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Digitalization of Aviation Security Logbook Recording at Mutiara Sis Al-Jufri Airport, Palu

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Abstract

Digital technology has transformed airport operations, yet AVSEC logbook recording at Mutiara Sis Al-Jufri Airport remains inefficient due to its manual process. This study aims to develop a digital system to enhance the efficiency and accuracy of activity logging. This study uses the Four-D (4D) R&D model, developing the system with AppSheet and Google Spreadsheet. Testing involved Black Box Testing and expert validation from aviation security and IT specialists.The digital logbook met user needs, earning feasibility scores of 100% (subject expert) and 98.75% (media expert). Black Box Testing confirmed proper functionality, and tests showed it improved speed, practicality, and efficiency over the manual method.

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1 INTRODUCTION

Air transportation is one of the primary modes of transport that plays a vital role in accelerating the mobility of people and goods, particularly in archipelagic countries such as Indonesia. One of the airports in Indonesia, Mutiara Sis Al-Jufri Airport, serves as the main air gateway for transportation in Central Sulawesi. This airport bears a significant responsibility in ensuring the smooth and secure operation of flights. The unit responsible for ensuring the fulfillment of aviation safety and security requirements is Aviation Security (AVSEC). Every incident or activity occurring at security checkpoints must be recorded in the operational logbook.

A logbook is a daily record or document containing detailed descriptions of activities performed, a clear explanation of operational tasks, and any challenges encountered in the field. It should be easily comprehensible for performance audits [1]. However, at this airport, AVSEC activity records are still maintained manually using paper-based media. This manual system is considered inefficient as it requires considerable time and effort. Manual logbook recording presents several weaknesses, such as vulnerability to damage, risk of loss, and the need for substantial physical storage space [2]. In addition, manual entry is prone to errors, such as inaccurate writing, deterioration of paper, or the loss of recorded data. The process is also less efficient, as it demands additional time and labor for management [3].

Therefore, transitioning from a manual logbook to a digital logbook is considered an appropriate solution. With the continuous advancement of digital technology, the process of entering logbook information becomes more convenient and practical. This approach also facilitates faster data compilation and retrieval, thereby improving work efficiency and organization [3].

Based on this background, the research problems addressed in this study are: (1) How can the design of a digital logbook system improve the efficiency of Aviation Security activity recording, and (2) What is the final outcome of the system development? This research is limited to the development of a system that includes only the features for data entry, storage, and printing of AVSEC logbooks in digital form, without integration with other airport systems. The objective of this study is to design an effective and efficient digital logbook system and to analyze the final outcome of its development in supporting aviation security operational activities at Mutiara Sis Al-Jufri Airport, Palu.

2 METHOD

In this study, the author employed the Research and Development (R&D) method. Research and Development is a methodology used to create a product and simultaneously evaluate whether the product can be effectively utilized [4]. The model adopted in this research is the Four-D (4D) model, developed by Sivasailam Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel in 1974. Initially, the Four-D model consisted of four stages: analysis, design, evaluation, and dissemination. However, following further refinement in training applications, the model became widely known as the Four-D model, comprising four phases: define, design, develop, and disseminate. This model is frequently applied in research and development to produce effective products that meet user requirements [5].

1. Define Stage
   The purpose of this stage is to establish and determine the development requirements through a needs analysis. This stage consists of five phases:
   a. Front-end analysis, Identifying the fundamental problems faced in order to obtain a clear understanding and alternative solutions for addressing these issues.
   b. Learner analysis, Identifying the characteristics and needs of the target users who are the focus of the product development.
   c. Task analysis, Identifying the essential tasks that must be carried out to meet the established minimum standards. The results of this analysis serve as the basis for determining the features that need to be included in the product to be developed.
   d. Concept analysis, Identifying the core concepts to be presented in a systematic manner and separating out irrelevant concepts. This analysis assists in illustrating how each developed feature will function.
   e. Specifying instructional objectives, Summarizing the results of the task analysis and concept analysis into objectives formulated in clear and measurable behavioral terms. This summary serves as the foundation for test preparation and product design.

2. Design Stage
   The design stage is based on the results of the analyses conducted in the previous stage. This stage consists of four phases:
   a. Constructing criterion-referenced tests, This phase serves as a link between the define stage and the design stage, in which the development of test standards is based on the results of specifying instructional objectives and learner analysis.
   b. Media selection, This phase involves aligning the results of the task analysis and concept analysis to determine the most appropriate medium or combination of media to be used, selecting those that best meet the identified needs.
   c. Format selection, This phase entails selecting the most suitable format to be applied in the product design. The choice of format depends on various factors identified during the earlier analysis stage.
   d. Initial design, This phase involves creating the complete initial design of the product prior to testing. The outcome of this phase is an initial prototype, which will subsequently be refined and further developed during the development stage.

3. Develop Stage
   This stage aims to realize the previously designed product or refine the prototype that has been created. It consists of two phases:
   a. Expert appraisal, Validation or assessment by experts or practitioners regarding the product design in terms of format, language, illustrations, and content. Feedback from experts assists in the revision process, ensuring the product becomes more accurate, effective, user-friendly, and possesses high technical quality.
   b. Developmental testing, Field testing conducted to obtain responses, reactions, and comments on the product under development. This testing should be carried out continuously until an effective and consistent product is achieved.

4. Disseminate Stage
   The purpose of this stage is to introduce the developed product so that it can be accepted and utilized by its intended users. This stage consists of three phases:
   a. Validating testing, The revised product from the development stage is implemented for the primary target users. At this stage, an evaluation is also conducted to assess the achievement of objectives and to determine the effectiveness of the developed product. If certain objectives are not met, the causes must be identified and solutions prepared to prevent similar issues during large-scale implementation.
   b. Packaging, Preparing the product in a form that is ready for distribution and use.
   c. Diffusion and adoption, The process of disseminating and encouraging the adoption of the product among target users.

The dissemination stage serves as the final step, aimed at implementing the system for its intended users—in this case, Aviation Security personnel at Mutiara Sis Al-Jufri Airport, Palu. The developed system is introduced and accompanied by user guidelines. Furthermore, initial usage observations are conducted to determine whether the application can improve the efficiency of work processes and digital AVSEC logbook recording. Feedback from users serves as an evaluation resource for future improvements.

This study was conducted up to the Develop stage and did not include the Disseminate stage. The focus of the research was on the design and development process of the digital logbook system as a prototype that could be tested on a limited basis. The exclusion of the dissemination stage was due to time constraints and the need for further preparations, such as user training and policy decisions by airport management, before the application could be implemented on a wider scale.

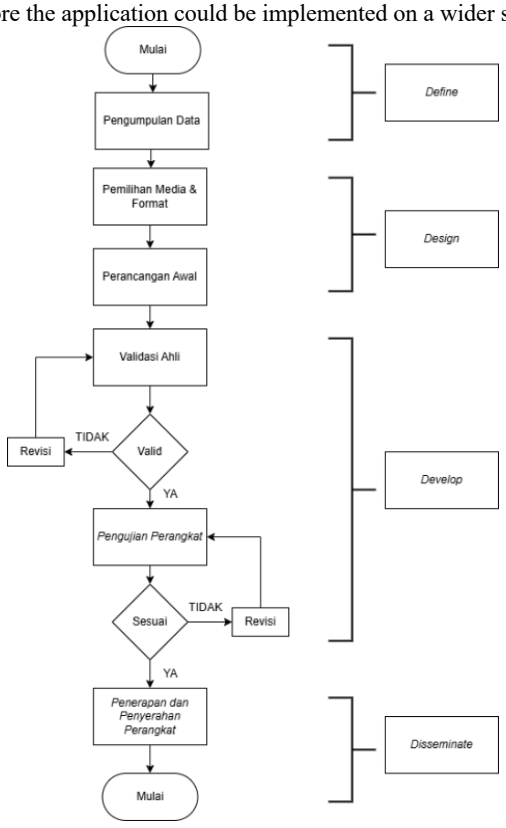


Figure 1 4D Model Workflow

The research instrument design in this study employs the Unified Modeling Language (UML) to create a representation of the system model to be developed. UML is a standardized modeling language used in software development to visualize, design, and document systems [6]. It models a system by illustrating the interactions between the system, external systems, and users through what is known as a Use Case Diagram. A Use Case Diagram provides a visual representation of the system's intended users (actors) and how they will interact with the system.

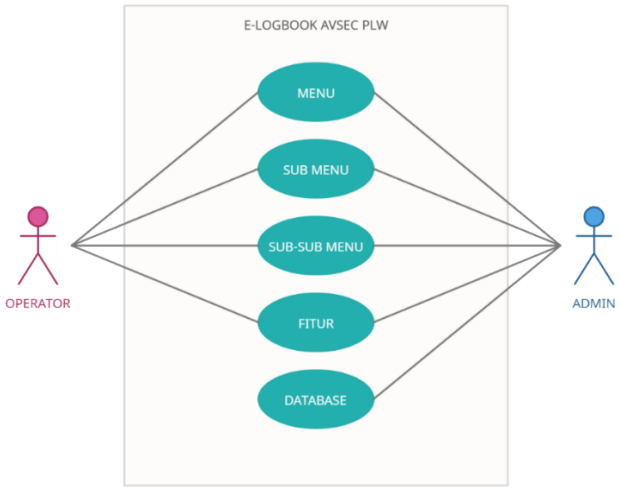


Figure 2 Use Case Diagram

The system workflow of the digital AVSEC logbook recording instrument is illustrated in a workflow diagram. A workflow is a structured work process in which a task or document is processed and passed sequentially from one party to another until the final objective is achieved in accordance with established procedures [7].

In this study, testing was conducted to evaluate system performance and to determine whether the system functions as intended or requires further improvement. The testing techniques used in this research include:

1. Testing
   Testing employed the Black Box Testing method to verify system functionality by comparing input with expected output. This testing is typically conducted in two stages: the first to examine the system's functionality, and the second to evaluate the application's interface and performance [8]. Additionally, simulation testing was conducted to compare the performance of the manual logbook system with the newly developed digital system.
2. Expert Validation
   Expert validation is conducted to ensure that the system meets the necessary standards for operational use. This process involves subject matter experts who assess the content feasibility and review both technical and functional aspects of the system.

The data analysis technique employed in this study utilized the Likert scale measurement formula. The Likert scale is a method used to determine the attitudes, opinions, or perceptions of an individual or group toward a particular subject [4]. Data analysis was carried out after the Develop stage was completed, based on the evaluation results provided by the experts. The Likert scale was applied to assess the validation outcomes from these expert evaluations.

Table 1 Likert Scale Values

Score	**Percentage (%)**	**Description**
5	81 – 100%	Highly Feasible
4	61 – 80%	Feasible
3	41 – 60%	Moderately Feasible
2	21 – 40%	Less Feasible
1	0 – 20%	Very Less Feasible

Interval data were analyzed by calculating the average of each respondent's answers, based on the value or score assigned to each response option. This approach helps identify the overall tendency of respondents' opinions. The analysis formula is as follows:

$$(\text{Total score obtained} \div \text{Ideal total score}) \times 100\%$$

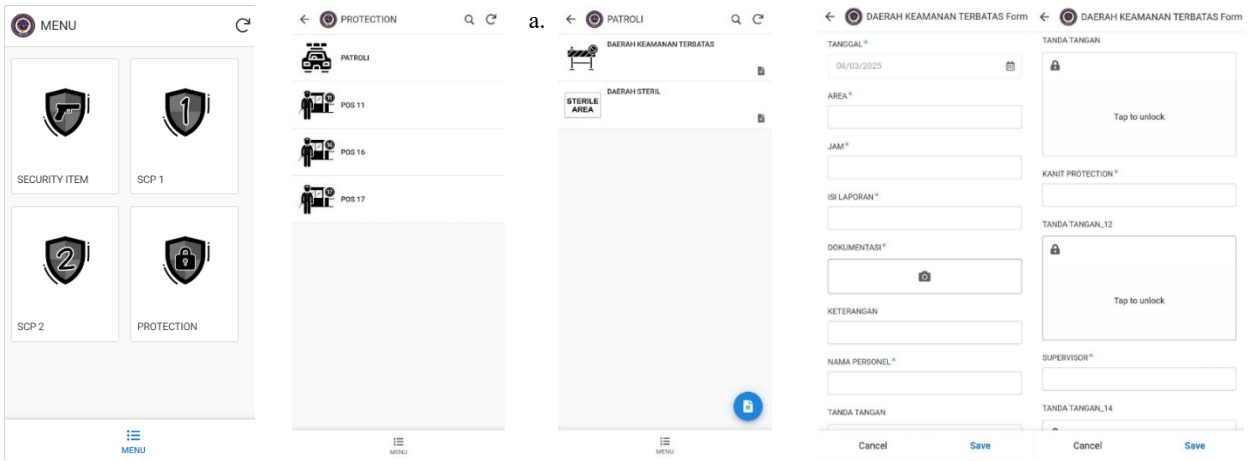
The percentage obtained from the data results is then interpreted into feasibility categories, allowing the information to be clearly presented and easily concluded.

RESULTS

Through the research and development process of a digital logbook recording system for the Aviation Security unit, using the 4D model, an application was produced to facilitate the daily activity recording of Aviation Security personnel. The development outcomes are presented and explained according to the stages of the model.

1. Define Stage
   In this stage, the researcher conducted an initial identification and analysis of the recurring problems faced by AVSEC personnel at Mutiara Sis Al-Jufri Airport, Palu, as well as their operational needs.
   a. Front-end analysis, The primary problem identified was that AVSEC logbook recording at Mutiara Sis Al-Jufri Airport was still performed manually. Based on this analysis, the researcher obtained an overall picture of user needs for a faster, more secure, and easily accessible recording system. An alternative solution identified was the development of a digital logbook recording system.
   b. Learner analysis, The results showed that most personnel possess basic skills in using digital devices such as smartphones and computers; however, they are not accustomed to using systematic applications for activity recording. From this analysis, it was determined that the system must be user-friendly, responsive, and operable without requiring specialized technical skills.
   c. Task analysis, This phase identified the primary tasks of AVSEC personnel related to logbook recording, such as documenting patrols, guard duties, sweeps, and activity reports. Based on this analysis, a digital logbook system was designed to include task-specific forms that could be completed quickly and in a structured manner.
   d. Concept analysis, The researcher identified the main concept to be incorporated into the system: a structured, easily accessible, and fully digital recording of daily AVSEC activities. The focus was placed on features directly relevant to AVSEC logbook operations at Mutiara Sis Al-Jufri Airport, while excluding unrelated concepts.
   e. Specifying instructional objectives, Clear objectives were formulated based on the results of the task and concept analyses. The stated objective was that AVSEC personnel should be able to correctly complete the digital logbook according to the type of activity, time, and duty location. These objectives became the foundation for system feature development, ensuring that the system effectively supports activity recording in line with operational requirements.

2. Design Stage
   In the Design stage, the researcher developed the initial design of the digital logbook system according to AVSEC operational needs.
   a. Constructing criterion-referenced tests, In this phase, the researcher developed evaluation instruments to bridge the define and design stages. The results of these tests served as a reference for designing the interface, menu structure, and application workflow to match the users' abilities and requirements.
   b. Media selection, This phase matched the results of the task and concept analyses to determine the most suitable medium for supporting digital logbook recording. Considering AVSEC personnel needs and the nature of their field duties, the researcher selected the AppSheet platform as the development tool and Google Spreadsheet as the data storage medium. This selection also took into account integration ease, efficiency, and user capability.
   c. Format selection, Based on previous analyses, the researcher selected a digital input form format integrated with a Google Spreadsheet-based tabular display. This format was chosen because it enables fast, structured, and easily comprehensible data entry for AVSEC personnel.
   d. Initial design, In this phase, the researcher developed the initial design of the digital logbook system, incorporating all planned features and the complete application workflow. The design was based on the identified needs and selected media. The outcome was an initial prototype of the AppSheet-based logbook application, which was functionally operational but had not yet undergone testing. The following are several interface displays of the developed system:
      b.



(a) (b) (c) (d)

Figure 4 (a) Menu (b) Sub Menu (c) Sub Sub Menu (d) Data Input Form

The Define and Design stages revealed that AVSEC's manual logbook system at Mutiara Sis Al-Jufri Airport Palu was ineffective for daily operations. A user-friendly, multi-device digital logbook was proposed using AppSheet integrated with Google Spreadsheet for data entry, storage, and real-time access. The simple, task-specific interface design became the foundation for further testing and development to create a more efficient and responsive application.

Upon completion of the application development, a testing process was conducted to ensure that the system functioned as intended and met the established objectives. The testing was performed using the Black Box Testing method, specifically employing the Use Case Testing technique. Use Case Testing is an approach that evaluates the system based on sequences of actions or activities typically performed by the user [9]. In addition, expert validation was carried out to assess the usability, functionality, content, and security aspects of the system. Feedback from the experts served as the basis for improvements and refinements before the system's broader implementation.

3. Develop Stage
   In the Develop stage, the completed application underwent initial testing to ensure all features functioned properly, followed by expert validation on functionality and interface design to assess operational feasibility. Feedback from this process guided revisions prior to wider deployment

   a. Developmental Testing
      At this stage, the researcher conducted testing on the developed digital logbook application using the Black Box Testing method. The testing involved providing inputs to the system's core features and observing whether the outputs produced aligned with the expected results.

Table 2 Black Box Testing

No.	Input Action	Expected Output	Conclusion
1	Pressing the "Sidebar" button	Displays features (about, feedback, share, app gallery, add shortcut)	Match
2	Selecting the "SCP" menu	Displays the SCP sub-menu	Match
3	Selecting the "Personnel List SCP" sub-menu	Displays the main page of the Personnel List SCP sub-menu	Match
4	Selecting the "Equipment List SCP" sub-menu	Displays the main page of the Equipment List SCP sub-menu	Match
5	Selecting the "SCP Personnel Rotation" sub-menu	Displays the main page of the SCP Personnel Rotation sub-menu	Match
6	Selecting the "SCP Findings" sub-menu	Displays the main page of the SCP Findings sub-menu	Match
7	Selecting the "Random SCP" sub-menu	Displays the main page of the Random SCP sub-menu	Match
8	Selecting the "Protection" menu	Displays the Protection sub-menu	Match
9	Selecting the "Patrol" sub-menu	Displays the Patrol sub-sub-menu	Match
10	Selecting the "Restricted or Sterile Area" sub-sub-menu	Displays the main page of the Restricted or Sterile Area sub-sub-menu	Match
11	Selecting the "Post 11" sub-menu	Displays the main page of the Post 11 sub-menu	Match
12	Selecting the "Post 16 or 17" sub-menu	Displays the Post 16 or 17 sub-sub-menu	Match
13	Selecting the "Post 16 or 17 Facilities List" sub-sub-menu	Displays the main page of the Post 16 or 17 Facilities List sub-sub-menu	Match
14	Selecting the "Post 16 or 17 Activity List" sub-sub-menu	Displays the main page of the Post 16 or 17 Activity List sub-sub-menu	Match
15	Selecting the "Security Item" menu	Displays the main view of Security Item	Match
16	Selecting the "Input Data" feature	Displays the data report input form	Match
17	Pressing the "Cancel" button	Data is discarded and returns to the main page	Match

No.	Input Action	Expected Output	Conclusion
18	Pressing the “Save” button	Data is saved to the database and appears on the main page	Match
19	Selecting the “Data Recap” feature	Opens the Google Spreadsheet where the data is stored (view only)	Match

b. Expert Appraisal (Expert Validation)
The digital logbook system was validated by aviation security and IT experts to evaluate its interface design, language, content completeness, and usability. Feedback from this process was used to revise and enhance the system, ensuring it is effective, user-friendly, and technically suitable for field implementation.

The validation of the digital Aviation Security logbook system in terms of content was carried out by Dr. Didi Hariyanto, S.Pd., M.Pd., a lecturer at the Surabaya Aviation Polytechnic and an expert in aviation security. The results of the content expert validation are as follows:

Table 3 Material Expert Results

No.	Aspect	Score	Category
1	Usability	100%	Highly Feasible
2	Functionality	100%	Highly Feasible
3	Content	100%	Highly Feasible
4	Security	100%	Highly Feasible
Total Score	—	**100%**	**Highly Feasible**

The media expert validation was conducted by Ahmad Musadek, S.T., M.MT., a lecturer at the Surabaya Aviation Polytechnic with expertise in media and information technology. The results of the media expert validation are as follows:

Table 4 Media Expert Results

No.	Aspect	Score	Category
1	Usability	100%	Highly Feasible
2	Functionality	100%	Highly Feasible
3	Content	95%	Highly Feasible
4	Security	100%	Highly Feasible
Total Score	—	**98.75%**	**Highly Feasible**

Subsequently, system testing was conducted with the aim of evaluating the effectiveness and efficiency level of the developed digital logbook application. The testing focused on three main aspects: recording time speed, work process efficiency (effort), and data storage effectiveness. Considering the limitations in conducting direct field trials, the testing was carried out through a simulation conducted by the researcher.

Table 5 System Comparison Simulation Test

No	Testing Activity	Manual Logbook	Digital Logbook
1	Data entry for 5 activities	5 minutes, <1.5 minutes (per activity)	3 minutes, <1 minute (per activity)
2	Data transmission and storage	5–6 minutes From the airport to the operations office for data archiving	<1 minute Data is directly stored in the spreadsheet and on the cloud
3	Data reporting	Documentation and data recording are reported separately	Documentation and data recording are conducted in a single process

No	Testing Activity	Manual Logbook	Digital Logbook
4	Workflow steps	1. Open file 2. Fill in logbook – print / 3. Print – fill in logbook 4. Request / wait for supervisor's signature 5. Deliver logbook to the operations office for archiving Total: 5 steps	1. Open application 2. Fill in logbook 3. Save (supervisor's signature can be added after input, and data is stored automatically) Total: 3 steps
5	Data retrieval	>30 seconds Retrieval can take considerable time, especially if storage is not well-organized	<30 seconds Retrieval uses a search feature

Testing through black box functional assessment and usage simulation showed the digital logbook operates optimally and meets design objectives. Compared to the manual system, it offers shorter data entry times, fewer workflow steps, and faster data retrieval. The system is technically sound and enhances AVSEC's operational efficiency, making it suitable to replace the manual logbook.

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