
IDENTIFICATION OF APRON MARKING STANDARDIZATION ON POTENTIALLY POSING SAFETY RISKS IN AIRCRAFT OPERATION AT AIRPORT

Aulia Pangestuti

Sultan Bantilan Airport, Sulawesi Tengah, Indonesia

*Correspondence e-mail: auliapangestuti4703@gmail.com

Abstract

Based on observations at Adi Soemarmo Airport Boyolali, several apron markings were found to have faded or overlapped, particularly in areas that have undergone layout changes due to terminal development. These conditions reduce the visibility of the markings, potentially posing safety risks in the operation of aircraft and Ground Support Equipment (GSE) vehicles. This study aims to analyze the conformity of apron markings at Adi Soemarmo Airport with the technical provisions stipulated in the Minister of Transportation Regulation No. 21 of 2023. A qualitative descriptive method was applied through direct field observation, photographic documentation, comparison with regulatory specifications, and consultation with Apron Movement Control (AMC) officers to verify operational implications and maintenance practices. The results show that several marking elements, particularly stand boundaries, lead-in/lead-out lines, and equipment parking indications, do not fully meet visibility and standardization criteria as required by regulation, mainly due to color fading and misalignment from overlapping paint layers. These deficiencies reduce the effectiveness of the apron as a navigational aid and may elevate operational risk during peak activity. The novelty of this study lies in employing a regulatory compliance-based assessment specifically referencing PR 21 of 2023, which has not been explicitly adopted in previous apron marking evaluations. The findings contribute both theoretically, by demonstrating apron marking conformity as a measurable safety indicator, and practically, by offering evidence-based recommendations to strengthen AMC supervision and maintenance planning for airside safety enhancement.

Keywords: aircraft operation, apron marking, apron movement control, safety risk



Licensees may copy, distribute, display and perform the work and make derivative works and remixes based on it only if they give the author or licensor the credits ([attribution](#)) in the manner specified by these. Licensees may copy, distribute, display, and perform the work and make derivative works and remixes based on it only for non-commercial purposes.

Introduction

Airports are critical infrastructure that play a vital role in supporting aviation activities. Based on Law Number 1 of 2009 concerning aviation, an airport is defined as an area on land or water with certain boundaries that is used as a place for aircraft to land and take off, pick up and drop off passengers, and carry out cargo loading and unloading activities and intermodal transportation transfers, equipped with aviation safety and security facilities. In this context, airports not only function as air transportation hubs, but also as the main gateways for economic activity and mobility in a region. Therefore, effective and sustainable airport management is necessary to ensure operational reliability and aviation safety performance (Su, 2021).

As aviation service providers, airport operators have a responsibility to deliver optimal service quality. One important aspect of airport operations is the airside area, which is directly linked to aviation safety (Wulandari & Tamara, 2024). The airside area consisting of runway, taxiway, and apron requires high precision and strict adherence to technical and safety standards which any deviation from these standards may significantly impact the efficiency and safety of flight operations, so, awareness and enforcement of airside safety measures have become increasingly critical to prevent potential hazards (Oka et al., 2022).

One of the main safety components in the airside area is apron markings, which act as visual guidance for pilots, ground handling personnel, and operational vehicles to move safely and efficiently (Nuriansyah, 2024). According to Minister of Transportation Regulation PR No. 21 of 2023, apron markings must be clear, highly contrasting, and unambiguous. Faded or substandard markings can cause navigation errors and increase the risk of ground incidents. Field observations at Adi Soemarmo Airport revealed that several apron markings had deteriorated in color and clarity, with overlapping lines resulting from suboptimal removal processes. These deficiencies reduce the effectiveness of markings as navigation aids and may lead to aircraft positioning errors, ground vehicle misrouting, and potential wing tip clearance violations (Hartini et al., 2024).

Ideally, apron markings should be maintained in optimal condition featuring bright colors, sharp lines, and high contrast to ensure visibility for pilots, Apron Movement Control (AMC) officers, and ground handling teams (Muttaqin et al., 2022). Regular maintenance and repainting in compliance with applicable standards are essential to preserve visibility and regulatory conformity. Previous studies have shown that poor marking visibility leads to operational inefficiencies and potential safety hazards, particularly in high-activity zones (Hidarwanti et al., 2021).

A body of Indonesian studies has addressed apron marking problems and related operational impacts in different airport contexts, where (Hidarwanti et al., 2021) reported that faded and overlapping markings at Sultan Aji Muhammad Sulaiman Sepinggan International Airport impeded Ground Support Equipment (GSE) operations and raised safety concerns. Meanwhile, (Hisan, 2023) documented non-standard stop lines at Sam Ratulangi Airport that contributed to parking irregularities during aircraft docking. Research by (Kirana et al., 2022) highlighted the importance of well-designed Equipment Parking Area (EPA) markings to organize GSE movements at Kalimantan Airport, while (Nisa et al., 2018) recommended creating dedicated EPA zones at Lombok International Airport to reduce parking chaos and improve safety. Collectively, these studies demonstrate that marking visibility and standardization materially affect apron safety and operational efficiency across Indonesian airports (Al Falaki et al., 2024).

Notwithstanding these contributions, the literature shows two limitations relevant to the present study. First, prior research tends to concentrate on operational symptoms (e.g., GSE disorder, non-standard stop lines, EPA absence) rather than systematically evaluating apron markings *against the most recent national regulatory standard* (PR 21/2023). Second, there is limited integration between observational evidence from AMC practitioners and a formal conformity assessment that maps marking conditions to explicit regulatory criteria. Although AMC's supervisory role is recognized (Muttaqin et al., 2022), there is insufficient published work that

operationalizes AMC observations into a compliance-based assessment tool for apron markings. These gaps suggest a need for a targeted conformity analysis that links field conditions to PR 21/2023 requirements and AMC inspection practices (Ellis et al., 2024).

Accordingly, this study aims to analyze the conformity of apron markings at Adi Soemarmo Airport with the technical and operational provisions outlined in PR 21/2023. Specifically, the research examines marking visibility, accuracy of layout elements (e.g., lead-in/lead-out lines, parking stand boundaries, EPA delimitation), and the presence of residual or overlapping marks that may cause ambiguity. The study uses qualitative descriptive methods-direct observation, AMC interviews, and documentation review-to produce an evidence-based assessment of compliance and to identify practical maintenance deficiencies (Ihsan et al., 2023). In sum, this research contributes to both scholarship and airport practice by (1) offering a conformity-based evaluation of apron markings anchored to PR 21/2023, (2) documenting field evidence from Adi Soemarmo Airport that exemplifies common apron marking failures, and (3) proposing practical measures for AMC and facilities units to mitigate marking-related risks. These contributions aim to strengthen the link between regulatory intent and on-the-ground airside safety implementation across Indonesian airports.

Methods

This research employed a descriptive qualitative design, aimed at obtaining a comprehensive understanding of actual field conditions. This method was chosen because the data collected are textual and descriptive in nature, allowing for an in-depth exploration of operational phenomena in the airside area based on empirical reality (Abrar et al., 2024; Hendra et al., 2023). The descriptive design aims to systematically describe the existing conditions of apron markings and their compliance with aviation safety standards (Yuliani, 2018). The research object consisted of the implementation and physical condition of apron markings, examined in relation to their conformity with national and international

aviation safety standards. The study focused on identifying inconsistencies, visibility issues, and maintenance practices that potentially pose safety risks in aircraft operations (Zellatifanny & Mudjiyanto, 2018). The research took place at Adi Soemarmo Airport, Boyolali, during the On-the-Job Training program organized by Palembang Aviation Polytechnic, spanning a five-month period from September 2024 to January 2025. Data was obtained through three main techniques:

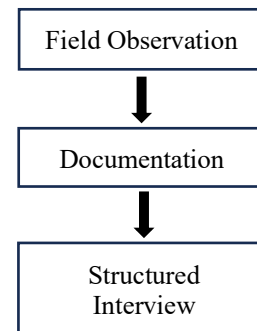


Figure 1. Data Collection Techniques

Direct observations were made in the apron area to assess the physical and functional condition of the markings. Observations focused on visibility, color clarity, paint thickness, positional accuracy relative to the apron layout, and the presence of operational safety signs. Visual documentation, including photographs and technical drawings, was collected to support and validate the observational data (Sivakumar, 2022).

Interviews were conducted with airport operations and maintenance personnel to gather information on maintenance procedures, repainting frequency, inspection schedules, and challenges faced in maintaining marking quality. Interviews were conducted with four sources, including Airside Airport Operations Admin Staff, Apron Movement Control Personnel, and Ground Handling personnel. Data were analyzed qualitatively using the Miles and Huberman interactive model, which consists of three main stages: data reduction, data display, and conclusion drawing (Mezmir, 2020).

Data Reduction

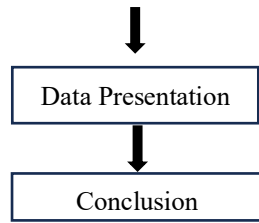


Figure 2. Data Analysis Techniques

Data Reduction, simplifying and categorizing data obtained from observations, interviews, and documentation into relevant themes such as visibility issues, fading paint, and inconsistencies in marking layout. Data Presentation, organizing the processed data in descriptive and tabular form to facilitate interpretation. Conclusion, conclusions from recurring patterns and verifying findings against Minister of Transportation Regulation No. 21 of 2023 concerning Technical and Operational Standards for Airports, particularly regarding marking specifications in airport areas.

To ensure the credibility and reliability of the findings, this study applied data triangulation of sources and methods was applied to cross-check consistency between observation results, documentation evidence, and interview data, which involved cross-verifying information obtained from observations, documentation, and interviews. This method was used to minimize researcher bias and ensure that the results accurately reflected actual field conditions (Fiantika & Maharani, 2022).

Results And Discussions

Based on field observations and interviews, most of the runway markings at Adi Soemarmo Airport have been implemented in accordance with aviation safety regulations and technical standards. The design, color coding, and placement of the markings are generally in line with international guidelines, ensuring the safe movement of aircraft and ground support vehicles. However, some inconsistencies were identified, particularly in areas affected by changes to the parking apron layout following the terminal expansion. These inconsistencies include misalignment, faded or overlapping markings, and incomplete repainting, which

reduce visibility especially during night operations or adverse weather conditions.



Figure 3. Condition of Parking Stand 6 Apron Markings

Table 1. Types and Standards of Apron Markings

No.	Type of Marking	Function and Standardization
1.	Apron Safety Line	Defines movement boundaries for Ground Support Equipment.
2.	Parking Clearance Line	Indicated restricted areas during aircraft movement; solid red line, sometimes bordered for visibility.
3.	Lead-in and Lead-out Line	Guides aircraft between taxiway and parking stands; yellow line with optional black background for better contrast.
4.	Equipment Parking Area	Defines designated areas for Ground Support Equipment; white lines.
5.	No Parking Area	Red hatch markings to prohibit parking or equipment placement in restricted zones.

Field observations revealed that the main inconsistencies are caused by frequent apron use, low-quality paint, and inadequate removal of previous markings. In several locations, old

markings were merely covered with similar-colored paint, leading to visual confusion among pilots, ground handling personnel, and AMC officers. Interviews with maintenance staff confirmed that repainting is often performed only when budget permits, while limited tools hinder the complete removal of old markings. Consequently, some areas fail to fully comply with the standards set in the Minister of Transportation Regulation No. 21 of 2023, which mandates clear and durable markings as essential visual safety aids.

These findings are consistent with previous research (Hidarwanti et al., 2021) which reported that unclear or faded runway markings at busy airports can lead to runway congestion, miscommunication among ground personnel, and even minor ground incidents. This indicates that the clarity and visibility of apron markings are critical determinants of operational safety. The findings of this study also indicate that deficiencies in apron marking clarity are not merely technical issues but are closely associated with human factors that influence decision-making among AMC personnel, marshallers, and GSE operators.

According to the principle of *visual cue reliability* described in ICAO Doc 9870 (Safety Management Manual), the quality of visual information in airside operations significantly affects situational awareness and distance perception. When the shape, color, or thickness of markings becomes inconsistent, operators tend to rely on subjective interpretation, increasing the likelihood of miscommunication, misalignment, and human error. Thus, maintaining high-standard apron markings functions not only as regulatory compliance but also as a proactive measure to mitigate human-performance-related risks.

Moreover, the results support the theory of visibility and legibility in aviation safety standards, which posits that clear visual guidance directly enhances both safety and efficiency in aircraft ground operations. In the context of Adi Soemarmo Airport, reduced marking visibility due to fading paint and overlapping lines has the potential to disrupt the accuracy of aircraft positioning and vehicle routing. Beyond safety implications, degraded apron markings have consequences for operational efficiency, particularly during peak

aircraft movements. Misaligned or unclear lead-in and lead-out lines may extend aircraft docking time, contribute to longer turnaround durations, and potentially propagate delays. From an economic standpoint, such inefficiencies can reduce effective apron capacity and negatively impact key airport performance indicators, including on-time performance (OTP). Therefore, improving apron marking quality enhances not only safety outcomes but also operational reliability and overall service quality at the airport.

Further analysis also revealed that oil and fuel spills from GSE accelerate the degradation of markings and increase surface slipperiness, thereby heightening safety risks for personnel and vehicles operating in the apron area. These findings highlight the importance of implementing a systematic reporting and cleaning mechanism supported by trained personnel and appropriate equipment to ensure continuous operational safety.

The results also highlight the need to integrate apron marking inspections and maintenance activities into the airport's Safety Management System (SMS), particularly within hazard identification and safety assurance processes. Existing reporting mechanisms are still predominantly ad hoc and rely heavily on individual AMC initiative. Incorporating apron marking assessments as a routine SMS element would allow early detection of potential hazards before they escalate into incidents. Such integration strengthens documentation practices, promotes data-driven safety monitoring, and ensures continuous oversight of physical infrastructure critical to airside operations.

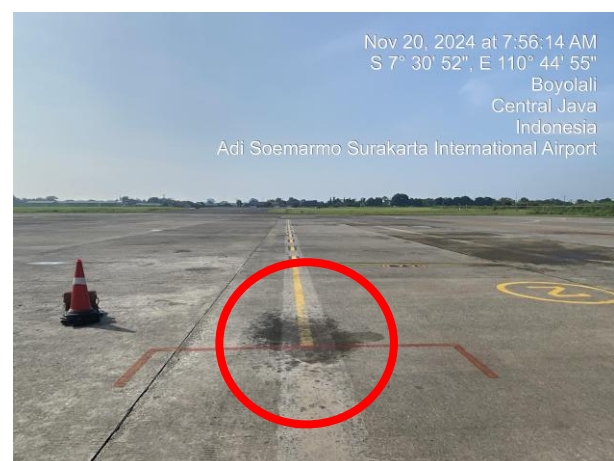


Figure 4. Fluid Spill on Parking Stand 2

To address this issue, it is necessary to establish a rapid reporting and cleaning mechanism supported by adequate equipment and trained personnel to ensure that the apron remains clean and safe for operations. Furthermore, adopting an integrated safety management approach where apron maintenance, operational monitoring, and safety audits are conducted in coordination will provide a comprehensive framework for continuous improvement in airside safety performance.

From a practical perspective, these findings highlight the urgent need for Standard Operating Procedures (SOP) governing the maintenance of runway markings. The following are the proposed stages in the SOP for Apron Facility Inspection: (1) Identification and documentation of apron marking conditions by AMC personnel. (2) Reporting the results of the identification to the Facilities Unit. (3) Joint verification between AMC and the Facilities Unit in the field. (4) Scheduling repairs by the Facilities Unit at a time that does not interfere with operations (window time). (5) Removal of old markings using specialized tools. (6) Repainting of markings with standard paint in accordance with PR 21 of 2023. (7) The ideal frequency for repainting apron markings is every 6 months to 1 year. (8) Evaluation of joint work results by AMC and the Facilities Unit. (9) Periodic monitoring by AMC of the condition of road markings as a form of ongoing supervision.

The presence of overlapping markings and incomplete removal of previous paint layers underscores the need for safety-driven budgeting in facility maintenance. Many Indonesian airports still perform repainting based on budget availability rather than on degradation level or recommended maintenance intervals. By adopting a condition-based maintenance (CBM) approach aligned with PM 21/2023, facility units can estimate budget requirements more accurately based on paint wear, operational intensity, and environmental exposure. Such policy improvements can prevent resource inefficiencies while significantly enhancing the quality and durability of apron markings.

From an academic standpoint, the study reinforces the significance of infrastructure maintenance as a determinant of operational safety and provides empirical evidence linking marking quality to safety performance in airport ground operations. The study's findings also emphasize the importance of strengthening the supervisory role of Apron Movement Control (AMC). Currently, AMC personnel often serve primarily as reporters, while decision-making regarding corrective actions lies with other units. To improve oversight effectiveness, AMC should be granted greater authority to perform marking condition grading, classify damage levels (minor, moderate, critical), and issue prioritized recommendations for repairs. Enhanced AMC involvement ensures that apron marking quality becomes an integral component of airside operational control rather than an isolated maintenance task recognized (Muttaqin et al., 2022).

The findings of this study indicate that the apron markings at Adi Soemarmo Airport largely conform to the safety standards specified in PR 21 of 2023. Nevertheless, several operational shortcomings persist, particularly in high-traffic areas where markings have faded or become overlapped due to incomplete removal of previous layers. Such conditions diminish marking visibility and, consequently, may compromise both the safety and efficiency of airside operations. These findings emphasize the necessity of implementing a systematic maintenance framework and a continuous evaluation process to ensure that all markings remain compliant with visibility and standardization requirements.

The issues identified in this study are also likely to be relevant to many other Indonesian airports, particularly medium-capacity airports with increasing flight movements (Hisan, 2023). Conditions such as fading, overlapping, and improperly removed markings represent common challenges that have received limited academic attention (Hidarwanti et al., 2021). Future research may develop a *marking deterioration index* based on color intensity, paint thickness, and service age. Experimental studies comparing different marking materials, application methods, and removal techniques

may also contribute valuable insights toward establishing improved national standards.

Conclusion

This research concludes that the condition of apron markings at Adi Soemarmo Airport generally complies with the safety standards stipulated in Minister of Transportation Regulation No. 21 of 2023; however, several discrepancies remain, particularly faded and overlapping markings in high-traffic areas that reduce visibility and may lead to operational errors on the airside. These findings reveal that while the design aspects of apron markings largely meet regulatory specifications, the airport's maintenance and supervision mechanisms are still suboptimal and require systematic improvement. Theoretically, this study reinforces the critical role of marking visibility, accuracy, and durability as core components of airside safety management, while practically it highlights the importance of proactive human performance—especially the involvement of AMC personnel—in ensuring operational reliability. Furthermore, the study emphasizes that sustaining apron marking quality is not merely a technical maintenance task but a multidimensional safety concern that intersects with human factors, regulatory enforcement, operational efficiency, and institutional coordination. Ensuring consistent marking clarity requires airports to adopt an integrated maintenance framework supported by routine inspections, data-driven planning, proper removal and repainting procedures, and strengthened collaboration between AMC and Facilities units. These insights underscore the need for airports to treat apron marking management as a key determinant of airside safety performance and provide a foundation for future research on standardized assessment tools and long-term maintenance strategies that can be applied across diverse airport environments.

References

- Abrar, R., Fatonah, F., Dayanthi, A. K., & Syahputra, M. E. (2024). Analysis of Corrective Maintenance Monitor Cca Tool Dvor Selex Type-1150a. *Journal of Airport Engineering Technology (JAET)*, 4(2), 95–100. <https://doi.org/10.52989/jaet.v4i2.146>
- Al Falaki, R. O., Budiarto, A., Nastiti, P. D., & Sukma, M. M. (2024). Examination of The Feasibility Standards for Ground Support Equipment (GSE) on the Effectiveness of Flight Operations on the Air Side of Mutiara Sis Al-Jufri Palu Airport. *Journal Of Nesia Social Science*, 1(3), 98–108. <https://nesiasains.com/index.php/JNSSc/article/view/27>
- Ellis, K., Vincent, M., Prinzel, L., Krois, P., Ackerson, J., Davies, M., Oza, N., Mah, R., Stephens, C., Glenn-Chase, A., Infeld, S., Brandt, S., Okolo, W., & Coughlan, J. (2024). An In-time Aviation Safety Management System (IASMS) Concept of Operations for Part 139 Airports. *AIAA Aviation Forum and ASCEND*, 2024. <https://doi.org/10.2514/6.2024-4661>
- Fiantika, F. R., & Maharani, A. (2022). Metodologi Penelitian Kualitatif. Padang: PT. Global Eksekutif Teknologi.
- Hartini, Syamsunasir, Hermawan, I. G. N. W., Moektiwibowo, R., Yulianti, B., Chaeroni, A., Jayadi, M., Kusumalestari, A. S., Hendradjaja, S. S., Sari, R. A., Franciscus, F., Rahmawati, C., & Awaludin, M. (2024). Manajemen Bandar Udara. In Hartini (Ed.), *Educacao e Sociedade* (Vol. 1, Issue 1).
- Hendra, O., Sadiatmi, R., & Hidayat, Z. (2023). Governance Network on Aviation Safety: a Systematic Literature Review. *Journal of Airport Engineering Technology (JAET)*, 4(1), 01–11. <https://doi.org/10.52989/jaet.v4i1.114>
- Hidarwanti, C. R., Olieve, A., & Kusno. (2021). Standarisasi Marka Apron Guna Menjamin Keselamatan Pergerakan Kendaraan Ground Support Equipment (GSE) Di Bandar Udara Internasional Sultan Aji Muhammad. *Prosiding Seminar Nasional Inovasi Teknologi Penerbangan (SNITP)*, 1–7.
- Hisan, M. Z. Al. (2023). Pengaruh Marka StopLine Terhadap Keselamatan Pergerakan Pesawat di Apron. *Politeknik Penerbangan Surabaya*.
- Ihsan, M. Z. Al, Hariyadi, S., & Nastiti, P. D. (2023). The Effect Of Stop Line Markings

- On The Safety Of Aircraft Movement On The Apron. *Proceeding of International Conference of Advanced Transportation, Engineering, and Applied Social Science*, 2(1), 698–704. <https://doi.org/10.46491/ICATEAS.V2I1.1729>
- Kirana, G. Z., Kustori, & Olieve, A. (2022). Pengoptimalan Marka Apron Untuk Menjamin Ketertiban Kendaraan Ground Support Equipment di Bandara Kalimantan Berau. *Prosiding Seminar Nasional Inovasi Teknologi Penerbangan (SNITP)*, 1–6.
- Mezmir, E. A. (2020). Qualitative Data Analysis: An Overview of Data Reduction, Data Display and Interpretation. *Research on Humanities and Social Sciences*, 10(21), 15–27. <https://doi.org/10.7176/rhss/10-21-02>
- Muttaqin, M. S., Dewantari, A., Tinggi, S., & Kedirgantaraan, T. (2022). Analysis of Apron Arrangement by Apron Movement Control (AMC) Officers in Supporting Aviation Safety and Services at Wulung Airport , Cilacap. *Jurnal Multidisiplin Madani*, 2(5), 2167–2186.
- Nisa, R. K., Kardi, & Sunarno. (2018). Kajian Pengalokasian Equipment Parking Area (EPA) Di Apron Bandar Udara Internasional Lombok. *Jurnal Ilmiah Aviasi Langit Biru Vol. 11 No. 1*, 11(1), 19–28.
- Nuriansyah, R. (2024). Analisis Pengawasan Unit Apron Movement Control (AMC) Terhadap Aktivitas Marshaller di Apron Bandar Udara H. Asan Sampit. *Jurnal Humaniora, Sosial Dan Bisnis*, 2(8), 1–9.
- Oka, I. G. A. A. M., Yuniar, D. C., Purwaningtyas, D. A., & Azzahra, N. (2022). Analysis of Saturated Capacity on the Runway Based on Advisory Circular 150/5060-5 As a Study Material for Airport Management Learning. *Journal of Innovation in Educational and Cultural Research*, 3(3), 373–381. <https://doi.org/10.46843/jiecr.v3i3.120>
- Sivakumar, S. (2022). A novel Integrated Risk Management Method for Airport Operations. *Journal of Air Transport Management*, 105, 102296. <https://doi.org/10.1016/J.JAIRTRAMAN.2022.102296>
- Su, W.-J. (2021). The Effects of Safety Management Systems, Attitude and Commitment on Safety Behaviors and Performance. *International Journal for Applied Information Management*, 1(4), 187–200. <https://doi.org/10.47738/IJAIM.V1I4.20>
- Wulandari, W., & Tamara, A. P. (2024). Analisis Pemahaman Petugas Magang tentang Marka untuk Keselamatan di Area Airside Bandar Udara Adi Soemarmo Surakarta. *Indonesian Journal of Aviation Science and Engineering*, 1(1), 6. <https://doi.org/10.47134/pjase.v1i1.2244>
- Yuliani, W. (2018). Metode Penelitian Deskriptif Kualitatif Dalam Perspektif Bimbingan dan Konseling. *QUANTA: Jurnal Kajian Bimbingan Dan Konseling Dalam Pendidikan*, 1(1), 1–10. <https://doi.org/https://doi.org/10.22460/q.v2i2p83-91.1641>
- Zellatifanny, C. M., & Mudjiyanto, B. (2018). Tipe Penelitian Deskripsi dalam Metode Penelitian. *Diakom: Jurnal Media Dan Komunikasi*, 1(2), 83–90. <https://doi.org/10.17933/diakom.v1i2.20>