DIJEFA: Dinasti International Journal of Economics, Finance & Accounting
E-ISSN: 2721-303X
P-ISSN: 2721-3021
https://dinastipub.org/DIJEFA dinasti.info@gmail.com +62 811 7404 455

DOI: https://doi.org/10.38035/dijefa.v7i2.6870
https://creativecommons.org/licenses/by/4.0/
Received: 16 May 2026 | **Revised:** 01 June 2026 | **Accepted:** 16 June 2026

Determining Factors in Handling Incidents Impacting Business Continuity in LRT Jabodebek Division

Diahayu Nugrahaning Widhi[1*], Tanti Novianti[2], Aruddy[3]
[1]IPB University, Bogor, Indonesia, diahayunugrahaning12@gmail.com
[2]IPB University, Bogor, Indonesia, tantinovianti@apps.ipb.ac.id
[3]IPB University, Bogor, Indonesia, aruddy2006@gmail.com

*Corresponding Author: diahayunugrahaning12@gmail.com[1]

Abstract: Operational continuity is crucial for rail-based public transportation systems because of their complexity and interconnection. This study assesses the coherence of Business Continuity Management/Business Continuity Plan (BCM/BCP) components and identifies key criteria for the establishment of BCM/BCP in the LRT Jabodebek Division of PT Kereta Api Indonesia (Persero). A mixed-methods approach was utilized, integrating document analysis, in-depth interviews, Focus Group Discussions (FGDs), and the Analytical Hierarchy Process (AHP). The results demonstrate that current BCM/BCP-related papers have not been cohesively integrated and are deficient in essential continuity components, such as Business Impact Analysis (BIA), Recovery Time Objectives (RTOs), and quantifiable continuity metrics. The AHP results indicate that Human Resources is the predominant criterion (41%), succeeded by Systems and Technology (25%), Infrastructure (15%), External Factors (11%), and Operations (7%). The Integrated Business Impact Analysis (BIA) has been identified as the foremost strategic choice. These findings underscore the significance of organizational preparedness, continuity governance, and human-centered resilience in sustaining operational continuity within highly automated railway systems.

Keywords: Business continuity, AHP method, Risk management, Public transportation, Operational resilience.

INTRODUCTION

The transformations taking place in today's increasingly fast-paced, dynamic, and competitive business landscape require every company to possess strong resilience in order to maintain operational sustainability. Companies now focus not only on achieving short-term profits but must also ensure long-term operational sustainability by anticipating risks that may arise in the future (Halim & Wijaya, 2020). Any type of disruption, whether caused by internal or external factors, can threaten the stability of ongoing business operations and result in losses that are not only financial but also damage the reputation and trust of stakeholders.

This context becomes increasingly significant when applied to the public transportation sector, particularly rail-based modes such as Light Rail Transit (LRT). Public transportation

systems serve not only as providers of passenger transport services, but also as the foundation of mobility for communities in densely populated urban areas. The services provided not only affect the comfort and safety of users' journeys but also directly impact time efficiency, the smooth operation of economic activities, and overall societal productivity. Therefore, the reliability and consistency of public transportation services are crucial indicators for evaluating the quality of urban governance in a region (Wei et al., 2024).

The primary characteristic of rail-based transportation modes is their complex and continuous nature. LRT operations require the coordination of various system components, including rolling stock, track infrastructure, signaling systems, scheduling management, and the human resources that operate daily services. This complexity makes service continuity highly vulnerable to disruptions, even on a small scale. A seemingly minor disruption can escalate into a significant problem that triggers a chain reaction of delays across the entire service network (Daniotti et al., 2024). According to Bergantino et al., 2024, the resilience of transport networks is a strategic element that must be supported by a structured, data-driven risk management system.

Operational disruptions in public transportation affect not only technical aspects but also the company's financial and reputational dimensions. From a financial perspective, recurring delays can result in lost potential ticket revenue, increased emergency operational costs, and the risk of administrative sanctions from regulators. In his study on the LRT system in Tokyo, (Nakamura, 2018) found that a two-hour disruption to the electrical system could result in significant economic losses. In terms of reputation, frequent service disruptions would lower customer satisfaction, erode public trust, and ultimately reduce user loyalty in the long term. (Cong et al., 2022) also found that more than 35% of passengers could not be evacuated until service returned to normal when the Recovery Time Objective (RTO) threshold was exceeded, underscoring the importance of structured service recovery planning.

An internationally recognized strategy for ensuring a company's operational continuity is the implementation of Business Continuity Management (BCM). This concept is realized in a Business Continuity Plan (BCP) document, which serves as a comprehensive guide to ensure services remain operational despite significant disruptions, whether technical or non-technical (ISO 22301:2019; Gujar, 2024). A BCP not only establishes risk mitigation measures but also mechanisms for rapid operational recovery to minimize potential financial losses. Business Impact Analysis (BIA), as a fundamental element of Business Continuity Management (BCM), serves to identify the most critical business processes, assess the impact of disruptions, and estimate the Recovery Time Objective (RTO) and Maximum Tolerable Period of Disruption (MTPD) for each key function (Federal Emergency Management Agency, 2019).

However, BCP development in the field often encounters various obstacles that can reduce its effectiveness. One of the primary obstacles is the insufficient integration between top management and operational units in the planning process. Numerous companies continue to use a top-down approach, where decisions are predominantly made by upper management without incorporating input from operational units possessing in-depth technical knowledge. Furthermore, the risk indicators included in the preparation of the BCP are often not based on objective and measurable facts, but rather are subjective, making systematic evaluation difficult (Wibowo & Hermawan, 2023). This condition can make the BCP irrelevant when companies face new challenges that require rapid adjustment. Herbane (2010) asserts that the evolution of BCM as a discipline necessitates an increasingly data-driven, cross-functional, and adaptive approach to the dynamics of the business environment.

PT Kereta Api Indonesia (Persero) LRT Jabodebek Division is a provider of contemporary mass transportation services in the Jabodetabek area, operating with Grade of Automation 3 (GoA3) technology based *on* Communication-Based Train Control (CBTC). The LRT Jabodebek plays a strategic role in supporting urban mobility and reducing reliance on

private vehicles, which contribute to traffic congestion and air pollution. The complexity of the operating system, which encompasses advanced technology, an extensive railway network, and a high passenger volume of approximately 100,000 individuals daily (PT KAI (Persero), 2022), renders the necessity for precise, adaptive, and comprehensive BCM/BCP documentation increasingly urgent. Without a well-structured BCP, any operational disruption—whether caused by technical issues, natural disasters, or policy changes—can trigger a domino effect that disrupts service operations on a large scale (Kusuma et al., 2025).

In addition to its functional significance in disaster preparedness, Business Continuity Management (BCM) and Business Continuity Planning (BCP) have been increasingly examined within the wider context of organizational resilience. Organizational resilience denotes an organization's ability to foresee, endure, adjust to, and recuperate from disruptive occurrences while sustaining critical functions and performance. In critical infrastructure sectors like rail transportation, resilience is influenced not just by technology reliability but also by the interplay of organizational capabilities, governance frameworks, operational processes, and human resource preparedness. Thus, business continuity must be regarded not alone as a technical recovery tool but as a strategic organizational competency that fosters long-term operational sustainability.

The continuation of railway operations, from a socio-technical systems perspective, relies on the interaction of human actors, technology systems, infrastructural assets, operational procedures, and external environmental variables. Malfunctions in a single component can disseminate across the entire network, resulting in cascading interruptions that compromise service dependability, passenger safety, and organizational efficacy. Consequently, recognizing and prioritizing the elements that most substantially impact business continuity is crucial for formulating an effective and evidence-based BCM/BCP framework. This viewpoint is especially pertinent for highly automated urban rail systems like the LRT Jabodebek, which utilize Communication-Based Train Control (CBTC) technology and necessitate ongoing coordination among various organizational entities.

Despite the acknowledged significance of BCM/BCP, empirical research on continuous governance in rail-based public transportation is few, especially in the Indonesian context. Current research has predominantly concentrated on risk management, infrastructure reliability, safety performance, or crisis management strategies, with limited exploration of the prioritization of continuity elements within a cohesive decision-making framework. Furthermore, prior studies infrequently integrate organizational resilience viewpoints with systematic prioritization methods to facilitate continuity planning. This study bridges the gap by incorporating Business Continuity Management principles, organizational resilience theory, and the Analytical Hierarchy Process (AHP) to identify and prioritize essential issues affecting business continuity in the LRT Jabodebek Division. The results are anticipated to enhance both the theoretical framework of operational resilience literature and the practical aspects of continuity governance in essential transportation infrastructure.

METHODS

This study utilized a mixed-methods approach, combining qualitative and quantitative analyses to assess and prioritize aspects affecting Business Continuity Management and Business Continuity Planning (BCM/BCP) in the LRT Jabodebek Division of PT Kereta Api Indonesia (Persero). The study was performed from January to March 2026.

Primary data were obtained via in-depth interviews, Focus Group Discussions (FGDs), and pairwise comparison questionnaires. Secondary data were sourced from internal organizational documents, encompassing risk registers, crisis management protocols, operational procedures, and BCM/BCP-related materials, in addition to pertinent literature and international standards such as ISO 22301 and ISO 31000.

Participants and informants were chosen through purposive sampling due to their direct engagement in operational continuity, risk management, emergency response, and the implementation of BCM/BCP. The research included members from three essential organizational functions: Safety, Health and Environment (SHE), Finance and Risk Management (FRM), and the Operations Control Center (OCC). The respondents' profile is displayed in Table 1.

Table 1. Profile of Expert Respondents

Code	Organizational Unit	Role in BCM/BCP
P1	Safety, Health and Environment (SHE)	Safety administration and crisis readiness
P2	Finance and Risk Management (FRM)	Risk evaluation and continuity management
P3	Operation Control Center (OCC)	Operational response and incident management

Source: Research data

Qualitative data were examined by thematic analysis, which included data reduction, coding, categorization, and theme creation. The discovered themes were utilized to assess current BCM/BCP components and develop the criterion and subcriteria incorporated in the AHP hierarchy.

The quantitative study utilized the Analytical Hierarchy Process (AHP) established by Saaty (1990). The AHP was chosen for its capacity to facilitate systematic ranking across several criteria, integrating expert opinion and consistency assessment via pairwise comparisons. The hierarchical framework comprised four tiers: (1) objective, specifically the priority of BCM/BCP elements; (2) criteria; (3) subcriteria; and (4) strategic options. Table 2 illustrates the structure of the AHP model.

Table 2. Hierarchical Structure of the AHP Model

Level	Description
Goal	Prioritization of BCM/BCP factors
Criteria	Human Resources, Systems and Technology, Infrastructure, Operations, and External Factors
Subcriteria	Nine subcriteria identified through document analysis, interviews, and FGDs
Alternatives	Integrated BIA, Recovery Time Objective (RTO), Quantitative Sustainability Indicators, Integration of Operational KPIs, and Threshold-Based External Risk Modelling

Source: Research data

Pairwise comparison matrices were constructed with Saaty's nine-point scale. Priority weights for criterion, subcriteria, and alternatives were determined based on expert evaluations. The Consistency Ratio (CR) was utilized to assess consistency, with a threshold of $CR \leq 0.10$ signifying adequate consistency.

RESULTS AND DISCUSSION

Systematic Analysis and Consistency of Factors in BCM/BCP Documents

In this study, systematization is understood as a logical structure that links risk identification, the determination of critical functions, impact analysis, and recovery strategies—in line with the fundamental principles of Business Continuity Management

(BCM), which emphasize a risk-based approach and Business Impact Analysis (BIA) (ISO 22301:2019). BCM/BCP documents are considered systematic if they meet four criteria: (1) risk factors and critical functions are explicitly identified; (2) there is a logical relationship between risks, operational impacts, and recovery strategies; (3) each factor is accompanied by measurable indicators; and (4) there are documented mechanisms for evaluation and periodic updates.

An analysis of operational documents, safety management systems, crisis management documents, and risk registers indicates that factors affecting the operational sustainability of the LRT Jabodebek have been identified and addressed in various documents in accordance with the functions of each unit. However, these measures remain sector-specific and have not yet been integrated into a single comprehensive framework. Risks are managed at the functional level, but have not yet been fully organized within an integrated continuity framework. The results of the BCM/BCP factor mapping are presented in Table 1.

Table 3. Mapping of Existing BCM/BCP Factors in the Greater LRT Jabodebek Division

No	Category	Sub-Factor	Governing Document	Form of Regulation	Measurable Indicator	BCM Maturity Level	Evaluative Notes
1	Human Resources	Crisis Team Structure	CMP	Role & Command Chain Assignment	No readiness indicator	Partial	Roles defined but no competency standard or readiness measure
		Emergency Simulation	SOP / SHE	Periodic Activity	Frequency not standardized	Partial	Simulation evaluation not based on measurable parameters
2	System & Technology	Signaling Disruption	Operations SOP	Technical Response Procedure	No RTO	Low	Recovery time not quantitatively defined
		Power Supply Disruption	Technical SOP	Technical Response	No recovery time target	Low	Not linked to critical function priorities
3	Infrastructure	Derailment & Fire	Emergency SOP	Evacuation & Handling	Descriptive	Partial	No business impact estimation
4	Operational	On-Time Performance	KPI	Performance Percentage	Measurable	Partial	Operational indicators not integrated in BCP scenarios
		Headway	Monitoring System	Real-time control	System measurable	Partial	No headway-based recovery scenario
5	External	Extreme Weather	SOP	Situational Response	No risk threshold	Low	Not based on risk modeling
		Financial Risk	RKA & Risk Register	Risk Identification	Qualitative	Partial	Not linked to long-term continuity strategy

Source: Research data

According to Table 3, some factors already have measurable indicators, the findings reveal that the current continuity-related documentation predominantly focus on operational response and regulatory compliance, rather than on continuity governance. From an organizational resilience standpoint, the lack of a cohesive Business Impact Analysis (BIA),

explicitly stated Recovery Time Objectives (RTOs), and quantifiable continuity indicators indicates that continuity management is disjointed across organizational activities. This state may impair the organization's capacity to foresee, assimilate, and recuperate from disturbances in a coordinated fashion, especially within highly interdependent transportation systems.

Determination of BCM/BCP Priority Factors Using the AHP Method

This analysis aims to prioritize operational sustainability factors in the development of BCM/BCP documents for the LRT Jabodebek Division using the Analytical Hierarchy Process (AHP). The hierarchical structure is organized starting with the primary objective (goal), followed by five main criteria, nine subcriteria, and concluding with five strategic alternatives. The five analysed criteria include: Human Resources (C1), Systems and Technology (C2), Infrastructure (C3), Operations (C4), and External Factors (C5).

Table 4. Weights and Priorities of the Main Criteria in AHP

Criteria	Weight	Priority
Human Resources	0,41	1
Systems & Technology	0,25	2
Infrastructure	0,15	3
External Factors	0,11	4
Operations	0,07	5

CR = 0,077 (Konsisten) | Source: Research data

According to Table 4, the Human Resources criterion (C1) has the highest priority with a weight of 0.41 (41%), indicating that human resource readiness is the most dominant factor in maintaining operational sustainability, particularly regarding personnel readiness, crisis team structure, and emergency response capabilities. The System and Technology criteria (C2) ranked second with a weight of 0.25 (25%), reflecting the importance of signaling system reliability and power supply continuity. Infrastructure (C3) has a weight of 0.15 (15%), External Factors (C5) of 0.11 (11%), and Operations (C4) of 0.07 (7%). The Consistency Ratio (CR) value of 0.077 is below the tolerance threshold of 0.10, so the evaluation is deemed consistent.

The dominance of Human Resources as the highest-priority criterion demonstrates that operational continuity within highly automated railway systems is not determined solely by technological sophistication. Although the LRT Jabodebek utilizes Communication-Based Train Control (CBTC) and GoA3 automation technologies, continuity during disruptive events ultimately depends on the capability of personnel to coordinate responses, make timely decisions, and implement recovery procedures. This finding supports the socio-technical systems perspective, which emphasizes that organizational performance emerges from the interaction between human actors and technological systems rather than from technology alone.

This result is also consistent with previous studies highlighting the importance of human-resource preparedness and crisis coordination in maintaining operational resilience. In complex transportation systems, technological failures frequently require rapid human intervention, making organizational readiness a critical component of continuity governance.

Table 5. Weights of Subcriteria and Priorities of Alternatives for the Human Resources Criteria

Subcriteria	Weight	Priority
C11 – Crisis Team Structure	0,36	87%
C12 – Emergency Drill	0,05	13%

Priority C11 – Crisis Team Structure	Weight	%	Priority C12 – Crisis Team Structure	Weight	%
A1 – Development of an Integrated Business Impact Analysis (BIA)	0,10	28%	A1 – Development of an Integrated Business Impact Analysis (BIA)	0,01	28%
A2 – Establishment of Recovery Time Objectives (RTOs)	0,07	20%	A2 – Establishment of Recovery Time Objectives (RTOs)	0,01	20%
A3 – Development of Quantitative Sustainability Indicators	0,09	24%	A3 – Development of Quantitative Sustainability Indicators	0,01	24%
A4 – Integrasi KPI Operasional dalam BCPA4 – Integration of Operational KPIs into the Business Continuity Plan (BCP)	0,03	7%	A4 – Integrasi KPI Operasional dalam BCPA4 – Integration of Operational KPIs into the Business Continuity Plan (BCP)	0,00	7%
A5 – Enhancement of Threshold-Based External Risk Modeling	0,07	21%	A5 – Enhancement of Threshold-Based External Risk Modeling	0,01	21%

Source: Research data

According to Table 5, the subcriterion “Crisis Team Structure” (C11) dominates with a weight of 87%, indicating that the clarity of the organizational structure and chain of command in a crisis situation is considered far more important than the frequency of emergency drills. In both subcriteria, the “Integrated BIA Development” (A1) alternative was the top priority with a percentage of 28%, followed by “Quantitative Indicator Development” (A3) at 24% and “Strengthening Threshold-Based External Risk Modeling” (A5) at 21%. This consistency indicates that strategies grounded in business impact analysis are considered the most effective in enhancing human resource preparedness.

The significance of the Crisis Team Structure subcriterion demonstrates that continuity management is heavily impacted by governance and coordination mechanisms during disruptive occurrences. This discovery corresponds with High Reliability Organization (HRO) theory, which asserts that entities functioning in high-risk settings rely on well-defined duties, efficient communication, and swift decision-making to sustain dependable performance. In railway transportation systems, the capacity of crisis teams to synchronize operational responses can markedly diminish the progression of service disruptions.

Table 6. Weights of Subcriteria and Priorities of Alternatives for the System and Technology Criteria

Subcriteria	Weight	Priority
C21 – Signaling Issues	0,10	**39%**
C22 – Power Supply Issues	0,15	**61%**

Priority C21 – Signaling Issues	Weight	%	Priority C22 – Power Supply Issues	Weight	%
A1 – Development of an Integrated Business Impact Analysis (BIA)	0,04	43%	A1 – Development of an Integrated Business Impact Analysis (BIA)	0,07	43%
A2 – Establishment of Recovery Time Objectives (RTOs)	0,01	14%	A2 – Establishment of Recovery Time Objectives (RTOs)	0,02	14%
A3 – Development of Quantitative Sustainability Indicators	0,02	16%	A3 – Development of Quantitative Sustainability Indicators	0,02	16%
A4 – Integrasi KPI Operasional dalam BCPA4 – Integration of Operational KPIs into the Business Continuity Plan (BCP)	0,01	7%	A4 – Integrasi KPI Operasional dalam BCPA4 – Integration of Operational KPIs into the Business Continuity Plan (BCP)	0,01	7%
A5 – Enhancement of Threshold-Based External Risk Modeling	0,02	20%	A5 – Enhancement of Threshold-Based External Risk Modeling	0,03	20%

Source: Research data

According to Table 6, Power Supply Disruptions (C22) have a higher weight (61%) compared to Signaling Disruptions (C21), which account for 39%. The direct dependence of train operations on the power supply makes electrical disruptions capable of causing broader systemic impacts. In both subcriteria, the Integrated BIA (A1) again emerged as the top priority (43%), confirming that an impact analysis-based approach is more efficient in managing technical risks.

The emphasis on power supply interruptions over signaling malfunctions underscores the significant reliance of railway operations on continuous energy supply. Signaling systems are essential for train control; nevertheless, power supply failures can concurrently impact many interrelated subsystems, leading to extensive operational repercussions. This discovery underscores the significance of infrastructure redundancy and recovery strategies in technology-driven transportation settings.

Table 7. Subcriteria Weights and Alternative Priorities for the Infrastructure Criteria

Subcriteria	Weight	Priority
C31 – Derailments & Fires	0,15	100%

Priority C31 – Derailments & Fires	Weight	Percent
A1 – Development of an Integrated Business Impact Analysis (BIA)	0,15	51%
A2 – Establishment of Recovery Time Objectives (RTOs)	0,01	6%
A3 – Development of Quantitative Sustainability Indicators	0,03	18%
A4 – Integrasi KPI Operasional dalam BCPA4 – Integration of Operational KPIs into the Business Continuity Plan (BCP)	0,02	11%
A5 – Enhancement of Threshold-Based External Risk Modeling	0,02	14%

Source: Research data

According to Table 7, Integrated Business Impact Analysis (A1) is the top priority in the Infrastructure subcriterion with a weight of 51%, indicating that a comprehensive understanding of the business impact of infrastructure incidents is the most strategic step.

Alternative Development of Quantitative Indicators (A3) ranks second at 18%, followed by Strengthening External Risk Modeling (A5) at 14%.

The prevalence of Integrated Business Impact Analysis (BIA) in the infrastructure category indicates that comprehending the operational and financial ramifications of infrastructure failures is crucial for continuity planning. Infrastructure events frequently generate cascading impacts throughout transportation networks, rendering impact-based prioritization essential for efficient resource allocation and recovery decision-making.

Table 8. Subcriteria Weights and Alternative Priorities in the Operational Criteria

Subcriteria	Weight	Priority
C41 – On-Time Performance	0,03	46%
C42 – Headway	0,04	54%

Priority C41 – On-Time Performance	Weight	%	Priority C42 – Headway	Weight	%
A1 – Development of an Integrated Business Impact Analysis (BIA)	0,01	41%	A1 – Development of an Integrated Business Impact Analysis (BIA)	0,01	41%
A2 – Establishment of Recovery Time Objectives (RTOs)	0,00	12%	A2 – Establishment of Recovery Time Objectives (RTOs)	0,00	12%
A3 – Development of Quantitative Sustainability Indicators	0,01	21%	A3 – Development of Quantitative Sustainability Indicators	0,01	21%
A4 – Integrasi KPI Operasional dalam BCPA4 – Integration of Operational KPIs into the Business Continuity Plan (BCP)	0,00	6%	A4 – Integrasi KPI Operasional dalam BCPA4 – Integration of Operational KPIs into the Business Continuity Plan (BCP)	0,00	6%
A5 – Enhancement of Threshold-Based External Risk Modeling	0,01	19%	A5 – Enhancement of Threshold-Based External Risk Modeling	0,01	19%

Source: Research data

According to Table 8, the Headway subcriterion (C42) has a slightly higher weight (54%) than On-Time Performance (C41), which is 46%, indicating that service interval stability is considered more important, as inconsistent headways can lead to passenger congestion and systemic disruptions. Integrated BIA (A1) remains the primary priority (41%) across both subcriteria.

The elevated priority given to headway stability over on-time performance suggests that respondents saw service regularity as a more critical factor in operational continuity. Adhering to regular service intervals mitigates passenger congestion and averts the propagation of systemic problems throughout the network. This discovery underscores the need of operational resilience methods that prioritize both timeliness and network stability.

Table 9. Subcriteria Weights and Alternative Priorities for External Factor Criteria

Subcriteria	Weight	Priority
C51 – Extreme Weather	0,04	36%
C52 – Financial Risk	0,07	64%

Priority C51 – Extreme Weather	Weight	%	Priority C52 – Financial Risk	Weight	%
A1 – Development of an Integrated Business Impact Analysis (BIA)	0,02	42%	A1 – Development of an Integrated Business Impact Analysis (BIA)	0,02	42%
A2 – Establishment of Recovery Time Objectives (RTOs)	0,01	13%	A2 – Establishment of Recovery Time Objectives (RTOs)	0,01	13%
A3 – Development of Quantitative Sustainability Indicators	0,01	18%	A3 – Development of Quantitative Sustainability Indicators	0,01	18%
A4 – Integrasi KPI Operasional dalam BCPA4 – Integration of Operational KPIs into the Business Continuity Plan (BCP)	0,00	6%	A4 – Integrasi KPI Operasional dalam BCPA4 – Integration of Operational KPIs into the Business Continuity Plan (BCP)	0,00	6%
A5 – Enhancement of Threshold-Based External Risk Modeling	0,01	20%	A5 – Enhancement of Threshold-Based External Risk Modeling	0,01	20%

Source: Research data

According to Table 9, Financial Risk (C52) has a higher weight (64%) compared to Extreme Weather (C51), which stands at 36%, indicating that financial pressures—such as limited recovery funding and fluctuations in operational costs—are considered a greater threat to sustainability. Integrated BIA (A1) has once again emerged as the top priority (42%) across both subcriteria, underscoring the consistency of the strategy grounded in business impact analysis across all criteria.

The increased emphasis on financial risk indicates that continuity management encompasses more than just operational and technological factors. The financial capacity of an organization dictates its capability to execute recovery strategies, sustain essential resources, and facilitate continuity efforts during disruptive occurrences. Thus, financial resilience must be regarded as a fundamental element of business continuity governance.

Overall, the AHP analysis shows that the Integrated BIA Development (A1) alternative consistently ranks as the top priority across all criteria and subcriteria, followed by the Development of Quantitative Sustainability Indicators (A3) and the Strengthening of Threshold-Based External Risk Modeling (A5). This consistency confirms that an approach based on business impact analysis and the strengthening of the risk framework is considered most relevant for improving the operational readiness of the LRT Jabodebek.

Implications of the Research Findings

This study adopted a mixed-methods approach by integrating qualitative and quantitative analyses. The qualitative analysis indicates that the LRT Jabodebek Division already possesses documents related to crisis management and operational continuity; however, some elements of the BCM/BCP have not yet been fully systematized and are not supported by clear and measurable indicators. The interrelation of operational, technological, and external factors has not yet been fully integrated into a comprehensive analytical framework.

The findings from the qualitative analysis are supported by the results of the AHP quantitative analysis, which indicate that human resources are the highest-priority criterion, followed by systems and technology, infrastructure, external factors, and operational factors. The integration of these two approaches is presented in Table 8.

Table 10. Imtegration of Qualitative Findings and AHP Result for BCM/BCP Development

Findings of the Qualitative Analysis	Results of the AHP Analysis	Implications for the Development of BCM/BCP
The identification of factors in the BCM/BCP document is not yet fully systematic.	Human Resources is the criterion with the highest weight (41%).	The organizational structure needs to be strengthened, and roles within the crisis team need to be clarified.
Indicators for evaluating operational continuity have not been clearly defined.	Systems and Technology is the second priority (25%).	Technical indicators need to be developed to measure the reliability of operational systems.
Coordination of incident response still depends on operational procedures.	Crisis Team Structure is the primary subcriterion, accounting for 87% of the Human Resources weight.	The chain of command and coordination mechanisms in emergency situations need to be clarified.
Technical and external risks have not been fully integrated into the document's analysis.	Power Supply Disruptions are the most critical subcriterion within Systems & Technology (61%).	Technical and external risk analysis needs to be integrated into the Business Continuity Management/Business Continuity Planning framework.

Source: Research data

The results of the analysis indicate that the development of BCM/BCP documents in the LRT Jabodebek Division must take into account high-priority factors based on the AHP analysis, as well as strengthen the systematic and measurable aspects of indicator setting. Therefore, BCM/BCP documents serve not only as administrative guidelines but also as an operational framework that supports decision-making in the face of disruptions or crisis situations.

The findings indicate that operational continuity in contemporary railway transportation systems is influenced by the interplay of organizational, technological, and environmental elements. Although technology reliability is significant, the preparedness of human resources and the governance processes for continuity seem to be more critical in influencing organizational resilience during disruptions. These findings enhance the operational resilience literature by illustrating that the success of continuity in highly automated transportation systems is substantially reliant on human-centered coordination and decision-making abilities.

The research further endorses the socio-technical systems perspective, positing that organizational effectiveness arises from the interplay among individuals, technology, and operational processes. While sophisticated technologies improve operational efficiency, resilience in crises still relies on human actors' capacity to organize reactions, understand information, and execute recovery operations successfully. Consequently, continuity planning must equilibrate technical investment with organizational readiness and crisis management proficiency.

Recommendations for Improving BCM/BCP

This study indicates five critical areas that require improvement in the creation of BCM/BCP documentation at the LRT Jabodebek Division based on the findings of the integrated analysis.

First, enhancing organizational structure and human resource capabilities. Organizations must enhance their crisis management team structure by delineating clearer roles and duties, establishing coordination mechanisms across work units, clarifying the chain of command, and instituting effective communication protocols. Personnel capacity is augmented via consistent training and simulations.

Secondly, enhancing the dependability of operational systems and technology. BCM/BCP papers must systematically integrate technical risk assessments, encompassing recovery processes that detail service restoration phases, coordination protocols across technical units, and prioritization for the restoration of the most critical systems.

Third, the creation of quantifiable operational sustainability metrics, such as operational recovery time, the frequency of disruption-related service delays, and the effectiveness of operational incident response.

Fourth, incorporating Business Impact Analysis (BIA) into BCM/BCP creation to pinpoint operational recovery priorities more precisely, identify the most important business processes, and quantify operational and financial implications.

Fifth, assess the availability and allocation of staff across pertinent units to prevent workload disparities that may impact reaction times during emergencies. The recommendations are encapsulated in Table 11.

Table 11. Issues and Recommendations for Improvement in the Development of BCM/BCP

Opportunities for Enhancement	Identified Issues	Suggestions for Enhancement
Human Resources Framework and Crisis Response Team	The roles and cooperation in incident response remain inadequately delineated.	Develop a more defined crisis team framework and improve training and simulation activities for incident management.
Operational systems and technologies	Technical hazards have not been properly incorporated into the BCM/BCP documentation.	Incorporate technological system risk assessment and operational recovery protocols into BCM/BCP documentation.
Indicators of operational sustainability	The indicators for evaluating service continuity have not been properly articulated.	Establish quantifiable metrics to assess operational continuity levels.
Business impact analysis	The methodology for assessing the consequences of occurrences lacks systematic rigor.	Incorporate Business Impact Analysis into the formulation of BCM/BCP papers.
Availability of operating staff	Certain work units have restricted staff.	Evaluate the staffing requirements and allocation within the units engaged in BCM/BCP management.

Source: Research data

Overall, the recommendations generated in this study are expected to assist the LRT Jabodebek Division in refining its BCM/BCP documents to make them more systematic, measurable, and adaptable to various operational and external risks.

CONCLUSION

This investigation revealed that the current BCM/BCP-related papers within the LRT Jabodebek Division have not been systematically incorporated into a cohesive business continuity structure. Despite the implementation of diverse risk management tools and operational protocols, numerous continuity components remain inadequately articulated, such

as Business Impact Analysis (BIA), Recovery Time Objectives (RTOs), quantitative continuity metrics, and external risk assessment frameworks.

The AHP findings reveal that Human Resources are the paramount factor in sustaining business continuity, succeeded by Systems and Technology, Infrastructure, External Factors, and Operations. The Crisis Team Structure, Power Supply Disruptions, Financial Risk, and Headway Stability have been identified as the most essential subcriteria. The formulation of an Integrated Business Impact Analysis (BIA) repeatedly emerged as the foremost strategic goal. The findings indicate that the sustainability of highly automated railway systems relies on technology reliability, organizational readiness, continuity governance, and efficient crisis management.

This study enhances the literature on organizational resilience and socio-technical systems by emphasizing the significance of human-centered continuity management in railway operations. The study was confined to a singular organizational context and lacked sensitivity analysis. Subsequent study may encompass a wider array of stakeholders and integrate sensitivity analysis to enhance the validation of prioritized outcomes.

REFERENCES

Arsip Dokumen PT KAI (Persero). (2022). *Company Profile PT KAI 2022*. 1–23. https://www.kai.id/static/company-profile/company_profile_2022.pdf.

Bergantino, A. S., Gardelli, A., & Rotaris, L. (2024). Assessing transport network resilience: empirical insights from real-world data studies. *Transport Reviews*, *44*(4), 834–857. https://doi.org/10.1080/01441647.2024.2322434.

Bešinović, N. (2020). *Resilience in railway transport systems : a literature review and research agenda*. *1647*. https://doi.org/10.1080/01441647.2020.1728419.

Cong, C., Li, X., Yang, S., Zhang, Q., Lu, L., & Shi, Y. (2022). Impact Estimation of Unplanned Urban Rail Disruptions on Public Transport Passengers: A Multi-Agent Based Simulation Approach. *International Journal of Environmental Research and Public Health*, *19*(15). https://doi.org/10.3390/ijerph19159052.

Daniotti, S., Servedio, V. D. P., Kager, J., Robben-Baldauf, A., & Thurner, S. (2024). Systemic risk approach to mitigate delay cascading in railway networks. *Npj Sustainable Mobility and Transport*, *1*(1). https://doi.org/10.1038/s44333-024-00012-6.

Dekker, M. M., & Panja, D. (2021). *Cascading dominates large-scale disruptions in transport over complex networks*. 1–17. https://doi.org/10.1371/journal.pone.0246077.

Duchek, S. (2020). Organizational resilience : a capability-based conceptualization. *Business Research*, *13*(1), 215–246. https://doi.org/10.1007/s40685-019-0085-7.

Federal Emergency Management Agency. (2019). *Business Process Analysis and Business Impact Analysis User Guide - July 2019*. *July*.

Gujar, P. V. (2024). *Business Continuity Management : Resilient Step for Organisations-A Review Business Continuity Management : Resilient Step for Organisations- A Review*. *February 2012*, 61–74.

Halim, Y. R., & Wijaya, H. (2020). *Jurnal Politeknik Caltex Riau Pengaruh Modal Intelektual Terhadap Kinerja Perusahaan Dengan Manajemen Risiko Perusahaan Sebagai Moderasi*. *13*(2), 78–87.

Hassel, H., & Cedergren, A. (2024). *A framework for business continuity management in a multiactor context*. *January*, 1–13. https://doi.org/10.1111/1468-5973.12573.

Herbane, Brahim. 2010. "The Evolution of Business Continuity Management: A Historical Review of Practices and Drivers." *Business History* 52(6): 978–1002. https://doi.org/10.1080/00076791.2010.511185.

Kriswardhana, W., Toaza, B., Eszterg´ar-Kiss, D., & Duleba, S. (2025). *Analytic hierarchy process in transportation decision-making : A two-staged review on the themes and*

trends of two decades. *261*(September 2024). https://doi.org/10.1016/j.eswa.2024.125491.

Kusuma, A., Karina, K., Anggraheni, E., & Pratama, M. A. (2025). Criticality disaster risk assessment for urban rail transport in Indonesia. *Journal of Infrastructure, Policy and Development*, *9*(1), 11040. https://doi.org/10.24294/jipd11040.

Michalak, M., Bagi´nski, J., Białas, A., Kozłowski, A., & Sikora, M. (2024). *A Generic Component for Analytic Hierarchy Process-Based Decision Support and Its Application for Postindustrial Area Management*.

Nakamura, T. (2018). Operational Resilience and Economic Losses in Urban Rail Disruptions: A Case Study of Tokyo Light Rail. *Journal of Urban Transportation Systems, 12(1),* 47–60.

Sahebjamnia, N, S A Torabi, and S A Mansouri. 2014. "Integrated Business Continuity and Disaster Recovery Planning: Towards Organizational Resiliency." *European Journal of Operational Research*. https://doi.org/10.1016/j.ejor.2014.09.055.

Steen, R., Haug, O. J., & Patriarca, R. (2024). *Business continuity and resilience management : A conceptual framework*. *May 2023*. https://doi.org/10.1111/1468-5973.12501.

Wei, Y., Yang, X., Xiao, X., Ma, Z., Zhu, T., Dou, F., Wu, J., Chen, A., & Gao, Z. (2024). Understanding the Resilience of Urban Rail Transit: Concepts, Reviews, and Trends. *Engineering*, *41*, 7–18. https://doi.org/10.1016/j.eng.2024.01.022.

Wibowo, B. S. A., & Hermawan, A. A. (2023). Faktor dan Rencana Aksi Implementasi BCMS Pada Sektor Publik: Studi Kasus Pada Sekretariat Utama BPKP. *Jurnal Akademi Akuntansi*, *6*(3), 323–344. https://doi.org/10.22219/jaa.v6i3.27089.