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Design of a Maintenance and Repair Management System for RAPS-3 at the Regional V Airport Authority Office of Makassar

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Abstract
This research is motivated by the absence of a maintenance and repair management system, in the form of standardized procedures and a history-monitoring feature, for the Recording Analysis Playback and Simulation System for Surveillance Data 3 (RAPS-3) equipment at the Regional V Airport Authority Office of Makassar, which has the potential to hinder the duties and functions of flight navigation oversight. This research aims to design a maintenance procedure, a repair procedure, and a monitoring feature for the maintenance and repair history of RAPS-3 using the Linktree application. The maintenance and repair procedures were prepared based on Minister of Transportation Regulation No. PM 50 of 2017, while the monitoring feature links technical documents comprising the Flight Telecommunication Facility History, the Facility Log Book, the Facility Condition Monthly Report, the Facility Damage and Repair Monthly Report, and the Facility Performance Evaluation Monthly Report, in accordance with Decree of the Director General of Air Transportation No. PR-DJPU 08 of 2025. The research employed a descriptive qualitative approach with data collection techniques comprising interviews, observation, documentation study, and audio-visual recording. The results of the research consist of a design for the RAPS-3 Maintenance Standard Operating Procedure (SOP), the RAPS-3 Repair SOP, and a Linktree-based monitoring feature for maintenance and repair history that can be accessed via a web link or QR code, thereby facilitating flight navigation personnel in carrying out equipment oversight and control duties.

Keywords: RAPS-3; maintenance procedure; repair procedure; Linktree; flight navigation

INTRODUCTION

Aviation technology is currently developing rapidly, requiring strict oversight in its implementation, one aspect of which is flight navigation. Under Law No. 1 of 2009 concerning Aviation, flight navigation is defined as the process of directing the movement of an aircraft from one point to another safely and smoothly to avoid flight hazards and/or obstacles. Flight navigation oversight in Indonesia is carried out, among others, by the Airport Authority Office, which, in accordance with Minister of Transportation Regulation No. PM 41 of 2011, is tasked with regulating, controlling, and supervising aviation activities, including flight navigation facilities and equipment. One such Airport Authority Office in Indonesia is the Regional V Airport Authority Office of Makassar, whose working area covers South Sulawesi, West Sulawesi, Central Sulawesi, and Southeast Sulawesi.

Carrying out flight navigation oversight at the Regional V Airport Authority Office of Makassar requires test equipment to serve as comparative data, one of which is the Recording Analysis Playback and Simulation System for Surveillance Data 3 (RAPS-3). RAPS-3 is an advanced, versatile tool for testing, evaluating, and certifying surveillance data used at Radio Detection and Ranging (RADAR) facilities. The presence of such test equipment aligns with the need for periodic inspection of flight navigation facilities highlighted by Geise et al. (2021), who emphasized that routine performance validation of equipment is an essential part of maintaining the reliability of navigation and surveillance systems. The RAPS-3 equipment at the research site is of the ACME Portable Corp brand, with a COMSOFT Solution system and LITEPAC PLUS type. This equipment is operated by the Flight Navigation Inspector, a personnel member fully assigned duties, responsibilities, and authority by the competent official to carry out safety, security, and flight-service oversight activities in accordance with KP 182 of 2017.

The problem underlying this research is that RAPS-3 at the Regional V Airport Authority Office of Makassar does not yet have a maintenance and repair management system set out in standardized procedures, so that using the equipment without such procedures has the potential to cause human error affecting the equipment's operation and lifetime. This is consistent with the findings of Ayegba and Taiwo (2024) that weak maintenance oversight contributes to errors that can disrupt operational safety, making proactive and documented oversight a fundamental necessity. Based on the above, the research problems addressed in this study are: (1) how to design a maintenance management system in the form of a RAPS-3 maintenance procedure in accordance with applicable provisions; (2) how to design a repair management system in the form of a RAPS-3 repair procedure to guarantee its performance and reliability; and (3) how to design a feature for monitoring the maintenance and repair history of the RAPS-3 equipment.

This research draws on the theory put forward by Irmayanti Yunus (2018) in the book Perawatan dan Perbaikan Peralatan Elektronika (Maintenance and Repair of Electronic Equipment), which states that to simplify work, a planner typically builds a maintenance work mechanism using a tool referred to as a Maintenance and Repair Management System. A similar approach is also found in the modern aviation industry, as described by Korchagin et al. (2022) through the Lean Maintenance 4.0 concept, which emphasizes the importance of standardizing maintenance work mechanisms for operational efficiency and reliability. The work procedure begins with the receipt of a Work Request (W.R) signed by management, which is then converted into a Work Order (W.O) studied by the planner to be developed into a complete work plan along with a maintenance implementation schedule. This kind of work-order assignment optimization is also affirmed by Hong et al. (2026), who showed that data-based scheduling can improve the consistency and efficiency of facility maintenance processes compared to assignments that rely solely on experience. This research aims to design a work mechanism for the RAPS-3 equipment consisting of a maintenance procedure, a repair procedure, and equipment history, so that RAPS-3 can support a reliable, accurate, and sustainable flight navigation oversight system. The results of this research are expected to be implemented by the Flight Navigation Inspector as a reference for equipment maintenance and repair, and to contribute to improving the safety and reliability of flight navigation services that impact the community of air transportation service users.

RESEARCH METHOD

This section describes the research design, the time and place of the research, the research subjects, the research procedure, the instruments and data collection techniques, and the data analysis technique used.

Research Design

This research employs a descriptive qualitative approach. According to Sugiyono (2011), qualitative research method is defined as a research method grounded in the philosophy of postpositivism, used to study objects under natural conditions, in which the researcher acts as the key instrument, data collection is carried out through triangulation (a combination of techniques), data analysis is inductive/qualitative in nature, and the research results emphasize meaning rather than generalization.

Time and Place of Research

The research was conducted in 2026, with the research site located at the Regional V Airport Authority Office of Makassar. The research location was determined to help ensure the accuracy of the data obtained.

Research Subject

The research subjects comprise three key actors: the Airport Inspector for Flight Navigation, the Flight Evaluator, and the Flight Supervisor at the Regional V Airport Authority Office of Makassar. These three actors were selected because they are directly involved in the oversight and operation of the RAPS-3 equipment.

Research Procedure

The research began with a literature study, problem identification, and data collection through observation, interviews, and documentation. The collected data were then analyzed to formulate a maintenance management system framework, comprising three design stages: the maintenance procedure, the repair procedure, and the equipment history monitoring feature. This design was then tested (trial and error) through a simulated implementation of the work mechanism, followed by an evaluation stage. This evaluation-and-revision cycle is consistent with the preventive maintenance approach put forward by Yildirim and Rana (2024), who showed that continuous condition monitoring of equipment can support more timely maintenance decision-making. If the evaluation results did not meet the objectives, the design was revised; once they did, the research proceeded to the conclusion-drawing stage. The complete research flow is presented in Figure 1.

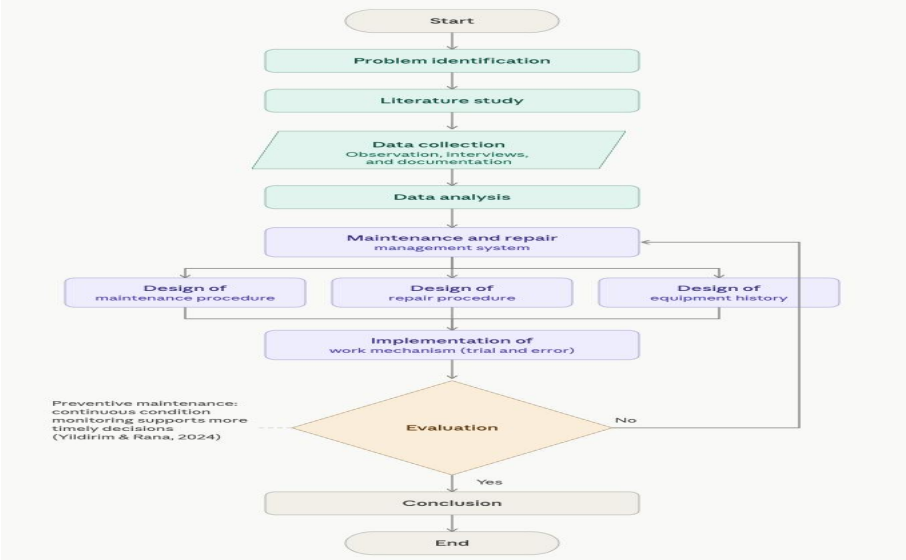

Figure 1. Research flow diagram

Primary data were collected through interviews with the three key actors, direct observation at the equipment location, a documentation study of the applicable technical manuals and flight navigation regulations, and audio-visual material in the form of video and the application designed in this research. Secondary data were obtained from documents, archives, and related publications previously collected by other parties. The research tools and materials used included the RAPS-3 equipment, field safety work equipment, an internet connection, supporting documents/applications, documentation equipment, and computer/laptop devices.

Instruments and Data Collection Techniques

The research instrument consisted of a semi-structured interview guide administered to the Airport Inspector for Flight Navigation, the Flight Evaluator, and the Flight Supervisor, along with a field observation sheet. Data collection was carried out through four techniques: interviews, direct observation, a documentation study of technical manuals and regulations, and audio-visual recording.

Data Analysis Technique

In this research, qualitative data analysis, following Sugiyono (2011), was carried out through the process of selecting (data reduction), sorting (categorization), and organizing the data collected from field notes, observation results, in-depth interviews, and documentation, so as to obtain an understanding that is in-depth, meaningful, and descriptive in nature. The analysis results were then described in narrative form, compared across data categories, and constructed into particular relationship patterns as the basis for formulating the maintenance procedure, the repair procedure, and the RAPS-3 equipment history monitoring feature.

RESULTS AND DISCUSSION

The object of this research is the Recording Analysis Playback and Simulation System for Surveillance Data 3 (RAPS-3) equipment, as shown in Figure 2, a tool for testing, evaluating, and certifying flight surveillance data developed by COMSOFT GmbH. The data tested and evaluated by RAPS-3 originate from Monopulse Secondary Surveillance Radar (MSSR) equipment, whose coverage reliability and accuracy, according to Minteuan et al. (2021), are strongly influenced by antenna design factors and signal propagation conditions, making periodic data testing important to ensure that its performance remains up to standard. RAPS-3 offers advantages such as broad support for radar data protocols and formats, data analysis, validation, and visualization functions, online and offline filtering based on user-defined rules, an ASTERIX test-data editor and simulator, and a modular design with a high degree of adaptability to software and hardware. Such data analysis and filtering capabilities are relevant to recent developments in radar resource management, as reviewed by Hashmi et al. (2023), who highlighted the importance of efficient radar data processing in supporting optimal surveillance functions.

Figure 2. RAPS-3 Equipment

The results of interviews with the Airport Inspector for Flight Navigation, the Flight Evaluator, and the Flight Supervisor, reinforced by field observation, show that, in general, the Maintenance Procedure and Repair Procedure for the RAPS-3 equipment at the Regional V Airport Authority Office of Makassar are not yet available. All three actors agreed that the existence of such procedures plays a highly important role in supporting oversight and control activities, since they serve to align flight navigation personnel's understanding of the steps involved in equipment maintenance and repair. The expected scope of the procedure covers the review of operational, technical, and administrative documents, while its purpose is to serve as a guideline for implementing activities that include conformity verification and effectiveness determination. The importance of the maintenance stage for radar performance is also demonstrated by Vidal et al. (2023) in the implementation of a transportable Mode S radar for civil aviation surveillance, which recorded a significant improvement in detection performance following the maintenance stage compared to before. The proposed procedure implementation flow begins with Flight Navigation Personnel (Inspectors, Supervisors, and Controllers), Section Heads (FPBU and PBU), up to the Head of the P2BU Division, with a legal basis comprising Law No. 1 of 2009 and its derivative regulations, including Minister of Transportation Regulation No. PM 50 of 2017 and Decree of the Director General of Air Transportation No. PR-DJPU 08 of 2025.

Design of the RAPS-3 Maintenance Procedure

The RAPS-3 maintenance procedure was designed by preparing a Standard Operating Procedure (SOP) Document for the Maintenance of RAPS-3 Equipment at the Class I Regional V Airport Authority Office of Makassar, referring to Minister of Transportation of the Republic of Indonesia Regulation No. PM 50 of 2017 concerning Guidelines for the Preparation of Business Process Maps and Standard Operating Procedures within the Ministry of Transportation. Under this regulation, an SOP is defined as a standardized set of written instructions concerning administrative processes, specifying how and when an activity must be carried out, where, and by whom. The RAPS-3 Maintenance SOP Document is composed of a Cover Page, Document Approval Sheet, Foreword, Table of Contents, SOP Revision History, Scope, Purpose and Objectives, Organizational Requirements, SOP Overview, Definitions/General Terms, Maintenance and Equipment Forms, Legal Basis, Warnings, Troubleshooting, Equipment, Description of Activity Types, Implementers, and Quality Standards. Such a complete document structure is important so that the SOP can be continuously updated in line with organizational developments, as emphasized by Rahman and Fadillah Nur (2023) in their study on SOP development within government agencies. Once the SOP was prepared, an implementation simulation was carried out to evaluate each step so as to obtain an effective and efficient procedure. This principle of periodic validation is consistent with Novák and Veľký (2025) and Wu et al. (2023), who each affirm that regular calibration and inspection of navigation facilities and their measurement reference points are required to ensure that the resulting data accuracy remains up to operational standards. With this SOP in place, maintenance activities can be carried out in accordance with the equipment's characteristics and applicable standards, thereby supporting the operational reliability of RAPS-3 in fulfilling the duties of the Airport Inspector for Flight Navigation, the Flight Evaluator, and the Flight Supervisor.

Design of the RAPS-3 Repair Procedure

In line with the findings on the maintenance procedure, the results of the interviews and observations also show that a Repair Procedure for RAPS-3 is not yet available, even though it is greatly needed to guarantee the equipment's performance and reliability after a failure. The repair procedure was designed by preparing a RAPS-3 Repair SOP Document that refers to the same regulation and section framework as the Maintenance SOP, namely Minister of Transportation Regulation No. PM 50 of 2017. The repair procedure governs the mechanism for handling equipment damage carried out by flight navigation personnel, so that its implementation does not give rise to differing interpretations that could disrupt equipment operations. This clarity of work stages is consistent with Rakhman (2023), who emphasizes that an SOP must be designed systematically so that it is easy to implement in both bureaucratic and technical processes in the field, and is further supported by the findings of Soediro and Nurbianto (2021) that consistent SOP implementation contributes to improved performance among those who carry it out. After the document was prepared, an

implementation simulation was carried out to ensure that each repair stage runs effectively and efficiently, so that when damage occurs to the RAPS-3 equipment, follow-up action can be taken promptly according to the level of damage.

Design of the Equipment Maintenance and Repair History Monitoring Feature

In addition to the two procedures above, the interview results show that a feature for monitoring the maintenance and repair history of the RAPS-3 equipment is greatly needed to make it easier for flight navigation personnel to access technical documents, particularly when carrying out maintenance or repair activities in the field. The monitoring feature was designed using the Linktree application because of the ease with which it can be customized, modified, and have links added, and because it can be accessed without requiring users to log in. Similar ease of use has also been reported by Renova et al. (2022) and Amaliah et al. (2021), who state that Linktree is effectively used as a medium for linking learning materials and work documents, as well as by Annisaturrodliyah and Marhayati (2024), who show that integrating Linktree with other interactive media can improve the effectiveness of information access for its users. The technical documents linked on Linktree were prepared based on Decree of the Director General of Air Transportation No. PR-DJPU 08 of 2025 concerning Technical and Operational Standards under Civil Aviation Safety Regulation Part 172-03 (Manual of Standard Part 172-03) on Performance Requirements, Maintenance Procedures, and Reporting for Flight Telecommunication Facilities. The seven features linked on the Linktree application are shown in Table 1. Specifically, for the Monthly Performance Evaluation Report feature, the Mean Time Between Failure (MTBF) indicator recorded follows the approach put forward by Tomaszewska (2023), who states that MTBF is a key indicator for quantitatively assessing the reliability of an air transportation system.

Table 1. Features of the Linktree application for monitoring RAPS-3 maintenance and repair history

No.	Feature Name	Basis/Document Content
1	Maintenance Procedure	RAPS-3 Equipment Maintenance SOP (PM 50/2017)
2	Repair Procedure	RAPS-3 Equipment Repair SOP (PM 50/2017)
3	Flight Telecommunication Facility History	Name/brand/type, part & serial number, installation date, flight inspection, replacement/modification/reconditioning/relocation
4	Facility Log Book	Date & time of execution, maintenance/repair notes, name & signature of personnel and person in charge
5	Flight Telecommunication Facility Condition Monthly Report	Operator, service, equipment condition by date, remarks, person in charge
6	Facility Damage and Repair Activity Monthly Report	Damage, follow-up action, time of occurrence and completion of repair, operational downtime hours
7	Flight Telecommunication Facility Performance Evaluation Monthly Report	Technical data, coordinates, year of installation, availability, MTBF, reliability

The Linktree monitoring application was named “RAPS-3 Equipment – Maintenance and Repair History Monitoring” as shown in Figure 3, and can be accessed in two ways: via a website link and via a QR Code, making it easier for flight navigation personnel to access the documents whenever needed.

Figure 3. Display of the Linktree application for monitoring RAPS-3 maintenance and repair history

After the design stage, the monitoring feature was tested (trial and error) on each menu created to ensure it matched operational needs. This testing is important given that Stazić et al. (2023) emphasize that data quality in a digital maintenance system greatly determines that system's reliability as a source of information, as also shown by Suprihartini et al. (2022) through a website-based equipment maintenance data storage system that proved effective in facilitating the recording and tracing of equipment history. The trial results show that the Linktree application can operate as designed, with no significant obstacles that would hinder equipment maintenance and repair activities. Overall, the three achievements of this research the Maintenance SOP, the Repair SOP, and the Linktree-based monitoring feature are mutually integrated: the Linktree application not only links historical documents and monthly reports but also contains direct links to both procedures. This integration represents the novelty of the research, as it combines a regulatory approach (SOPs based on PM 50/2017 and PR-DJPU 08/2025) with a simple, easily accessible information-technology approach (Linktree), which has rarely been applied to the maintenance management system for flight navigation equipment within Airport Authority Offices.

Discussion

Overall, the findings of this research show that the absence of a documented maintenance and repair management system is a fundamental issue with far-reaching impact, rather than merely an administrative shortcoming. Consistent with the Maintenance and Repair Management System theoretical framework put forward by Yunus (2018), a work mechanism that begins with a work request and ends with an implementation schedule can only run effectively if it is set out in a standardized procedure. Without a written reference, flight navigation personnel tend to act based on individual experience, as warned by Hong et al. (2026) regarding the risk of inconsistency in work assignments based on experience alone. This finding reinforces the argument that procedural standardization, as

affirmed by Korchagin et al. (2022) through the Lean Maintenance 4.0 concept, is relevant not only to manufacturing industries or large-scale commercial aviation but is also essential for flight navigation oversight units at the scale of a regional office, such as the Regional V Airport Authority Office of Makassar.

The design of the RAPS-3 Maintenance SOP and Repair SOP produced by this research shows a pattern similar to research on SOP preparation in other government agencies. Rahman and Fadillah Nur (2023) and Sampe and Fauzi (2023) show that the existence of a structured SOP contributes to work consistency and organizational accountability, while Rakhman (2023) emphasizes that the effectiveness of an SOP depends heavily on the clarity of its stages and the ease of its implementation in the field. The consistency of these findings with the results of this research indicates that the principles of SOP preparation are cross-sectoral in nature, even though the objects they regulate differ—ranging from village government, to corporate human resources, to technical flight-navigation equipment. Nevertheless, this research makes a distinctive contribution because the SOPs designed do not stand alone but are directly integrated with an equipment history recording system that refers to Decree of the Director General of Air Transportation No. PR-DJPU 08 of 2025, so that compliance with the procedure can be traced through digital documentation rather than relying solely on physical documents, which are prone to loss or damage.

The choice of the Linktree application as the basis for the monitoring feature was a strategic decision that took into account ease and sustainability of use. The finding that Linktree effectively links various documents into a single interface is consistent with the results of Renova et al. (2022) and Amaliah et al. (2021) in the learning context, as well as Annisaturrodliyah and Marhayati (2024), who report improved effectiveness of information access through the integration of Linktree with other interactive media. The fundamental difference between this research and those previous studies lies in the domain of application: whereas earlier research made use of Linktree for learning purposes, this research extends its use to a technical-operational domain, namely the recording of flight-navigation equipment maintenance and repair history. This extension of the domain is worth noting because it demonstrates the flexibility of the single-link (link-in-bio) platform as an alternative digital-recording solution that is lightweight, inexpensive, and does not require the development of a dedicated information system. Nevertheless, as cautioned by Stazić et al. (2023), the reliability of a digital recording system depends heavily on the quality and consistency of the data entered into it, so that personnel discipline in updating documents on Linktree remains key to the long-term success of the implementation, in line as well with the findings of Suprihartini et al. (2022) on a website-based maintenance data storage system.

In terms of equipment reliability, the relationship between scheduled maintenance and radar performance is further confirmed by Vidal et al. (2023), who recorded an improvement in Mode S radar detection performance following maintenance, and by Minteuan et al. (2021), who affirm that radar coverage accuracy is influenced by the antenna's physical condition and calibration. This reinforces the urgency of the RAPS-3 Maintenance SOP designed in this research, while also opening up opportunities for further development in the form of recording quantitative reliability indicators such as Mean Time Between Failure (MTBF), as recommended by Tomaszewska (2023), so that facility performance evaluation is not merely descriptive but also statistically measurable. Integrating such quantitative indicators is one relevant direction for further research. This research certainly has limitations that should be taken into account when interpreting its results. First, the research was conducted at a single case-study site, so generalization to other Airport Authority Offices should be made with caution, given that equipment characteristics and organizational needs may differ across regions. Second, evaluation of the SOPs and the monitoring feature is still limited to the trial-and-error testing stage and has not yet covered a long-term implementation period, so that its impact on reducing damage rates or improving work efficiency cannot yet be measured quantitatively. Third, the monitoring feature's dependence on a third-party platform (Linktree) also carries a sustainability risk should there be future changes in service policy, so that the recommendation to develop toward an official institutional website should become a priority for follow-up. Taking these limitations into account, further research is recommended to conduct a longitudinal evaluation of the effectiveness of the implemented SOPs and monitoring feature, and to expand the scope of the research to several Airport Authority Offices in order to obtain a more

comprehensive picture of the implementation of digital-based maintenance management systems in Indonesia's flight-navigation sector.

CONCLUSION

The design of a maintenance and repair management system for RAPS-3 at the Regional V Airport Authority Office of Makassar yielded three main achievements. First, the RAPS-3 maintenance procedure prepared based on Minister of Transportation Regulation No. PM 50 of 2017 proved necessary to align flight navigation personnel's understanding in carrying out maintenance steps according to standard, thereby helping to guarantee the equipment's operation and lifetime that a well-documented SOP becomes a work reference that helps an organizational unit carry out its functions consistently. Second, the RAPS-3 repair procedure, prepared with reference to the same regulation, plays an important role in governing the repair mechanism so that no differing interpretations arise that could disrupt equipment operations. Third, a Linktree-based feature for monitoring maintenance and repair history was successfully designed to make it easier for flight navigation personnel to access technical documents namely the maintenance procedure, the repair procedure, facility history, the facility log book, and the three types of monthly reports all of which were prepared based on Decree of the Director General of Air Transportation No. PR-DJPU 08 of 2025. As a follow-up, the three designs need to be promptly ratified and disseminated to flight navigation personnel, while the monitoring feature is recommended for further development using an official website to better ensure the security and maintenance of document data.

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AUTHOR CONTRIBUTIONS

Conceptualization, S.P., R.W and A.T.; Methodology, S.P.; Investigation and Data Collection, S.P., and M.K.A.,; Data Analysis, S.P. and R.A.; Writing-Original Draft, S.P., R.A., and A.T; Writing-Review and Editing, R.A., and A.T.; Supervision, R.A. and A.T.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest in this research.

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