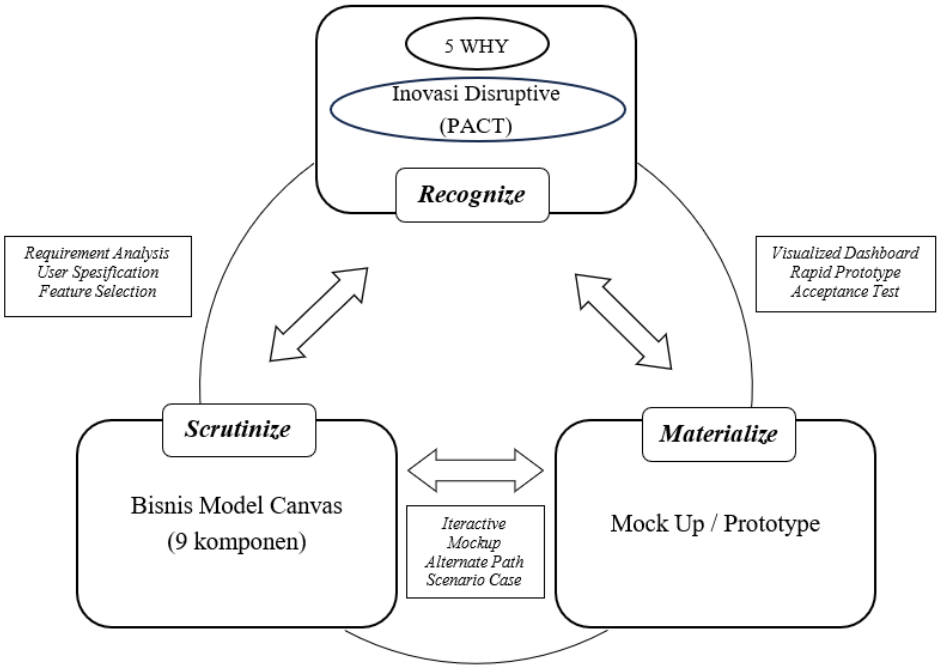

Fig. 9. Implementation of RSM Design Approach

This research uses a qualitative descriptive approach to deeply understand problems, needs, and the operational context of the surveillance process for competency certificates of electrical technical personnel. The qualitative approach allows researchers to obtain a holistic picture of business processes, implementation barriers, and stakeholder perceptions of the surveillance system that is currently still conducted manually. According to Creswell (2014), qualitative methods have strengths in exploring complex processes, especially when the phenomenon being studied has not been extensively explained in literature or does not yet have an established digitalized system [26]. In the context of this research, this approach becomes relevant because previous research related to competency certificate surveillance is still very limited, as also shown through the previous bibliometric analysis.

Data collection was conducted through direct observation, semi-structured interviews, and document study reflecting the actual conditions of the surveillance process at LSK [27], [28]. This empirical data is juxtaposed with various standards and regulations, including national provisions related to surveillance as well as international references such as ISO, IEEE, and NIST [22]. In an effort to ensure the designed system complies with international standards and best practices, this research refers to ISO 17024:2012, ISO 9001:2015, ISO 56002:2019, NIST 800-30, IEEE 1233, and Director General Decree DJK 217 of 2018.

The mapping of principles and clauses contained in the above international standards and regulations will be grouped into two categories, namely external and internal principles:

Table 2. Mapping of Information System Design Principles

ISO / Regulation	Principle	External	Internal
17024:2012	Independent (Freedom from interested parties)	√	
	Maintenance (Competency maintenance)	√	
	Monitoring and evaluation		√
	Data security and confidentiality		√
	Improvement (Improvement and sustainability)		√
9001:2015	Customer Focus (Focus on customer needs)	√	
	Leadership		√
	Engagment of people (Involvement of people/interested parties)	√	
	Improvement (Innovative system development and continuous improvement)		√
	Evidence based Desicion Making (Decision-making		√

ISO / Regulation	Principle	External	Internal
	based on evidence or accurate data)		
56002:2019	Leadership (Leadership in innovation)		√
	Organize (Organized innovation)		√
	Engagment of people (Involvement of interested parties)	√	
	Integration (Integrated with other innovation elements)	√	
NIST 800-30	Identification (Risk Identification)		√
	Analyze (Risk Analysis)		√
	Evaluating (Risk Evaluation)		√
	Manage (Risk Management)		√
IEEE 1233:1996	Functional requirements (Reminder, Surveillance, Reporting)	√	
	Performance requirements (Accessibility, storage, response time)	√	
	User friendly (UI/UX)	√	√
Director General (Kepdirjen) DJK 217:2018	Maintenance (Competency maintenance)	√	
	Customer Focus (Focus on customer needs)	√	
	Monitoring dan evaluasi		√
	Improvement (Innovative system development and continuous improvement)		√

Currently, LSKs in Indonesia conduct surveillance using manual methods or simple systems. The surveillance system is expected to be simpler and more accessible to interested parties. Analysis of requirement identification is conducted based on requests and expectations of interested parties, in line with disruptive innovation trends in Indonesia [25].

The system development technique in this research uses the Disruptive Innovation approach introduced by Christensen (1997). This approach is relevant when new solutions need to replace inefficient old systems, as is the case with the current manual surveillance process. Disruptive innovation focuses on process simplification, service time reduction, and system accessibility improvement [30]. In the context of this research, the principles used include growth-oriented, profit maker (increasing value for certification bodies), integration (process integration), and channel utilization (utilization of effective service channels) [25].

The application of the disruptive innovation approach in surveillance system development enables the emergence of solutions that are easier to use, affordable, quickly implemented, and oriented toward meeting core user needs. As stated by Christensen and Raynor (2003), the key to disruptive innovation is creating new services capable of overcoming existing service limitations while maintaining operational efficiency [31], [32], [33], [34]. In this research, this approach is applied in mock-up design through emphasis on scheduling automation, surveillance evidence integration, compliance notifications, and certificate status dashboards.

3. Results and Discussion

The RSM design stages begin with Recognize, which focuses on the process of identifying needs in developing the application using PACT. Then Scrutinize, which is a continuation of needs identification and specifications analyzed in the form of feature checklists leading to disruptive innovation (growth-oriented, profit makers, integration, channel utilization). Next is Materialize to provide solutions to problems through mock-up design or surveillance system prototype [25], [35].

3.1. Recognize

To analyze the balance between demand and expectations from interested parties, design is carried out based on aspects found in current and future design problems [25], [30]. Informants in this research consisted of DJK Regulators, LSK Directors, LSK Managers, and surveillance officer administrators. The root problems of certificate surveillance implementation are based on People, Activities, Context, Technology (PACT) aspects consisting of 12 criteria.

Table 3. Interview Mapping Results

No	Criteria	Design problem (Identify, Current Situation, Solving)		Design Issues (Predict, Future Condition, Anticipate)	
		Problem	**Expectation**	**Future**	**Anticipation**
1	Input-Output Channel	Manual (physical documents, email and WhatsApp), delayed, and prone to input errors	Integrated digital system	Data volume increasingly large, automation of input-output with system validation required	Web/cloud-based system with API integration
2	Mental Model	Inconsistent reports	Clear procedural guidelines	System must be flexible following new rules	Modular system design that is easily updated
3	Social Differences	Different report quality	Equality of work culture and discipline among staff	More personnel involved	System provides digital SOPs
4	Safety Critical	Delays or errors in surveillance reporting	Quality Service Level (TMP)	Increasing regulatory compliance related to K2	System must have automatic notifications to prevent delays
5	Cooperative-Complex	Coordination among parties (Directorate General, LSK, Assessors) not implemented		Collaboration complexity will increase	System with online collaboration features and monitoring and inspection trails
6	Temporal Aspect	Certificate reminder process not timely	Auto-reminder	Need for increasingly high response speed	Digital calendar-based reminder
7	Physical Circumstances	Diverse geographical locations of technical personnel, difficult to directly access technical personnel work locations	Web-based face-to-face system for surveillance implementation at certain locations	Need for remote services increasing	Web/mobile-based system to reduce geographical barriers
8	Organizational Context	Surveillance procedures at LSK not yet fully digitally documented	Easily accessible SOPs	Pressure for accreditation according to international standards increasingly strict	System supports complete digital documentation according to standards
9	Social Context	Technical personnel often lack information about surveillance obligations	Earlier socialization to technical personnel	Need for transparency and public information access increasingly large	System provides open information portal
10	Data & Media Characteristic	Data still scattered in various formats (excel, pdf, hardcopy)	Data type uniformity	Data integration	System with a single structured database
11	Communication Channel	Manual communication among parties (email/telephone/ WhatsApp) and not traceable	Official communication media capable of tracing	Need for formal communication evidence increasingly urgent	System provides official communication features and communication logs
1 2	Physical Differences	Differences in digital adaptation ability levels	System must be user-friendly	Digital competency gap still exists	System must be user-friendly and equipped with usage training

3.2. Scruntinize

3.2.1. Inspire

In the inspire stage, researchers map initial data collection results in the form of feature checklists consisting of weaknesses, responses, and features based on initial findings of Design Problems and

Design Issues [25]. This process adapts common patterns found in interviews, field observations, and analysis of ongoing surveillance processes.

Table 4. Feature Checklist

No.	Weakness (Barrier)		Response		Menu	
	Code	Description	Code	Description	Code	Description
1	K1	Certificate validity period data difficult to monitor manually	R1	System needs to automatically remind surveillance period	F1	Automatic expiration notification
2	K2	Surveillance flow varies among certificate types	R2	System needs configurable surveillance flow	F2	Dynamic surveillance workflow
3	K3	Surveillance documents often incomplete	R3	Need standard document list that must be attached	F3	Surveillance document checklist
4	K4	Communication between assessors and applicants not documented	R4	System must provide internal communication channel	F4	Internal surveillance chat/inbox
5	K5	Field verification time-consuming due to manual coordination	R5	Digital/face-to-face scheduling	F5	Built-in application face-to-face scheduling
6	K6	No dashboard to monitor surveillance progress	R6	Need real-time status display	F6	Surveillance progress dashboard
7	K7	Surveillance history not well documented	R7	System must store history log	F7	Surveillance history and record
8	K8	Competency evaluation not standardized	R8	Need uniform digital assessment form	F8	Digital assessment form

3.2.2. Define

The define stage involves conceptual system design through business mapping using Business Model Canvas (BMC). BMC is used as an analysis tool to identify user needs, value flows, and key resources needed in designing a surveillance information system for competency certificates of electrical technical personnel. This approach is chosen because BMC can describe strategic organizational elements comprehensively and structurally, facilitating researchers in evaluating alignment between actual business processes, regulatory requirements, and system features to be developed. The BMC consisting of nine components is used to examine aspects of service value, cost structure, revenue flow, user segmentation, up to partner needs [30].

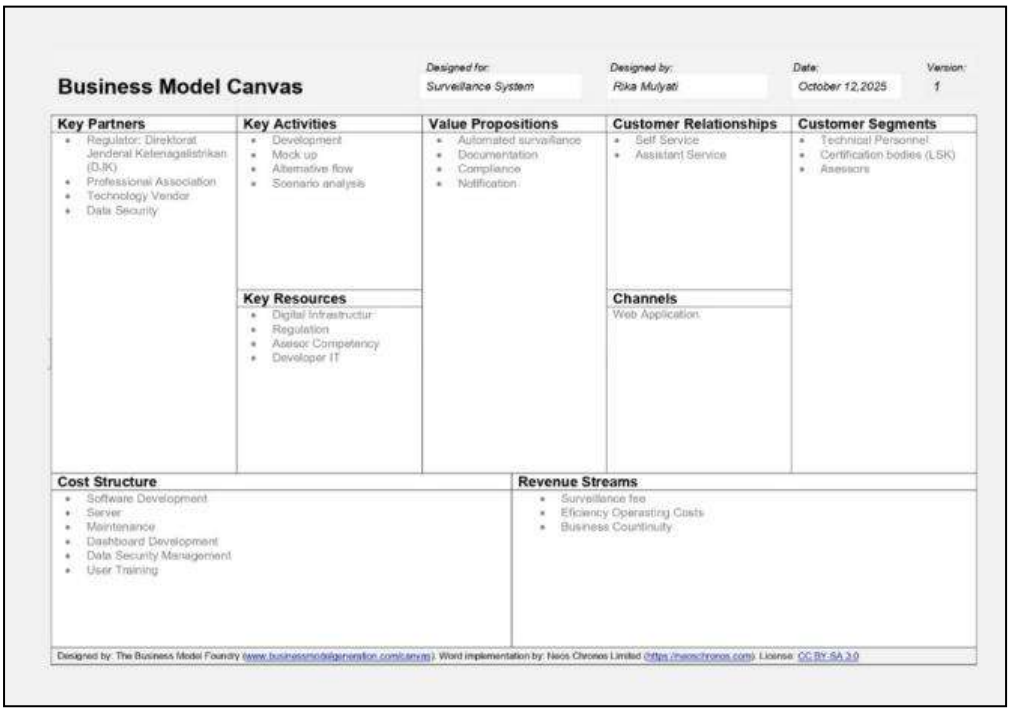

Fig. 10. Business Canvas Model Certificate Competency Surveillance

BMC helps visualize a system's value structure and ensures alignment between certification body objectives and designed digital services. Overall, BMC mapping at the Scrutinize stage provides a strong conceptual foundation in designing a surveillance information system that meets user needs and regulatory requirements. The results of this analysis become the basis for formulating core features and mock-up workflows developed at the Materialize stage. Through BMC, this research not only produces a comprehensive system design but also ensures that every element in the business model supports the main objective, namely improving the effectiveness and efficiency of the surveillance process for competency certificates of electrical technical personnel.

3.2.3. Perceive

The perceive stage describes user customer journey based on user persona in user experience and journey through various stages of interaction with the application [32]. The most involved user personas are Certificate Holders and LSK Admins.

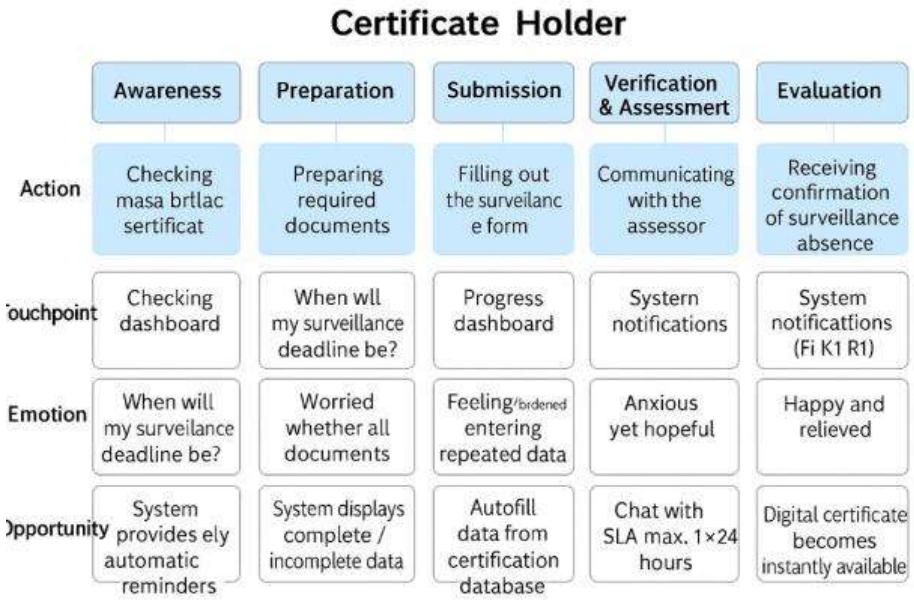

Fig. 11. User Journey Maps Certificate Holder

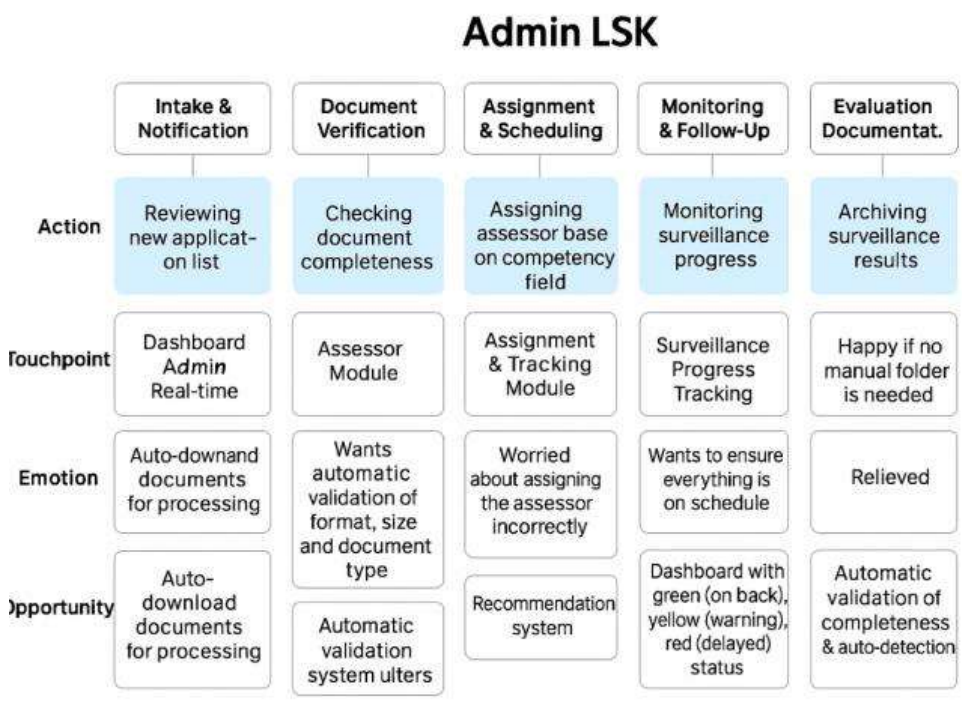

Fig. 12. User Journey Maps LSK Admin

3.3. Materialize

The Materialize stage is the stage of concretizing the design into a system mock-up. At this stage, the conceptual design that has been formulated is translated into interface mock-ups, visual dashboards, reporting features, and surveillance implementation modules. The rapid prototyping approach is used to accelerate the design evaluation cycle, as recommended by Sommerville (2016) in developing systems that require rapid user feedback [36], [37], [38]. The prototype results are then tested through acceptance tests to see the extent to which the design meets user needs and addresses problems identified at the Recognize stage [38].

The mock-up or prototype to be created consists of several modules:

1) LSK Admin Dashboard Module
2) Surveillance Monitoring Module
3) Reminder and Notification Module
4) Document Validation Module
5) Summary Report Module
6) Certificate Holder Data Management Module
7) History Module

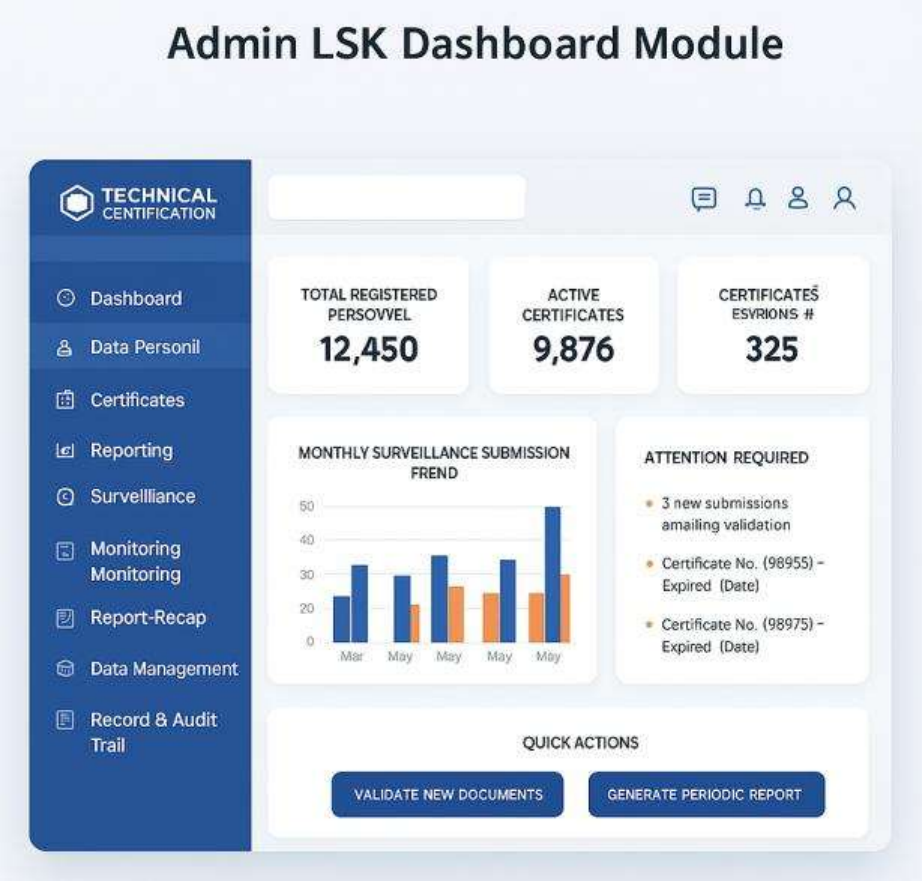

Fig. 13. Dashboard Module Design

Fig. 16. Surveillance Monitoring Module Design

Fig. 15. Notification Design

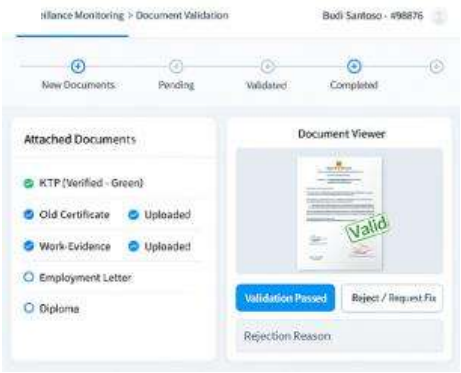

Fig. 14. Document Validation Design

4. Conclusion

This research aims to design and develop a competency certificate surveillance information system for electrical technical personnel with the Recognise-Scrutinize-Materialize (RSM) approach. Based on the results of needs analysis, process evaluation, and problem mapping through observation, interviews, and document study, this research shows that manual surveillance implementation still has significant weaknesses. These problems include delays in meeting certificate renewal requirements, irregularity of documentation flows, dependence on paper-based processes, and manual communication as well as backlog risks due to minimal real-time status monitoring [39]. The use of the RSM approach successfully provides a systematic methodological structure in identifying needs and designing solutions that fit the operational context of LSK. The Recognize stage enables comprehensive identification of barriers affecting surveillance process effectiveness. Subsequently, the Scrutinize stage produces business process modeling, customer journey, feature analysis, and initial system design representing the real needs of stakeholders, including LSK admins, assessors, and certificate holders. The Materialize stage then formulates the system design in the form of a structured mock-up based on relevant standards and guidelines, such as ISO, NIST, IEEE, and applicable electricity regulations.

The research results confirm that the integration of international standard clauses and national regulations can be used as the basis for more consistent, documented, and auditable surveillance system architecture. The resulting prototype has the potential to improve process efficiency, reduce human error, minimize delays, and provide increased accuracy in monitoring the life cycle of competency certificates. In addition, this research shows that literature related to competency certificate surveillance is still very limited, as evidenced through bibliometric analysis, so this research makes a substantive contribution to the development of regulation-based surveillance systems in the electricity sector. Overall, the designed system provides measured and relevant solutions to LSK needs in improving certification service quality and ensuring the continuous compliance of technical personnel with electrical safety provisions. This research also opens space for further research, such as comprehensive system testing, integration of artificial intelligence for automatic recommendations, and full implementation in the operational environment of certification bodies.

Acknowledgment

The authors would like to express their sincere gratitude to the Directorate General of Electricity (DJK), the management of Competency Certification Bodies (LSK), and all informants who contributed their time, insights, and valuable information during the observation and interview processes. The authors also acknowledge Universitas Telkom for providing academic support and facilities that enabled the completion of this research.

Declarations

Author contribution. (1) Rika Mulyati: Conceptualization, methodology, data collection, analysis, system design, and original draft preparation. (2) Muharman Lubis: Supervision, methodology validation, critical review, and conceptual guidance. (3) Sinung Suakanto: System design evaluation, technical review, and manuscript revision. (4) A. Taupik Rahman: Visualization, prototype development support, and design validation.
Funding statement. This research received no external funding.
Conflict of interest. The authors declare no conflict of interest.
Additional information. No additional information is available for this paper.

Data and Software Availability Statements

The data supporting the findings of this study were obtained through observations, semi-structured interviews, and document analysis conducted at Competency Certification Bodies (LSK). Due to confidentiality agreements and regulatory restrictions, the datasets are not publicly available. The system design outputs, including mock-ups and prototypes, were developed solely for research purposes and are available from the corresponding author upon reasonable request.

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