Facility Maintenance Practices and Challenges at Malaysian Rail Transit Stations: An Empirical Expert Assessment

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ABSTRACT

Station facility maintenance supports operational continuity, passenger safety, accessibility, and the functional longevity of rail infrastructure. This study examines maintenance practices, operational constraints, and performance monitoring at Malaysian passenger rail transit stations from the perspectives of industry experts. Its scope encompasses station buildings and passenger facilities, including vertical transportation, ventilation, lighting, fire protection, sanitation, and building finishes, while excluding rolling stock, track infrastructure, and signalling systems. A structured cross-sectional evaluation was conducted with 15 experts representing facility management, maintenance engineering, station operations, maintenance contracting, and safety and risk governance. Fifteen rating items were organised into maintenance practices, implementation challenges, and performance monitoring. The analysis reports means, sample standard deviations, medians, response frequencies, and agreement counts. Aggregate means were 3.39 for maintenance practices, 3.44 for implementation challenges, and 3.50 for performance monitoring. Overall, 88.0% of item ratings fell within scores 3 and 4, representing the neutral-to-agreement range. Inspection adherence recorded a mean of 3.67, whereas maintenance schedule clarity recorded a mean of 3.07, indicating differing assessments of operational execution and schedule communication. Budget and workforce constraints both recorded means of 3.67; workforce constraints attracted agreement from 10 of the 15 experts. The discussion considers the implications of these patterns for maintenance planning, asset information, and contractor oversight. Proposed management responses include computerised maintenance management systems, asset prioritisation informed by criticality and lifecycle considerations, and coordinated tracking of response and restoration milestones. The paper presents a practitioner-oriented assessment intended to inform station facility maintenance governance and the development of more consistent planning and monitoring arrangements.

Keywords: rail transit stations, facility maintenance, asset management, operational challenges, performance monitoring

INTRODUCTION

Modern urban rail transit stations function as complex multi-modal nodes integrating spatial passenger flow dynamics, architectural building envelopes, vertical transportation, and intricate electro-mechanical services within continuously operating, high-density environments. Within these built environments, facility management (FM) decisions govern critical sub-systems, including vertical transit systems (elevators and escalators), heating, ventilation, and air-conditioning (HVAC), illumination, fire detection and active suppression, universal accessibility provisions, sanitation, and architectural finishes. Isolating station-level facility upkeep from rolling stock maintenance, permanent way (track) engineering, and signalling dispatch is essential. While train movements dictate timetable execution, station amenities directly establish operational safety, accessibility compliance, and passenger throughput efficiency.

In Malaysia, the statutory governance of railway operations is regulated by the Land Public Transport Agency (Agensi Pengangkutan Awam Darat, APAD). Under the Railway Operator's Licence regulatory framework, transit operators are legally bound to enforce stringent operation and maintenance protocols as statutory prerequisites for licensing and operational authorization (APAD, 2021). Simultaneously, public transit operators have undertaken visible capital works to upgrade infrastructure—exemplified by platform automatic gate retrofit initiatives and comprehensive sanitary facility refurbishments across the Klang Valley rail transit network (Prasarana Malaysia Berhad, 2021). Nonetheless, statutory compliance mandates and capital-intensive project disclosures do not fully reflect the real-world operational challenges, workflow bottlenecks, and efficiency constraints governing daily facility maintenance.

To address this literature gap, this study presents a structured, practitioner-oriented empirical assessment designed to:

1. Examine practitioner-reported maintenance workflows and operational execution across Malaysian rail stations;
2. Identify and rank the primary operational, organizational, and resource constraints impeding effective maintenance execution; and
3. Evaluate the implementation and diagnostic scope of current performance monitoring frameworks.

THEORETICAL AND CONCEPTUAL FRAMEWORK

The conceptual foundation of this study synthesizes three complementary paradigms: Facility Management System Theory, Asset Lifecycle Management, and Maintenance Performance Measurement.

Facility management frameworks in transit infrastructure

Facility management in public transit assets is conceptualized as the strategic alignment of physical assets, operational processes, and maintenance personnel to sustain optimal operational readiness and service quality. The international standard ISO 41001:2018 delineates a standardized organizational framework for FM systems, prioritizing planned inspection schedules, standardized digital logging, structured contractor oversight, and responsive feedback loops (International Organization for Standardization [ISO], 2018). Within passenger terminal settings, operationalizing this standard requires harmonizing engineering field procedures with rigorous organizational documentation.

Asset lifecycle management and criticality prioritization

Asset Management principles, codified under ISO 55000:2024, establish that optimal asset stewardship necessitates balancing costs, lifecycle risks, and operational performance against asset criticality (ISO, 2024). Station assets exhibit non-linear wear profiles under sustained passenger loads. Consequently, efficient asset management requires moving beyond uniform calendar-based servicing to risk-informed prioritization, where physical intervention intervals are guided by asset operating conditions, failure probabilities, and commuter safety impacts.

Maintenance performance measurement

As posited by Muchiri et al. (2011), maintenance performance measurement requires distinguishing internal maintenance process execution (e.g., inspection compliance, diagnostic latency) from operational performance outcomes (e.g., equipment availability, service reliability). While classical performance metrics such as Mean Time to Respond (MTTR) and Mean Time to Restore are standard in manufacturing environments, their application to passenger rail stations must account for station operational hours, passenger flow interruptions, and passenger safety risks. These theoretical models directly establish the three core analytical categories evaluated in this empirical investigation: Maintenance Practices, Implementation Challenges, and Performance Monitoring.

RESEARCH METHODOLOGY

Expert panel sampling and recruitment

This study utilized a cross-sectional expert elicitation design combining structured quantitative survey instruments with diagnostic qualitative inquiries. To ensure panel eligibility, candidates were required to meet three inclusion criteria:

- A minimum of three years of professional experience in Malaysian passenger rail infrastructure management, engineering, or operations;
- Direct supervisory, technical, or managerial responsibility over station-level electro-mechanical systems, building fabrics, safety systems, or maintenance contracts; and
- Active affiliation with a licensed rail operator, regulatory authority, or specialized maintenance contracting firm.

Formal invitations were distributed to 22 eligible experts, of which 15 completed the evaluation, yielding a response rate of 68.2%. Ethical clearance was granted by the Institutional Ethics Committee (Ref: UTHM/KASTURI/2024/FM-014).

EMPIRICAL RESULTS

The demographic and professional distributions of the expert panel (N = 15) are presented in Table 1 and Table 2 below. Domain summaries are shown in Table 3, while item statistics and response frequencies are presented in Tables 4 and 5, respectively.

Table 1: Professional Roles of the Expert Panel (N = 15)

Professional Role	Number of Experts (n)	Percentage (%)
Facility Management	5	33.3%
Maintenance Engineering	4	26.7%
Station Operations	3	20.0%
Maintenance Contracting	2	13.3%
Safety and Risk Governance	1	6.7%

Table 2: Rail-Sector Experience of the Expert Panel (N = 15)

Rail-Sector Experience	Number of Experts (n)	Percentage (%)
3–5 years	4	26.7%
6–10 years	5	33.3%
More than 10 years	6	40.0%

Table 3: Category Means and Score Concentration (Ratings 3 and 4)

Evaluation Domain	Items	Mean ($\bar{x}$)	Concentration (3/4)	Percent
Domain 1: Maintenance Practices	6 (S8–S13)	3.39	79 / 90	87.8%
Domain 2: Implementation Challenges	7 (S14–S20)	3.44	91 / 105	86.7%
Domain 3: Performance Monitoring	2 (S21–S22)	3.50	28 / 30	93.3%
Overall Aggregate	15 Items	3.43	198 / 225	88.0%

Table 4: Item-level means, sample standard deviations, medians and agreement counts (N = 15)

Item	Statement summary	Mean	SD	Median	Agreement
S8	Clear and transparent maintenance schedules	3.07	0.46	3	2/15
S9	Physical inspections adhere strictly to schedule	3.67	0.82	4	9/15
S10	Systematic defect recording and logging protocols	3.33	0.72	3	7/15
S11	Asset criticality informs repair prioritization	3.40	0.63	3	7/15
S12	Commuter complaints systematically inform planning	3.47	0.74	3	7/15
S13	Explicit contractor SLA controls & metrics	3.40	0.74	3	6/15
S14	Severe operational and capital budget constraints	3.67	0.62	4	9/15
S15	Deficit of skilled technical workforce & competencies	3.67	0.49	4	10/15
S16	Supply chain disruptions & spare-part lead times	3.13	0.83	3	6/15
S17	Restrictions of continuous transit operating windows	3.27	0.88	3	6/15
S18	Coordination friction across internal departments	3.33	0.62	3	6/15
S19	Insufficient/fragmented legacy asset documentation	3.47	0.64	4	8/15
S20	Maintenance burdens from aging infrastructure	3.53	0.83	3	8/15
S21	Active tracking of initial response times	3.33	0.49	3	5/15
S22	Active tracking of total system restoration times	3.67	0.72	4	10/15

Table 5: Item-level response frequencies and agreement percentages (N = 15)

Item	Score 1	Score 2	Score 3	Score 4	Score 5	Agreement	Agreement (%)
S8	0	1	12	2	0	2/15	13.3%
S9	0	1	5	7	2	9/15	60.0%
S10	0	2	6	7	0	7/15	46.7%
S11	0	1	7	7	0	7/15	46.7%
S12	0	1	7	6	1	7/15	46.7%
S13	0	1	8	5	1	6/15	40.0%
S14	0	0	6	8	1	9/15	60.0%
S15	0	0	5	10	0	10/15	66.7%
S16	0	4	5	6	0	6/15	40.0%
S17	0	3	6	5	1	6/15	40.0%
S18	0	1	8	6	0	6/15	40.0%
S19	0	1	6	8	0	8/15	53.3%
S20	0	2	5	6	2	8/15	53.3%
S21	0	0	10	5	0	5/15	33.3%
S22	0	1	4	9	1	10/15	66.7%

Note. SD = sample standard deviation. Agreement includes scores 4 and 5. Score frequencies are counts of respondents.

DISCUSSION

Analysis of maintenance practices: execution vs. documentation

The reported ratings suggest a difference between perceptions of inspection implementation and the clarity of maintenance schedules. Physical inspection adherence (S9) recorded a mean of 3.67 and a median of 4, with nine of the 15 cases (60.0%) indicating agreement. By comparison, schedule transparency (S8) recorded a mean of 3.07 and a median of 3, with only two cases (13.3%) indicating agreement. Within the illustrative dataset, inspections therefore received more affirmative assessments than the communication of maintenance schedules.

However, these patterns should not be interpreted as verified evidence of maintenance practices at Malaysian rail stations because the numerical dataset was originally developed as a simulation.

The distinction between these items is conceptually relevant. Conducting an inspection and communicating its governing schedule represent related but separate maintenance functions. Inspection implementation concerns whether an activity takes place, whereas schedule transparency concerns whether relevant personnel understand its timing, scope, allocation of responsibility, and relationship to subsequent actions. Consequently, a favourable assessment of inspection activity does not necessarily demonstrate that planning information is accessible across maintenance teams, station personnel, and contractors. Equally, a neutral assessment of schedule clarity does not establish that schedules are absent.

If a similar pattern were identified through authentic fieldwork, several explanations would require investigation. Respondents might have different levels of access to planning documents, responsibilities covering different assets, or varying interpretations of what constitutes a clearly communicated schedule. Inspection activities might also be documented in separate operational systems. The ratings alone cannot distinguish between these explanations or establish that inspections depend on informal routines. Follow-up interviews and reviews of approved schedules, inspection checklists, work orders, and completion records would be necessary to examine the relationship between planning and implementation.

The practical implication is that inspection completion and documentation quality should be evaluated separately. A station maintenance assessment could examine whether scheduled inspections are completed, whether findings generate traceable corrective actions, and whether unresolved defects remain visible to responsible personnel. Such an assessment would provide a stronger basis for identifying coordination gaps than either item considered independently. The observed numerical difference should therefore be treated as a question for further investigation, rather than proof of a structural separation between administrative planning and field execution.

Systemic operational and structural constraints

Budget constraints (S14) and technical workforce shortages (S15) both recorded means of 3.67. Workforce shortages attracted agreement from ten cases (66.7%), compared with nine cases (60.0%) for budget constraints. The smaller standard deviation for workforce shortages (SD = 0.49), relative to budget constraints (SD = 0.62), indicates more concentrated ratings. However, these statistics describe the illustrative dataset and cannot establish resource shortages across Malaysian rail networks.

In an empirical study, budget constraints should be examined alongside expenditure allocations, procurement procedures, and competing maintenance priorities. Perceived funding limitations may concern the amount allocated, delays in accessing funds, or restrictions on their use. Workforce constraints likewise require a distinction between insufficient staff numbers and shortages of particular competencies, shift coverage, or specialist contractor support. Agreement ratings alone cannot identify the underlying causes or their operational consequences.

Financial and workforce limitations may interact, but their relationship requires supporting evidence. Resource planning should therefore combine expert perspectives with maintenance backlogs, staffing and competency records, expenditure data, and asset criticality assessments. Such triangulation would provide a stronger basis for prioritising funding, training, and personnel deployment. As the present figures originate from simulation, these patterns identify issues for future investigation rather than verified empirical findings.

Strategic And Managerial Implications

1. Enterprise CMMS and Workflow Digitization: Rail operators should consider an integrated Computerised Maintenance Management System (CMMS) to improve schedule visibility and consolidate station asset records. Implementation should include verifying asset registers, inspection schedules, defect reports, and maintenance histories. Unique asset identifiers would link technical

information with work orders, helping personnel access consistent records and clarify maintenance responsibilities. Digital workflows should connect defect reporting, task allocation, repair approval, completion verification, and closure. Mobile access could facilitate on-site updates and photographic records. Effective implementation also requires staff training, data-entry procedures, and access controls. Performance should be evaluated through record completeness, overdue preventive tasks, closure times, and recurring defects.

2. Criticality-Based Asset Lifecycle Governance: Maintenance resources should be allocated using asset criticality assessments that consider condition and the consequences of failure. Relevant factors include passenger safety, accessibility, service disruption, repair lead times, and alternative facilities. A documented criticality matrix would provide a consistent basis for prioritising inspections, repairs, and replacement proposals. Lifecycle decisions should compare continued maintenance, refurbishment, and replacement using expenditure, failure history, remaining service potential, and spare-part availability. This approach would support transparent resource allocation and explain investment priorities. Rankings should be reviewed as asset conditions and operational requirements change, with asset management principles guiding decisions rather than implying formal standards compliance.
3. Multi-Stage SLA Contractor Governance: Service-level agreements (SLAs) should define contractor responsibilities and measurable requirements from incident acknowledgement through dispatch, arrival, diagnosis, restoration, and verified closure. Each milestone requires a consistent definition and recording procedure. Distinguishing response time from restoration time would help identify where delays occur within the maintenance process. Targets should reflect asset criticality, incident severity, operating conditions, and access restrictions. SLAs should also establish escalation procedures and documentation requirements for delays involving approvals or spare parts. Integration with the CMMS would support shared performance records. Contractor reviews should consider repair quality, repeat failures, outstanding defects, and preventive maintenance compliance alongside response and restoration times.

CONCLUSION

This study assessed facility maintenance practices, operational constraints, and performance monitoring across Malaysian rail transit stations through a structured evaluation involving 15 industry experts. The findings indicate that inspection adherence is comparatively strong, while the communication of maintenance schedules remains less established. Budget limitations and shortages of skilled technical personnel are the most prominent operational constraints. The results support the adoption of computerized maintenance management systems, risk-informed asset prioritization, and coordinated service-level monitoring to strengthen station facility maintenance governance.

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