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Monitoring the Movement of Vehicles and Ground Support Equipment to Improve Standard Operating Procedure Compliance at the Airside of Sultan Aji Muhammad Sulaiman Sepinggan International Airport

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ABSTRACT

This study examines the effectiveness of Apron Movement Control (AMC) supervision in enforcing Standard Operating Procedure (SOP) compliance for vehicles and Ground Support Equipment (GSE) at Sultan Aji Muhammad Sulaiman Sepinggan International Airport. It also identifies factors associated with violations and develops operational recommendations. Using a mixed-methods approach, the research combined observation, structured interviews, documentation, and a four-point Likert questionnaire administered to 31 ground handling personnel. Quantitative analysis included validity and reliability testing, correlation, simple linear regression, the coefficient of determination, and significance tests. Field observations revealed unroadworthy equipment, expired safety equipment and access cards, malfunctioning lights and brakes, worn tires, missing company identification, and hydraulic leaks. Supervision had a moderate positive correlation with SOP compliance ($r = 0.432$; $R^2 = 0.187$), accounting for 18.7% of the variation in compliance. The regression test showed a statistically significant association ($p = 0.01498871$), while operational, maintenance, procurement, budgetary, disciplinary, and enforcement factors were also associated with compliance. AMC supervision should therefore be supported by regular inspections, preventive maintenance, training, digital monitoring, and consistent sanctions.

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INTRODUCTION

Airports are integral to national transportation systems, supporting the movement of people and goods while serving as operational environments in which safety, efficiency, and coordination are essential. Law No. 1 of 2009 concerning Aviation defines an airport as a designated land and/or water area used for aircraft takeoff and landing, passenger movement, cargo loading and unloading, and intra- and intermodal transport, together with the facilities required for aviation safety, security, and related services [1]. Located in Balikpapan, East Kalimantan, at 1°16′6″ south latitude and 116°53′40″ east longitude, Sultan Aji Muhammad Sulaiman Sepinggan International Airport is a regional aviation hub in eastern Indonesia. Its operations are supported by 14 ground handling companies, including PT Garuda, PT Lion Air, PT Gapura Angkasa, and PT Aerofood Catering Indonesia, which provide passenger, baggage, cargo, catering, and helicopter-support services.

As flight operations become more frequent and complex, airports rely increasingly on Ground Support Equipment (GSE), such as push tractors, baggage loaders, ground power units, air start units, and catering trucks. The condition and performance of this equipment directly affect the safety, punctuality, and efficiency of ground operations. Improper operation or unroadworthy equipment may lead to delays, ground accidents, or flight incidents. Airside access is therefore limited to authorized personnel, vehicles, and equipment operating under strict safety requirements. Within this environment, Apron Movement Control (AMC) coordinates and supervises the movement of aircraft, vehicles, personnel, and equipment [2]. The supervision of GSE operations refers to the Decree of the Director General of Civil Aviation No. SKEP 140/VI/1999 and Regulation No. KP 635/2015.

Preliminary observations nevertheless indicated that operational practice did not always conform to the regulatory framework. During random checks, AMC personnel found malfunctioning vehicle lights, damaged turn-signal covers, expired fire extinguishers, unauthorized or expired entry permits, and missing safety devices, including flame traps and rotary warning lights. Previous studies at Indonesian airports have addressed AMC performance, GSE supervision, and operational discipline [3]-[6]. The original manuscript, however, characterizes research on GSE supervision in Indonesia as limited and notes that AMC effectiveness has seldom been evaluated by combining qualitative and quantitative evidence.

Against this background, the study aims to: (1) evaluate the effectiveness of the AMC unit in enforcing SOP compliance for GSE use at Sultan Aji Muhammad Sulaiman Sepinggan International Airport; (2) identify factors associated with violations; and (3) formulate strategic recommendations to strengthen the safety culture and improve airside operational efficiency. The resulting site-specific assessment documents operational violations, examines the relationship between supervision and SOP compliance, and develops recommendations grounded in the reported findings.

METHODS

2.1 Research Design

A mixed-methods design was used to combine quantitative and qualitative evidence [7]. The quantitative component drew on a structured questionnaire, while direct observation, structured interviews, and document analysis supplied the qualitative evidence. KP 635/2015 and SKEP 140/VI/1999 served as regulatory references for evaluating vehicle and GSE operations. Together, these methods enabled the study to examine supervisory practices and operational violations alongside the statistical relationship between supervision and SOP compliance.

In this study, the independent variable (X) is the supervision of vehicle and GSE operations, while the dependent variable (Y) is SOP compliance at the airside area of Sultan Aji Muhammad Sulaiman Sepinggan International Airport. The relationship between these variables is crucial in assessing the extent to which supervision impacts operational discipline and adherence to procedures within the airport environment.

2.2 Research Location, Object, Period

The research was conducted in the airside area of Sultan Aji Muhammad Sulaiman Sepinggan International Airport, covering aircraft aprons, taxiways, and other operational zones. It focused on the operation and control of vehicles and GSE, compliance with SOPs, the effectiveness of supervision by the relevant authority, and recurring concerns affecting airside safety. Data were collected from October 2024 to July 2025. Access to day-to-day operations was also available during an On-the-Job Training period from 7 October 2024 to 20 February 2025. The random-check findings presented in the results cover the period from November 2024 to January 2025.

2.3 Research Variables and Instrument

Supervision of vehicle and GSE operations was treated as the independent variable (X), while airside SOP compliance was the dependent variable (Y). Respondents completed a structured questionnaire distributed through Google Forms. The instrument used a four-point Likert scale, from strongly disagree to strongly agree, to capture perceptions of supervision, SOP compliance, and areas requiring improvement. According to the validity tables, each variable comprised five items; however, the item statements, indicator sources, and method used to calculate the composite scores were not provided.

2.4 Population and Sample

The population comprised 45 ground handling personnel who operated vehicles and GSE in the airport airside area. Applying the Slovin formula with a 10% margin of error produced a sample of 31 respondents. The complete sample-size calculations reported in the original manuscript are reproduced in Table 1. The manuscript also identifies purposive sampling as the respondent-selection technique because participants had direct experience of GSE operations.

Table 1. Sample-size calculations using the Slovin formula

Margin of error (e)	Slovin calculation	Sample size (n)
1%	$45 / (1 + 45 \times 0.01^2)$	$44.8 \approx 45$
2%	$45 / (1 + 45 \times 0.02^2)$	$44.2 \approx 44$
3%	$45 / (1 + 45 \times 0.03^2)$	$43.2 \approx 43$
4%	$45 / (1 + 45 \times 0.04^2)$	$42.0 \approx 42$
5%	$45 / (1 + 45 \times 0.05^2)$	$40.4 \approx 40$
6%	$45 / (1 + 45 \times 0.06^2)$	$38.7 \approx 39$
7%	$45 / (1 + 45 \times 0.07^2)$	$36.9 \approx 37$
8%	$45 / (1 + 45 \times 0.08^2)$	$34.9 \approx 35$
9%	$45 / (1 + 45 \times 0.09^2)$	$33.0 \approx 33$
10%	$45 / (1 + 45 \times 0.10^2)$	$31.0 \approx 31$

2.5 Data Collection

Structured interviews with AMC personnel and ground handling service providers explored supervisory procedures, operational challenges, and personnel understanding of the applicable regulations. The manuscript does not report the number of interviewees or the criteria used to select them During the OJT period, direct observations covered vehicle and GSE operations, random checks, and roadworthiness assessments. Documentary evidence included inspection reports, random-check logs, and photographs of non-compliant practices. Questionnaires were also distributed to 31 ground handling personnel who worked actively in the airside area.

2.6 Observation Criteria and AMC Procedures

The documented AMC procedure defined the operational context and the controls expected during GSE and vehicle inspection, registration, and supervision. It comprised the following activities:

1. The General Manager (GM.BPN) forwards a request to inspect GSE and vehicles to Airport Operations (BPN.AO), which then assigns the inspection to Apron Operations (BPN.OA).
2. BPN.OA instructs the Airline Service Supervisor and AMC officers to inspect airside personnel, GSE, and operational vehicles; compile annual GSE and vehicle data with Airport Commercial; and monitor ground handling activities.
3. The Airline Service Supervisor and AMC verify the submitted documents. Complete applications proceed to the next stage, while applicants are contacted when documents are incomplete. AMC then issues a readiness confirmation. Approved applications proceed, whereas rejected applications must be resubmitted.
4. AMC coordinates inspection fees with the Commercial Unit, schedules the technical inspection, and performs the physical examination. Compliant units proceed to the next stage. When non-compliance is identified, AMC records the finding, requests corrective action, enters the result on the designated GSE and personnel supervision form, and informs the applicant.
5. As part of registration, AMC and Airport Commercial measure each GSE unit and vehicle, after which Airport Commercial prepares a measurement report. A verification sticker is placed on the upper-right side of an operational vehicle, as viewed by the driver, or on a clearly visible part of the GSE. The sticker remains valid for one year and must be renewed annually.
6. During operations, AMC verifies that vehicles and GSE display valid stickers and that their operators hold valid licenses. Non-GSE vehicles require AMC approval before entering the apron. GSE must be serviceable, certified, and operated by certified personnel; it must also be re-inspected following modification or repair. Equipment is positioned in accordance with technical guidance. When not in use, GSE must be parked in a designated area with the brake engaged. Engines may not be left unattended, and GSE may not pass behind a parked aircraft without AMC approval.
7. AMC and the Airline Service Supervisor monitor ground handling operations, document their observations, and report problems to BPN.OA for follow-up. Roadworthiness inspections cover braking systems, warning lights, and fluid leaks. Any unit that fails to meet safety requirements must be withdrawn from service and replaced with compliant equipment.

2.7 Data Analysis

Qualitative analysis involved data reduction and display, followed by pattern identification, thematic categorization, and interpretation against relevant theoretical references. Conclusions were drawn from this process. Quantitative data were processed in Microsoft Excel. Item validity was assessed using Pearson Product Moment analysis, while reliability was evaluated with Cronbach's alpha. The analysis also included descriptive statistics, correlation, simple linear regression, the coefficient of determination (R^2), t and F tests, Hartley's homogeneity test, and the Liliefors normality test. The manuscript does not report the significance level, the basis for selecting the critical values, or the detailed procedures used for the Hartley and Liliefors tests.

3. RESULT AND DISCUSSION

3.1 Implementation of AMC Supervision Airside Area of Sultan Aji Muhammad Sulaiman Sepinggan Airport

The AMC unit monitored the movement of aircraft, vehicles, personnel, and GSE, oversaw airside cleanliness, and documented apron operations. Field observations confirmed that AMC conducted runway inspections, vehicle and GSE roadworthiness tests, and random checks. Even with these controls in place, airside operators did not consistently achieve full compliance. The inspections uncovered serious violations, including suspected falsification of GSE operating licenses and the continued use of unroadworthy equipment. This pattern points to an enduring gap between the prescribed supervisory system and its day-to-day implementation.

In accordance with KP 635/2015, AMC routinely performed random inspections and roadworthiness assessments. Records from November 2024 to January 2025 showed that several vehicles and GSE units failed to meet the reported requirements. The deficiencies involved lighting, tires, fire extinguishers, vehicle identification, access documents, braking systems, warning devices, speed measurement, and hydraulic systems.

3.2 Observed Vehicle and GSE Violations

Specific findings included malfunctioning turn-signal lights on Baggage Towing Tractors (BTT), worn or bald tires, expired portable fire extinguishers (APAR), and vehicles without the required company logo measuring at least 30 × 30 cm. Several operator PAS cards, identified in the manuscript as Personnel Access System cards had also expired. On some vehicles, warning lights had been replaced with units that did not follow the applicable specifications, reducing the consistency of visual signals on the apron.

Other technical deficiencies included inoperative hand brakes on several BTT units, inactive rotary beacon lights on High Lift Loaders (HLL), faulty speedometers on Water Service Trucks (WST), and non-functioning BTT reverse lights. One High Lift Loader operated by PT Shinko developed a hydraulic oil leak in the Charlie Apron area. The unit was grounded immediately, and the affected apron surface was cleaned to eliminate the slip hazard. The manuscript classifies this incident as a direct violation of KP 635/2015.

3.3 Factors Associated with Non-compliance

The qualitative evidence linked persistent non-compliance to a combination of operational and organizational conditions. Some ground handling personnel showed limited discipline and awareness, while periodic maintenance was sometimes neglected. Slow procurement, inadequate spare-part inventories, budget constraints, and operational pressure also encouraged the continued use of non-compliant equipment. Weak enforcement and limited accountability further reduced the practical effect of existing procedures. As a result, roadworthiness and safety-device requirements were not consistently met despite the presence of a regulatory and procedural framework.

These conditions point to the need for structured supervision, more frequent random and unannounced inspections, consistent sanctions, digital monitoring and reporting, preventive maintenance, and quicker procurement of essential parts. Regular training, dissemination of operating procedures, and Ramp Safety Campaign activities may also strengthen personnel understanding and the airside safety culture [8]. These recommendations arise from the observed conditions; the present study did not test them through an intervention.

3.4 Instrument Validity and Reliability

Instrument validity was assessed using responses from 31 participants. As reported in Table 2, the calculated r-value for each item in variable X exceeded the critical value of 0.456. All five items were therefore classified as valid.

Table 2. Validity results for variable X: supervision of vehicle and GSE movement

Statistic	Item 1	Item 2	Item 3	Item 4	Item 5
Calculated r	0.6655544	0.6695421	0.609384767	0.51724875	0.7276758
Critical r	0.456	0.456	0.456	0.456	0.456
Decision	Valid	Valid	Valid	Valid	Valid

Table 3 likewise reports a critical r-value of 0.456 for variable Y, with all five calculated values exceeding this threshold. The accompanying narrative in the original manuscript, however, gives a threshold of 0.449. The validity decisions have not been recalculated in this revision.

Table 3. Validity results for variable Y: airside SOP compliance

Statistic	Item 1	Item 2	Item 3	Item 4	Item 5
Calculated r	0.82872637	0.53689978	0.66319632	0.501931	0.83776268

Statistic	Item 1	Item 2	Item 3	Item 4	Item 5
Critical r	0.456	0.456	0.456	0.456	0.456
Decision	Valid	Valid	Valid	Valid	Valid

Cronbach's alpha was 0.614 for variable X and 0.638 for variable Y. The original manuscript interpreted both coefficients as evidence of acceptable internal consistency, although it did not specify the reliability threshold used for this interpretation.

3.5 Correlation, Regression, and Statistical Tests

Quantitative analysis indicated a moderate positive association between supervision and SOP compliance. Table 4 presents the complete regression statistics, ANOVA output, coefficients, and confidence intervals reported in the original analysis.

Table 4. Correlation and simple linear regression results

(a) Regression statistics

Statistic	Value
Multiple R	0.43292614
R Square	0.18742504
Adjusted R Square	0.15940522
Standard Error	2.47953467
Observations	31

(b) ANOVA

Source	df	SS	MS	F	Significance F
Regression	1	41.12468188	41.1246819	6.68901518	0.014988706
Residual	29	178.294673	6.14809217		
Total	30	219.4193548			

(c) Regression coefficients

Term	Coefficient	SE	t	p	Lower 95%	Upper 95%	Lower 90%	Upper 90%
Intercept	4.37862441	2.304261649	1.90022883	0.06738664	-0.334119817	9.09136864	0.463391167	8.293857653
X	0.46358732	0.179246408	2.58631305	0.01498871	0.096987257	0.83018739	0.159024907	0.768149739

The narrative analysis reported r = 0.432 and R^2 = 0.187. Supervision therefore accounted for 18.7% of the variability in SOP compliance, while the remaining 81.3% was associated with factors outside the fitted model. The reported regression equation was:

$$Y = 4.37 + 0.46X \quad (1)$$

where X denotes supervision of vehicle and GSE operations and Y denotes airside SOP compliance. The coefficient indicates that each one-unit increase in X was associated with a 0.46-unit increase in the predicted value of Y. In the original hypothesis test, t = 2.586 exceeded the stated t-table value of 1.309. The coefficient output also gave p = 0.01498871. On this basis, the manuscript rejected the null hypothesis and reported a statistically significant positive association between supervision and SOP compliance. It did not state the alpha level, the degrees of freedom used to select the critical t-value, or whether the test was one- or two-tailed.

The Hartley homogeneity test produced a calculated F-value of 1.147, which was below the reported critical value of 1.82. The original manuscript consequently classified the two variables as homogeneous. For the Liliefors test, the critical L-value was 0.1446 for 31 respondents. The calculated values, 0.1443 for X and 0.1139 for Y, were both below this threshold, leading the manuscript to classify the data for both variables as normally distributed. The group structure used in the Hartley test and the rationale for testing X and Y rather than the reported regression residuals were not provided.

3.6 Integrated Discussion and Operational Implications

The statistical results and field observations offer complementary perspectives. Although supervision was positively associated with SOP compliance, it explained only 18.7% of the observed variability. This limited contribution is consistent with the persistence of non-compliant practices despite runway inspections, roadworthiness tests, and random checks. The regression model did not measure the sources of the remaining variation. Qualitative evidence nevertheless identified operational urgency, equipment condition, maintenance practices, procurement delays, spare-part limitations, budget constraints, personnel discipline, regulatory awareness, enforcement, and accountability as relevant contextual factors.

Expired fire extinguishers, malfunctioning lighting and braking systems, worn tires, inactive warning devices, and hydraulic leaks illustrate why procedural supervision alone cannot resolve maintenance and resource constraints. Slow procurement and limited spare-part availability may delay repairs or equipment replacement [9]. The results also align with previous research that identified persistent gaps between AMC supervision and operational discipline [6]. Taken together, this evidence supports the original interpretation that supervision is necessary but must be integrated with technical, logistical, financial, and human-resource measures.

Operationally, the results call for more frequent and thorough equipment evaluations, unannounced inspections, preventive maintenance schedules, faster procurement of critical GSE components, digital monitoring and reporting, and closer communication between AMC and ground handling providers. Training, effective dissemination of procedures, stronger accountability, greater regulatory awareness, and consistent sanctions are also needed to support behavioral compliance. These recommendations address the conditions observed in the study, but their effectiveness was not evaluated through an intervention or a before-and-after comparison.

4. CONCLUSION

This study evaluated AMC supervision of vehicles and GSE at Sultan Aji Muhammad Sulaiman Sepinggan International Airport, identified factors associated with SOP violations, and formulated recommendations for airside operations. Supervision had a statistically significant positive association with SOP compliance but accounted for only 18.7% of the observed variability. It therefore supported compliance without being sufficient, on its own, to ensure consistent adherence across airside operations. Field evidence revealed continuing problems related to equipment roadworthiness, safety devices, maintenance, operator documents, discipline, regulatory understanding, enforcement, procurement, spare parts, budget constraints, and operational urgency. Airport management and ground handling service providers should combine supervision with personnel coaching, continuous training, preventive maintenance, digital monitoring, improved procurement, stronger accountability, and consistent sanctions. Further research could assess whether integrating supervisory measures with human-resource coaching improves airside operational compliance. The central conclusion remains that AMC supervision is necessary and should be reinforced by broader operational and organizational measures.

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