

# Design and Evaluation of a Virtual Tour–Based Application for the Placement Criteria of the Instrument Landing System (ILS)

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**Abstract** - The Instrument Landing System (ILS) is a critical component of aviation navigation that ensures aircraft landing accuracy and safety. However, public understanding of restricted ILS areas and equipment placement criteria remains limited, as existing informational media—such as regulatory documents or slide presentations—lack interactivity and spatial visualization. This study aims to design and evaluate a Virtual Tour-based ILS Application as an interactive educational medium to visualize and explain the placement criteria of ILS equipment in a three-dimensional (3D) environment. The research used the ADDIE (Analysis, Design, Development, Implementation, Evaluation) instructional design model to systematically develop the application. The content and functional design were derived from the Indonesian Civil Aviation Authority's SKEP/113/VI/2002 and ICAO Annex 10 Volume I standards. Data collection methods included observation, expert validation, and user testing. The application was evaluated using three quality dimensions of the ISO 25010 software standard: functional suitability, compatibility, and usability. Participants included media experts, subject matter experts, and 20 community members residing near Budiarto Airport, Indonesia. As a result, the Virtual ILS application achieved high evaluation scores across all dimensions—functional suitability (97.5%), compatibility (100%), and usability (90.16%)—indicating excellent performance, ease of use, and educational value. The interactive 3D visualization effectively improved users' comprehension of ILS restricted zones and equipment placement requirements, compared to conventional informational media.

**Keywords** — *Instrument Landing System (ILS); Virtual Tour; Aviation Education; Air Navigation; ISO 25010; ADDIE Model; Human-Computer Interaction.*

## I. Introduction

In aviation, one of the key technologies that plays a crucial role in ensuring safety is the Instrument Landing System (ILS).[1]The Instrument Landing System (ILS) functions to provide accurate signals to aircraft regarding the runway centerline (localizer), descent angle (glide path), and distance to the landing point (marker beacon).[2]. The ILS plays a critical role in ensuring the safety and precision of aircraft landings by providing accurate azimuth and glide path signals to pilots. Due to its sensitivity to interference, the system requires restricted areas free from physical obstructions that may disrupt signal propagation. These areas are strictly regulated under provisions such as the Indonesian Ministry of

Transportation Regulation Number 33 of 2015 concerning permits for access to restricted areas.[3] as well as Law Number 1 of 2009, Article 210, concerning the Aviation Operational Safety Zone (KKOP), which prohibits the presence of buildings or objects exceeding the prescribed height limits.[4]. A study by Aldiefa[5] found that community mobility around the localizer equipment at Adi Soemarmo Airport, Solo, contributed 11.76% to the degradation of signal transmission performance due to the presence of a roadway within the critical area.[6]

Public awareness of this safety zone remains limited, as existing information is currently available only through regulatory documents and technical manuals. A survey conducted by the researcher involving 20 respondents around Budiarto Airport, Curug, also indicated that 18 respondents did not yet understand the criteria for ILS equipment placement or the boundaries of its restricted areas. This limitation is attributed to the conventional modes of information delivery, such as regulatory documents, technical manuals, and PowerPoint presentations.[7], this makes the information difficult for the general public to understand. In line with the advancement of the digital era, there is a need for more engaging, innovative, and easily accessible educational media without limitations of time and location.[8]

In the context of education, Wibawa[9] emphasizes that the utilization of technology in the era of the Industrial Revolution 4.0 aims to facilitate learning activities through the integration of interactive and adaptive digital media. One form of digital technology application that is relevant to modern educational needs is the use of Virtual Tours, which can present realistic and interactive visualizations of complex environments.[10]

Virtual Tour technology has significant potential to address these challenges. According to Nata et al.[11], Virtual Tour–based media can stimulate imagination, enrich the learning experience, and provide realistic visualizations of complex objects. Taufiqurrohman et al.[12] also demonstrated that the use of Virtual Tour–based educational media can improve learners' understanding, with an average score of 85.54, higher than that achieved using PowerPoint media, which scored 83.1.[13][14]

Several previous studies have utilized Virtual Tour technology as an interactive learning medium. However, research that specifically visualizes the placement criteria of



Instrument Landing System (ILS) equipment as well as the boundaries of restricted air navigation areas in the form of three-dimensional simulations remains limited. Therefore, this study proposes a scientific contribution in the form of developing a Virtual Tour-based Virtual ILS application that integrates 3D visualization, aviation regulatory standards, and system quality evaluation based on ISO 25010 as an interactive educational medium for communities around airports.

## II. Research Method

This study applies the ADDIE instructional design model (Analysis, Design, Development, Implementation, and Evaluation)[15] as a systematic framework for the development of a Virtual Tour-based Virtual ILS application. During the Analysis phase, problem identification and user needs analysis are conducted to formulate the functional specifications and required system components.[16] The Design phase focuses on developing the system architecture and user interaction flow through the preparation of storyboards, HIPO diagrams, activity diagrams, and use case diagrams to ensure alignment between user requirements and the application design.[17] The Development phase involves the development of the user interface using Visual Studio Code.[18], three-dimensional (3D) modeling of ILS equipment and the airport environment using SketchUp, realistic visual rendering using Enscape, and integration of the rendered outputs into the Lapentor platform to develop an interactive 360° virtual tour.[19] In the Implementation phase, the application is deployed and its accessibility is tested across various devices (computers, laptops, and smartphones) as well as web browsers to ensure system compatibility.[20]

The Evaluation phase is conducted comprehensively through validation by subject matter experts and media experts. The sampling technique employed in this study is purposive sampling, defined as the deliberate selection of respondents based on specific criteria, namely individuals residing in the vicinity of Budiarto Airport, Curug. A total of 20 respondents were selected to represent initial users in the application evaluation stage based on the ADDIE model. This number is considered sufficient to obtain preliminary feedback on the functionality, compatibility, and usability of the application prior to further development.[21] The research instrument employs a Guttman scale questionnaire to assess the material and media aspects,[22] as well as a five-point Likert scale to measure usability based on the indicators of learnability, efficiency, memorability, errors, and satisfaction.[23] Data analysis is conducted quantitatively by converting the scores into percentages to determine the feasibility level of the application based on relevant software evaluation standards.[24]

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Data Analysis Technique: quantitative data analysis is applied to the collected data. To measure the improvement in users' understanding of the material presented in the Virtual ILS application, the analysis may be developed using a pre-test and post-test approach. The differences between the results before and after using the application are then analyzed using N-Gain calculations to determine the level of improvement in users' understanding quantitatively. The evaluation data are derived from questionnaire responses that have been converted into a Likert scale by calculating the total scores of respondents' answers, which are subsequently translated into percentage scales[26]. The Guttman scale is used in the expert validation stage to obtain definitive responses in two categories, namely "yes" and "no," which are then converted into binary scores to determine the validity level of the material and media.[27] Meanwhile, a five-point Likert scale is used in usability testing, with a score range of 1–5 representing the respondents' level of agreement. The obtained scores are then transformed into percentages to determine the feasibility category of the application. The percentage calculation is performed using the following formula:

$$Percentage = \frac{Obtained\ Score}{Maximum\ score} \times 100\% \quad (1)$$

After obtaining the percentage calculation results, the data are converted into categorical statements based on the Likert Percentage Interpretation criteria as presented in the following table.[28]. Prior to use in testing, the questionnaire instrument is first subjected to validity and reliability testing to ensure measurement consistency and accuracy. Reliability testing is conducted using the Cronbach's Alpha coefficient.[29] The instrument is considered reliable if the Cronbach's Alpha value exceeds 0.70, thereby making it suitable for use as a data collection tool in the study[30].

**Table 1.** Likert Percentage Interpretation

Percentage	Feasibility Criteria
0% - 20%	Very Infeasible
21% - 40%	Infeasible
41% - 60%	Moderately Feasible
51% - 80%	Feasible
81% - 100%	Highly Feasible

## III. Result and Discussion

### A. Analysis Phase

The problem analysis phase begins with observational activities involving prospective users to identify actual needs in the development of the Virtual ILS application.[31] The observation is conducted systematically to assess the level of public understanding regarding the placement criteria of Instrument Landing System (ILS) equipment, as well as



awareness of the existence of restricted areas surrounding aviation navigation facilities.[32] Prior to the development phase, the researcher distributed a preliminary questionnaire (preliminary survey) to respondents as part of the user requirement analysis process.[33] The instrument is designed to measure initial understanding, sources of information obtained, and the need for more interactive educational media. [34]

The survey results indicate that the majority of respondents do not yet have adequate understanding of the boundaries of ILS equipment areas and the consequences of activities conducted in their vicinity.[35] These findings are then formulated into user stories and system functional requirements as the basis for the design and development of the application. Detailed survey data are presented in the table below.

**Table 2.** First Questionnaire Result.

No	Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Score
A1	Have you ever heard of the term “restricted area of navigation equipment ” (e.g., ILS)?	0	0	0	1	8	44
A2	In your opinion, are there areas around the airport where certain activities are prohibited or restricted (e.g., construction or flying kites)?	0	0	0	6	4	44
A3	To what extent are you aware of signs/markers indicating the boundaries of navigation	0	0	0	4	5	41

No	Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Score
	equipment areas?						
A4	To what extent do you understand the consequences of entering or conducting activities near navigation equipment ?	0	0	0	7	2	38
A5	From which sources do you most frequently obtain information regarding safety around the airport?	0	0	0	1	8	44

**Table 3.** User Requirements

No.	User Requirements
UR 1	Users require interactive explanations regarding the concept of restricted areas of navigation equipment (e.g., ILS, VOR, NDB, radar, etc.).
UR 2	Users require visual representations (such as interactive maps or 3D/Virtual Tour models) that illustrate the boundaries of prohibited or restricted areas around airports.
UR 3	Users require visual guidance on signs/markers indicating the boundaries or locations of navigation equipment areas.
UR 4	Users require explanations of the consequences or risks associated with conducting activities near restricted areas (e.g., navigation interference, potential accidents).
UR 5	Users require engaging and easily accessible educational media (mobile/virtual) to enhance awareness of the importance of safeguarding navigation equipment areas.

The material needs analysis is conducted to ensure that the content integrated into the Virtual ILS application is valid, well-structured, and compliant with applicable regulatory standards. This phase includes the identification, selection, and synthesis of various official reference sources to guarantee the accuracy

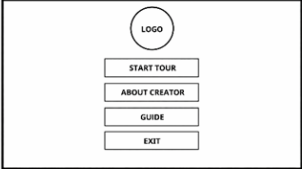
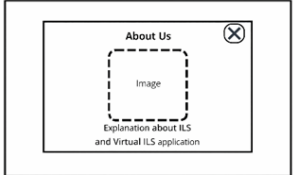


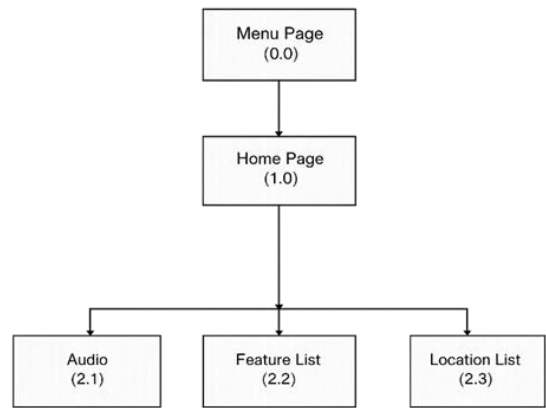
of the substance presented in the learning media. Data collection is carried out by reviewing relevant regulatory documents and technical manuals as the conceptual and operational basis for designing three-dimensional visualizations. The main materials used refer to the regulations of the Directorate General of Civil Aviation, namely SKEP/113/VI/2002 on the Placement Criteria for Aviation Electronic and Electrical Facilities, as well as documents from the United States Federal Aviation Administration (FAA) in the Standard Inspection Manual related to the Instrument Landing System (ILS), covering components such as the Localizer, Glide Path, and Marker Beacon[36]. The results of this document analysis are then translated into visual representations and interactive narratives within the application, ensuring that the information provided is not only technically accurate but also easily understood by the general public.

**B. Design Phase**

To address the issues identified during the analysis phase, an interactive web-based application was developed to provide information to the public. The design phase involves planning the system and interface of the Virtual ILS application. This phase comprises three components: storyboard, HIPO diagram design, and use case diagram. The storyboard provides a sequential visual representation of summarized scenarios presented in sketch form. Meanwhile, the HIPO diagram represents a hierarchical depiction of the input, process, and output flows within the application.[37]

**Table 4.** Story Board.

Page	Story Board	Notes
Menu Page		The Menu Page serves as the opening page when the application is accessed via a web browser and contains: 1. Virtual ILS Logo 2. Start Tour 3. About the Creator 4. Guide 5. Exit
Intro Pop Up Page		When users click the Intro button on the main page, an Intro Pop up page appears. The Intro Pop up page provides information about the Virtual ILS application and includes: 1. Exit 2. Intro Pop up Title 3. Image 4. Description of the Virtual ILS application



**Figure 1.** HIPO Diagram (Hierarchy Input Process Output)

**Table 5.** Overview Diagram

Input	Process	Output
Menu Page	Menu Page	Displays the menu page of the Virtual ILS application, containing: 1. Start Tour button 2. About the Creator button 3. Guide button 4. Exit button
.....	.....	.....
Featur es List	Popup Features List	Displays a popup of the Virtual ILS feature list, containing: 1. Little Planet button 2. Toggle Floorplan button 3. WebVR button 4. Toggle Gyroscope button 5. Intro Pop up button
.....	.....	.....

This Activity Diagram illustrates the complete workflow of the application, from initial installation to application closure. The stages of using the Virtual ILS application are described below.



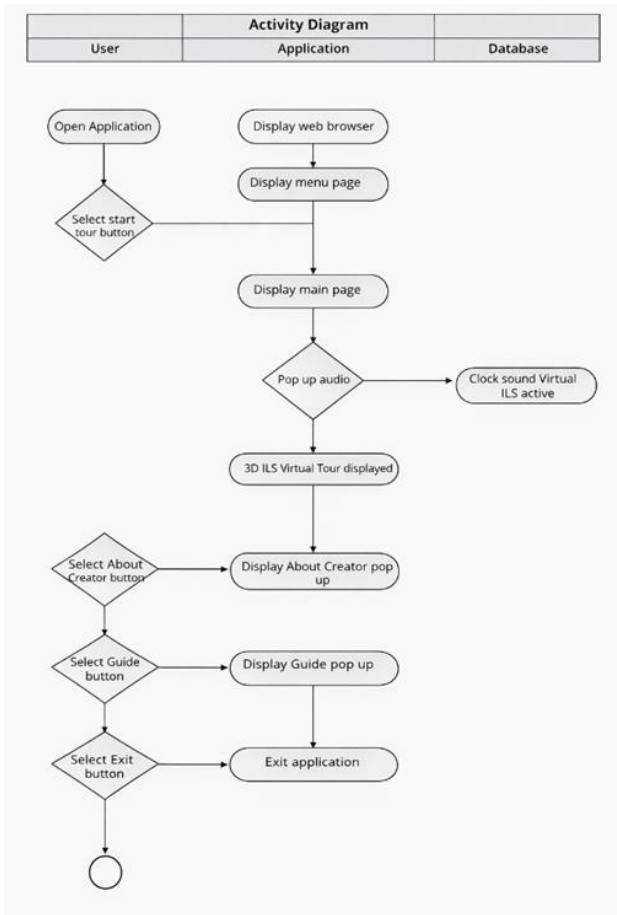


Figure 2. Activity Diagram

The Use Case Diagram depicts the system functionalities accessible to users. In this study, the use case diagram is employed to develop the Virtual ILS application in accordance with user requirements related to the visualization of restricted areas and the placement criteria of ILS equipment.

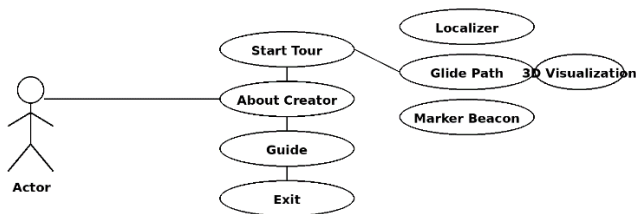


Figure 3. Use Case Diagram

### C. Development Phase

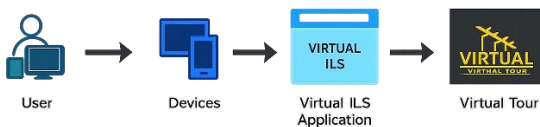


Figure 4. Application Flow Chart

Before developing the application, design validation is conducted to optimize the accuracy of the material to be presented in the application, and media expert validation is performed to assess the design that has been created.

#### 1. Media Expert Validation

Media experts have validated the media aspects, and the data show an assessment score of 96.8%, placing it in the "Highly Feasible" category. Therefore, the Virtual ILS application is highly suitable for use as a Virtual Tour-based information medium, based on media evaluation.

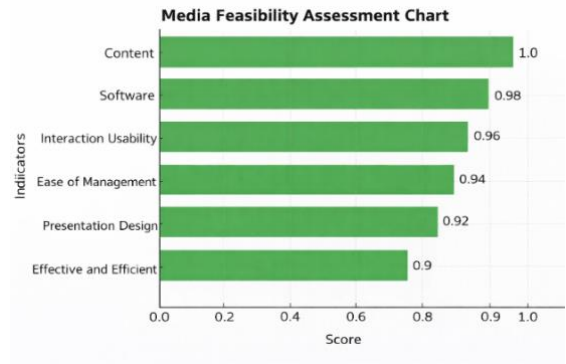


Figure 5. Media Expert Validation

#### 2. Material Expert Validation

Validation results from an Air Navigation Engineering subject matter expert at the Indonesian Aviation Polytechnic, Curug, indicated a score of 4 with a percentage value of 98.2%. Therefore, the material contained in the Virtual ILS application is categorized as "Valid" and is highly suitable for use in the study.

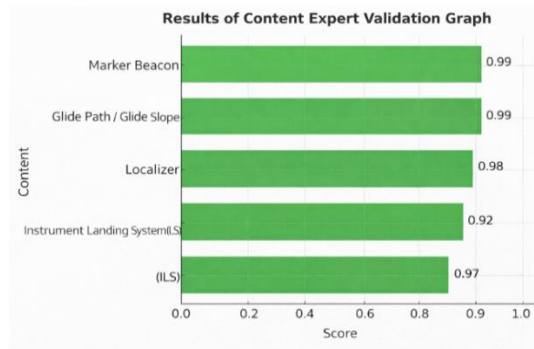


Figure 6. Material Expert Validation

The development of the Virtual ILS application is carried out systematically through several integrated stages. The initial stage utilizes Visual Studio Code to develop and manage the source code of the menu page, ensuring functional integration with the main page of the Virtual Tour application. Next, three-dimensional object design and modeling are conducted using SketchUp Pro 2023, encompassing the creation of scenery, airport side layouts, and precise details of the Instrument Landing System (ILS) equipment closely resembling real conditions. The modeling process employs the Push and Pull method to transform two-dimensional planes into



converted into a 1–5 Likert scale. The survey was distributed to residents of Kemuning Village. Figure 8 presents the results of the usability aspect testing.

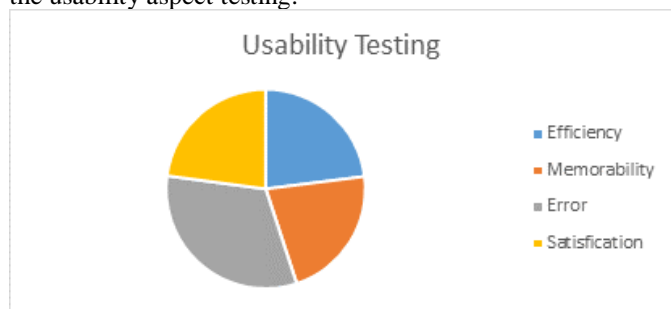


Figure 9. Usability Testing

Table 7. Usability Testing

Respondent	Learnability	Efficiency	Memorability	Error	Satisfaction	Score
1	15	10	10	15	10	60
2	15	10	10	15	10	60
3	15	10	10	15	10	60
4	15	10	10	15	10	60
5	12	8	8	12	8	48
6	15	10	5	0	10	40
7	15	10	10	15	10	60
8	15	10	10	15	10	60
9	15	10	10	15	10	60
10	14	10	10	15	10	59
11	15	10	10	15	10	60
12	15	10	10	15	10	60
13	13	10	9	15	9	56
14	15	10	9	14	10	58
15	14	10	9	13	9	55
16	14	9	10	14	10	58
17	15	10	9	15	9	58
18	14	10	10	14	10	58
19	14	10	9	13	10	56
20	15	8	9	14	10	56
Result	289	196	187	274	195	1082
Maximum Score	15	10	10	15	10	60
Percentage	96,33%	98%	93,50%	91,33%	97,50%	90,16%

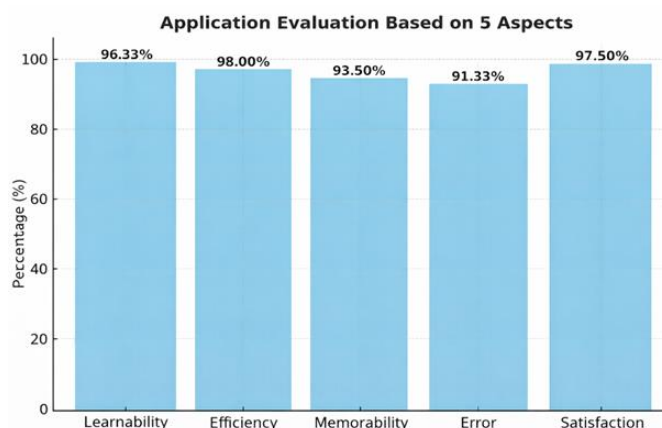


Figure 10. Result of User Evaluation

Based on calculations from a total of 20 respondents from Kemuning Village, the developed application meets the evaluation standards across five aspects: learnability (96.33%), efficiency (98%), memorability (93.50%), errors (91.33%), and satisfaction (97.50%). The following presents the percentage calculations for each aspect of the usability testing conducted:

$$\begin{aligned}
 \text{Usability Percentage} &= \frac{\text{Testing Results Scores}}{\text{Maximum Score}} \times 100\% \quad (2) \\
 &= \frac{1082}{1200} \times 100\% = 90,16\%
 \end{aligned}$$

Therefore, the assessment results indicate that the use of the Virtual Tour-based Virtual ILS application by the sample yielded a percentage of 90.16%. Based on this percentage, the Virtual ILS application is categorized as "Highly Feasible" in terms of usability.

This study has limitations due to the relatively small number of respondents, meaning the results cannot yet be generalized widely. Additionally, the relatively high evaluation scores may be influenced by respondents' subjective perceptions of the media used. Future research is recommended to involve a larger number of respondents to obtain more comprehensive results.

#### IV. Conclusion

1. The Virtual ILS application was successfully developed as an information medium capable of visualizing the placement criteria of Instrument Landing System (ILS) equipment, including the Localizer, Glide Path, and Marker Beacon, in the form of a 3D Virtual Tour.
2. The application is accessible via web browsers, enabling the public to obtain information without entering restricted areas within the airport environment.
3. The application of the ADDIE method (Analysis, Design, Development, Implementation, and



Evaluation) has proven effective in the development process, from user needs analysis, system design, and 3D visualization, to implementation and evaluation stages.

4. The application's quality evaluation refers to the ISO 25010 standard, covering media, material, functional suitability, compatibility, and usability aspects.
5. Quality testing results indicate a very high feasibility level, with details as follows: Media aspect: 96.8% (Highly Feasible), Material aspect: 98.2% (Valid), Functional Suitability: 97.5% (Highly Feasible), Compatibility: 100% (Highly Feasible), and Usability: 90.16% (Highly Feasible).
6. The application has been proven to function properly, is compatible across various devices and browsers, and is easy for users to operate.
7. The Virtual ILS application effectively enhances public understanding of restricted airport areas and the placement criteria of ILS equipment.
8. This application serves as an interactive and effective educational medium, supporting aviation safety and promoting the Aviation Operation Safety Zone (KKOP).

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