Design of a Digital-Based Airport Terminal Facilities and Infrastructure Map to Improve Service at Adi Soemarmo Airport

Galih Nuswantara[1], Laila Rochmawati[2], Dani Chandra Yudho Pranoto[3]

Air Transport Manajement, Aviation Polytechnic of Surabaya

[1,2,3] *Politeknik Penerbangan Surabaya*
**Corresponding author. Email: nuswantara@poltekbangsby.ac.id*

ABSTRACT
In airport service management, passenger satisfaction is an important indicator, and one of the determining factors is ease of access to terminal facilities and infrastructure. Currently, Adi Soemarmo Airport does not have an interactive digital map, which makes it difficult for passengers to find facilities such as waiting rooms, toilets, and check-in counters. This situation underscores the need for a technology-based information system to improve passenger services. The goal of this study is to design a web-based digital map that will facilitate navigation of the terminal facilities and improve service quality. The research method uses an R&D approach involving needs analysis, field observation, terminal layout documentation, and expert validation. The resulting product is a digital map application with features such as "My Location," "Select Destination," "Show Directions," and "Help." Validity test results showed scores of 80% from subject matter experts, 100% from IT experts, and 92% from airport experts, for an average accumulated score of 90.6%. This score is categorized as feasible for use. These results confirm the high feasibility of the designed digital map in terms of content, technology, and operations. It can be implemented as an innovation in passenger services at Adi Soemarmo Airport.

Keywords: passenger satisfaction, digital map, airport infrastructure, expert validity, airport services

1. INTRODUCTION

Adi Soemarmo Airport in Boyolali Regency is one of the airports that serves domestic and international flights in the Central Java region. The airport plays a vital role as an air transportation hub in supporting the mobility of people and goods, as well as being the first face that reflects the image of a region. The existence of commercial flights has made it easier for the community to establish connections in the economic, government, tourism, and other sectors [1].

Along with the development of the digital era, information technology has become an important foundation in supporting the operational success of an organization [2]. Digital transformation has brought significant breakthroughs in the field of information and communication, enabling organizations to improve the effectiveness of their services [3]. Adi Soemarmo, as one of the means of air transportation in the Surakarta region [4], currently still has limitations in providing information media for passengers. This condition has an impact on reducing the comfort and experience of service users in utilizing airport facilities.

A digital map is a non-physical form of a conventional map that can be accessed through electronic devices [5]. Maps also serve as a means of communication between information creators and users [6]. In the context of transportation organizations, innovation in information interaction is an important contribution to making airport management more adaptive and able to meet the diverse needs of passengers [7]. One form of innovation in information presentation is the use of QR Code technology, which can store data in two dimensions and make it easier for users to access digital maps compared to conventional barcodes [8].

Furthermore, facilities can be defined as anything that helps facilitate an activity, whether physical or non-physical [9]. Service itself is a series of activities that arise from the interaction between service providers and users to provide solutions to specific needs [10]. Thus, the existence of interactive digital maps at airports can be

seen as part of the facilities and services that support efficiency, comfort, and passenger satisfaction.

Currently, the information available at Adi Soemarmo is still limited, thereby reducing time efficiency and passenger comfort. Therefore, innovation in the form of an interactive digital map that can be accessed via mobile devices, accurately displays the location of facilities, and provides real-time walking route guidance is needed. This study aims to design a web-based digital map prototype to map terminal facilities and infrastructure, thereby improving service quality at Adi Soemarmo Airport.

2. METHODOLOGY

This type of writing is a form of research and development (R&D), as described in Writing Methodology by Dr. Sugiyono (2013). R&D is a method of writing used to produce products and test the effectiveness of these methods [11]. Writing design is the framework used to carry out writing [12]. According to Sugiyono (2013), producing a specific product requires writing that analyzes needs. Additionally, to ensure the product's effectiveness and functionality in society, it is important to conduct research that tests the product's effectiveness.

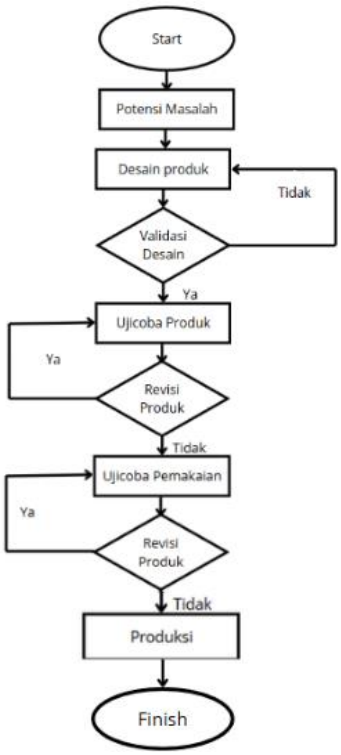

Figure 1 Research Workflow Structure

Based on Figure 1, the research process comprises the following stages:

1. **Potential and Problems** were identified through field observations at the Adi Soemarmo Airport terminal. The main issues were that many passengers had difficulty locating facilities, there was limited staff available to assist them, and there were no digital maps.
2. **Product Design** Based on the needs analysis, a web-based digital map prototype was designed that can be accessed via QR codes placed at strategic points throughout the airport. The digital map displays the terminal layout, facility locations, and user access routes.

   a. Digital Map Design

   The digital map was designed to create a web-based prototype that displays the layout of Adi Soemarmo Airport's terminal and the locations of its facilities and infrastructure. The design emphasizes simplicity and ease of access, making it easy for all passengers to understand. The map includes interactive icons for facilities such as toilets, waiting rooms, check-in counters, prayer rooms, and other support services, as well as brief descriptions and important contact information for each facility. The interface is responsive, allowing it to be opened on mobile devices without installing additional applications.

   b. QR Code Design

   To support quick access, the digital map is linked via QR codes placed at strategic points with high passenger density. The QR codes are proportional in size, have high color contrast, and feature additional visual elements, such as the airport logo and instructions to "Scan for Airport Map." The physical QR codes are printed on information boards that are easily accessible to passengers. These QR codes connect users' devices directly to the digital map page, shortening and simplifying the access process
3. **Design validation** The initial design was validated by subject matter experts, IT experts, and aviation experts to assess content feasibility, system functionality, and suitability for the airport context.

   Validity is a test to explain how good the data collected from research instruments is [13]. The preliminary design was then validated by experts to ensure its suitability and effectiveness. Validation was conducted by Dr. Laila Rochmawati, SS., M.Pd. as product content validator, Mr. Rizky Edsha Wardana as airport expert, and Mr. Dani Chandra YP, S.Kom. as product system validator. This process aimed to obtain input on the feasibility, content accuracy, and technical suitability of the system. This stage uses a questionnaire instrument. The results of this validation process are calculated using an assessment instrument, so that the level of

product feasibility can be determined before entering the field trial stage.

Meanwhile, usability testing involves general users through a Likert-scale-based questionnaire to measure the level of ease of use, calculated using the formula [14].

$$\text{Feasibility Percentage} = \left(\frac{\text{Observed Score}}{\text{Expected Score}}\right) \times 100\%$$

Table 1 feasibility percentage

No.	Category	Percentage
1	Very Feasible	81% ≤ X ≤ 100%
2	Feasible	61% ≤ X ≤ 80%
3	Fairly Feasible	41% ≤ X ≤ 60%
4	Less Feasible	21% ≤ X ≤ 40%
5	Not Feasible at All	< 20%

To ensure the system is running effectively and according to its objectives, validation tests are conducted using the ISO 25010 Software Quality Model. ISO/IEC 25010 is a quality model that can be used as a standard for measuring software quality [15].

4. **Product Trial** Initial trials were conducted with a small group of five passengers and five airport staff members. This stage aimed to evaluate the feasibility of the digital map prototype's basic functions, such as location features, destination selection, and route calculation, as well as the interface's ease of use. The results were then used to make initial revisions to the display, navigation, and accuracy of the information.
5. **Product revision** Feedback from the trial phase was used to improve the digital map's appearance, content, and navigation.
6. **Field Usage Test** After the revisions were made, the prototype was tested more extensively in real conditions at the airport with a larger group of participants. Users were asked to access the digital map via QR codes placed at strategic points and then evaluate the practicality of access, the clarity of the information provided, and the usefulness of the navigation features.

   Additionally, the field test stage used a stress test method involving a simulation with the maximum estimated number of visitors to the airport terminal. This simulation ensured that the system would remain responsive and stable and capable of accurately displaying facility data even when accessed simultaneously by many users. The results of this test formed the basis for final product refinement prior to implementation.
7. **Final revision** The product was refined based on field test results to ensure that it met user needs.
8. **The final product** was a digital map with QR code support ready for implementation as a means of passenger information in the airport.

3. RESULT

1. **Potential and Problems**

   Identification was carried out through field observations at the Adi Soemarmo Airport terminal. The main finding was that information media were limited, which caused many passengers to have difficulty finding public facilities, such as restrooms, prayer rooms, and waiting rooms. Additionally, there were no digital maps available for independent access. A questionnaire administered to five passengers reinforced these findings; all respondents expressed the need for a practical, easy-to-use digital map accessible via mobile devices.
2. **Product Design**

   The solution is a web-based digital map that can be accessed via a QR code. This product displays terminal layouts, facility locations, and key features such as "My Location," "Destination Location," and "Show Me the Way" to display the user's access route. The flowchart illustrates the interaction process between the user and the system, from scanning the barcode to displaying the destination route on the digital map.

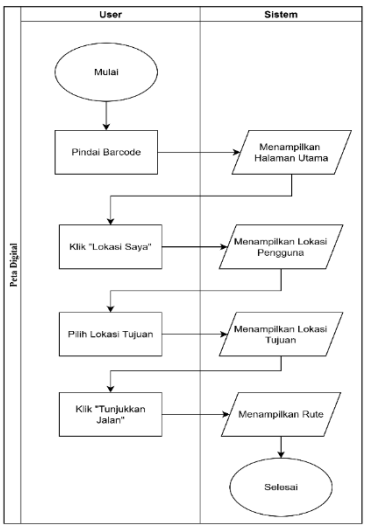

Figure 2 System Flowchart

The map interface was designed with floor plan design software and implemented with HTML, CSS, and JavaScript to ensure responsiveness on mobile devices.

```
<!DOCTYPE html>
<html lang="id">
<head>
  <meta charset="UTF-8" />
  <meta name="viewport" content="width=device-width, initial-scale=1.0"/>
  <title>Peta Bandara Adi Soemarmo</title>

  <!-- Leaflet CSS -->
  <link rel="stylesheet" href="https://unpkg.com/leaflet/dist/leaflet.css" />
  <link rel="stylesheet" href="style.css" />
  <link href="https://fonts.googleapis.com/css2?family=Nunito:wght@400;600;700&display=swap" rel="stylesheet">

  <!-- Leaflet JS -->
  <script src="https://unpkg.com/leaflet/dist/leaflet.js"></script>

  <!-- Script utama -->
  <script src="map_final_patched.js" defer></script>

  <!-- Modal Close Script -->
  <script>
    function closeModal() {
      document.getElementById("landingModal").style.display = "none";
    }
```

Figure 3 HTML Coding

The author designed QR code posters that were placed in strategic areas of the terminal, such as the entrance, waiting room, and check-in area, to make them easily accessible to passengers. These posters displayed a unique QR code that, when scanned, directed users directly to the airport's digital map page. The poster design is simple yet informative with contrasting colors and brief instructions, allowing even ordinary passengers to easily understand how to use it.

Figure 4 QR codes implemented in posters

3. **Design validation**

Three experts carried out the validation: a subject matter expert, an IT expert, and an aviation expert. They evaluated the design according to the ISO 25010 — Software Quality Model standard, which assesses usability, functional suitability, performance efficiency, reliability, and accuracy. The validation results showed scores of 80% from the subject matter expert, 100% from the IT expert, and 92% from the aviation expert, for an average of 90.6%. These results indicate that the digital map is fit for use.

4. **Product Trial**

A limited trial was conducted with five passengers and five airport officials. Respondents were asked to access the digital map and try out its features. The evaluation results showed that initial satisfaction levels were relatively low (55–75%). The main criticisms were related to the consistency of symbols, the clarity of the display, and the lack of visual appeal.

5. **Product revision**

Based on the initial trial results, improvements were made to the product. These revisions aimed to improve visual quality, align symbols with airport standards, and simplify the layout for easier understanding.

6. **Field Usage Test**

A field trial involving a wider range of respondents (both passengers and officers) was conducted to test the product's effectiveness in real-world conditions. The testing included a stress test using a simulation of the highest visitor volume. Results showed that the system could process over 3,000 requests with an average response time of 303 ms and no significant system failures. User satisfaction increased as well, with most respondents giving a rating above 85%.

7. **Final revision**

The results of the field testing formed the basis for final product improvements. These revisions focused on minor visual improvements, simplified navigation icons, and optimized access speed on mobile devices.

8. **The final product**

The final product is an interactive digital map that is ready to be implemented at Adi Soemarmo Airport. It can be easily accessed by scanning the QR code installed in strategic areas of the terminal. The digital map displays the terminal layout, facility locations, and interactive routes to help passengers navigate the airport independently. The official website can be accessed at http://petadigitalsoc.my.id/. This product is

expected to meet users' needs in exploring areas more easily and efficiently. The final result can be seen as follows:

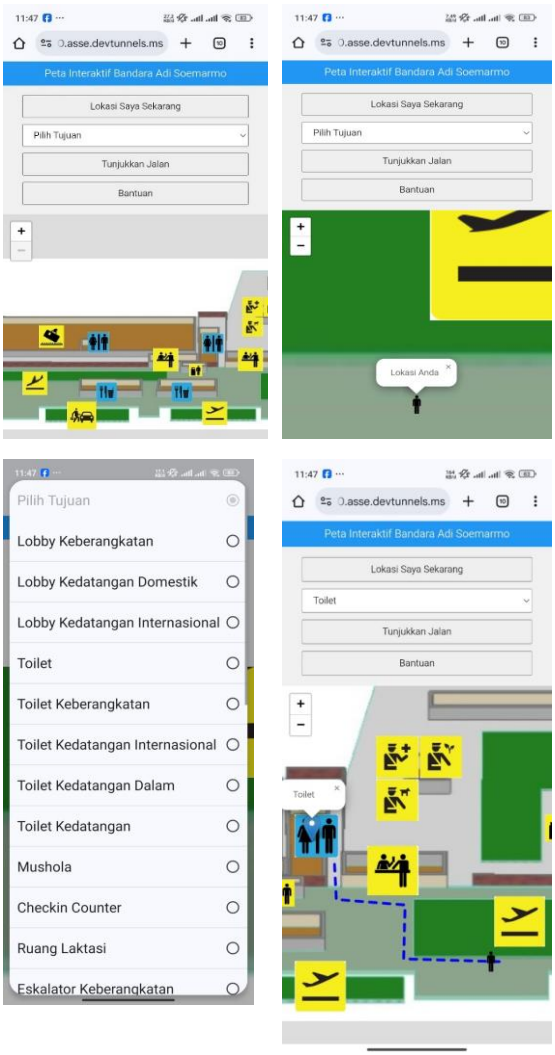

Figure 5 Airport Digital Map Interface Display, Main Display (left up), The My Location feature (right up), Destination Location Feature (left down), Show Way Feature (right down)

This is the first screen users see when opening the application. It displays an interactive visual map of the airport, including terminals, gates, restrooms, check-in counters, and other facilities. It also shows UI elements, such as headers and menu buttons. Its main function is to provide users with initial orientation before selecting advanced features without displaying navigation paths or user positions.

This feature displays the user's current position on the map using a special icon, either manually or automatically via location detection. Its purpose is to provide an initial reference for users before starting navigation to a specific destination.

This feature allows users to select a destination, such as a gate, restroom, waiting room, or check-in counter, from an available list. The system marks the destination with an icon or label for easy recognition as the final point before the route is displayed.

This feature calculates and displays the fastest or shortest route between the starting point and the destination. The route is visualized using lines that adjust to actual conditions and follow the corridors and structure of the airport floor plan. This feature helps users navigate efficiently and accurately.

4. CONCLUSION

This research produced a web-based digital map that can be accessed via a QR Code at Adi Soemarmo Airport as a solution to the limitations of conventional information media. Identification of potential and problems showed that passengers had difficulty finding facilities, while there was no adequate digital map service available. The product design in the form of an interactive digital map displays terminal layouts, facility locations, and navigation routes that can be easily accessed via mobile devices.

Validation by experts—consisting of subject matter experts, IT experts, and aviation experts—resulted in an accumulated score of 90.6%, indicating that the product is feasible for use. Initial trials with five passengers and five officers showed that the system works well, although improvements are still needed in terms of visual appearance and symbol consistency. After revisions, a more extensive field trial showed a significant improvement in system satisfaction and performance, with an average score of over 85%.

The final result, a digital map accessible via QR Code, has been produced and can be used by passengers at the airport. With this system, passengers can more easily find facilities, save time, and enhance their travel comfort. This research proves that the integration of information technology, particularly web-based digital maps, can support service quality improvement in the air transportation sector.

5. AUTHORS' CONTRIBUTIONS

This article was jointly developed through clearly defined roles and responsibilities undertaken by the author and academic supervisors. The following contributions summarize the participation of each party throughout the research and publication process:

1. Design Planning and Concept Development: Author 1 initiated the research idea, formulated the problem statements, established the

objectives, and designed both the research methodology and instruments based on the Research and Development (R&D) approach.

2. Data Collection and Analysis: Author 1 conducted field observations at Adi Soemarmo Airport, distributed questionnaires to passengers and airport staff, processed the data using descriptive statistical analysis, and interpreted the research findings related to service quality and digital navigation needs.

3. Digital Map System Development: Author 1 designed and implemented a web-based digital map system, including the integration of facilities layout, route-finding features, and QR Code access. The system was tested through functional trials, small group try-outs, and stress tests under simulated user loads.

4. Academic Supervision and Guidance: Author 2 and Author 3 provided scientific supervision, validated the instruments and design process, and offered input on the structure, content, and presentation of the research to ensure academic rigor.

5. Manuscript Writing and Revision: Author 1 prepared the entire manuscript draft, from introduction to conclusion, and revised it according to feedback from supervisors and examiners.

6. Final Approval: All authors and supervisors reviewed and approved the final version of the manuscript for publication.

This study presents an innovative and practical solution to enhance passenger experience and service quality at Adi Soemarmo Airport through the development of a QR Code–based digital map system. The structured collaboration between the author and supervisors ensured academic integrity and impactful research outcomes.

ACKNOWLEDGMENTS

The author sincerely thanks Adi Soemarmo Airport for their support and permission in facilitating the data collection process. Appreciation is also extended to all respondents for their willingness to participate and share valuable insights that contributed to this research. Special gratitude is given to the supervising lecturer for continuous guidance and constructive feedback, as well as to research colleagues for their ideas and encouragement throughout the study. Without the assistance and cooperation of all these parties, this research would not have been possible.

REFERENCES

[1] A. N. Marsyi'ah and N. Wulan, "Analisis Implementasi Fungsi Manajemen Pada Unit Informasi Dalam," *J. Kaji. dan Penelit. Umum*, vol. 1, no. 4, pp. 106–125, 2023, [Online]. Available: https://doi.org/10.47861/jkpu-nalanda.v1i4

[2] L. L. Johanis and A. R. Tanaamah, "Analisis Tata Kelola Teknologi Informasi Pada Kantor Otoritas Bandar Udara Wilayah Viii Manado Menggunakan Framework Cobit 5 Pada Domain Mea," *Indones. J. Bus. Intell.*, vol. 5, no. 1, p. 52, 2022, doi: 10.21927/ijubi.v5i1.2266.

[3] V. N. Cahya Ningtyas and R. Angin, "Inovasi Menuju Transformasi Digital dalam Pelayanan Publik Kajian Sistem Manajemen Pelayanan Desa (SIMPEDA) di Desa Balung Lor," *Indones. J. Public Adm. Rev.*, vol. 1, no. 1, pp. 1–11, 2023, doi: 10.47134/par.v1i1.1937.

[4] Sulthan Abdi Rahman Mafaza and Eny Sri Haryati, "Analisis Safety Management System Petugas AMC Dalam Menangani Bahaya Hewan Liar di Area Airside Bandar Udara Adi Soemarmo Surakarta," *J. Multidisiplin Madani*, vol. 2, no. 5, pp. 2533–2550, 2022, doi: 10.55927/mudima.v2i5.370.

[5] K. Widyatmoko and V. A. Budiman, "Peta wisata interaktif," vol. 12, no. 5, pp. 1–9, 2016, [Online]. Available: https://core.ac.uk/download/pdf/35382127.pdf

[6] M. A. C. Donya, B. Sasmito, and A. L. Nugraha, "Visualisasi Peta Fasilitas Umum Kelurahan Sumurboto Dengan Arcgis Online," *J. Geod. Undip*, vol. 9, no. 4, pp. 52–58, 2020.

[7] E. Radiansyah, "Peran Digitalisasi Terhadap Kewirausahaan Digital Tinjauan Literatur Dan Arah Penelitian Masa Depan," *J. Ilm. Manaj. Bisnis Dan Inov. Univ. Sam Ratulangi (JMBI Unsrat)*, vol. 9, no. 23, pp. 828–837, 2022.

[8] V. Rahmadhani and Widya Arum, "Literature Review Internet of Think (Iot): Sensor, Konektifitas Dan Qr Code," *J. Manaj. Pendidik. Dan Ilmu Sos.*, vol. 3, no. 2, pp. 573–582, 2022, doi: 10.38035/jmpis.v3i2.1120.

[9] N. W. Sutisna and A. Effane, "Fungsi Manajemen Sarana dan Prasarana," *Karimah Tauhid*, vol. 1, no. 2, pp. 226–233, May 2022, doi: 10.30997/KARIMAHTAUHID.V1I2.7719.

[10] A. Nur Alamsyah, "Pengaruh Kualitas Pelayanan Informasi Terhadap Kepuasan Penumpang Di Pt. Angkasa Pura I Bandar Udara Internasional Ahmad Yani Semarang," *Flight Attend. Kedirgant. J. Public Relation, Pelayanan, Pariwisata*, vol. 4, no. 1, pp. 177–181, 2022, doi: 10.56521/attendant-

dirgantara.v4i1.441.

[11] Hanafi, “The Concept of Research in Education,” *Routledge Libr. Ed. Philos. Educ. 21 Vol. Set*, vol. 21, no. 1989, pp. 137–153, 2022, doi: 10.4324/9780367352035-10.

[12] M. Waruwu, “Metode Penelitian dan Pengembangan (R&D): Konsep, Jenis, Tahapan dan Kelebihan,” *J. Ilm. Profesi Pendidik.*, vol. 9, no. 2, pp. 1220–1230, 2024, doi: 10.29303/jipp.v9i2.2141.

[13] R. N. Amalia, R. S. Dianingati, and E. Annisaa’, “Pengaruh Jumlah Responden terhadap Hasil Uji Validitas dan Reliabilitas Kuesioner Pengetahuan dan Perilaku Swamedikasi,” *Generics J. Res. Pharm.*, vol. 2, no. 1, pp. 9–15, 2022.

[14] U. U. Sufandi, M. Priono, D. A. Aprijani, B. A. Wicaksono, and D. Trihapningsari, “Uji Usability Fungsi Aplikasi Web Sistem Informasi Dengan Use Questionnaire (Studi Kasus: Aplikasi Web Sistem Informasi Tiras Dan Transaksi Bahan Ajar),” *J. Pendidik. Teknol. dan Kejuru.*, vol. 19, no. 1, pp. 24–34, 2022, doi: 10.23887/jptk-undiksha.v19i1.42320.

[15] M. D. Mulyawan, I. N. S. Kumara, A. Bagus, Ida Swamardika, and K. O. Saputra, “Kualitas Sistem Informasi Berdasarkan ISO / IEC 25010,” *J. Ilm. Teknol. Elektro*, vol. 20, no. 1, pp. 15–28, 2021.