

An Assessment of Digital Terrain Model Provision for The Requirements of Flight Procedure Design

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ABSTRACT

The provision of Digital Terrain Model (DTM) data plays a critical role in the safe and efficient design of flight procedures within AirNav Indonesia. This study evaluates the workflow and identifies technical gaps in the current DTM data provision process at the Aeronautical Information Cartography Unit. Qualitative research was conducted from January to July 2025, involving semi-structured interviews with six key personnel, direct observation, and document analysis. Results show that all DTM data provision activities depended on a single individual, with no formal standard operating procedures available. This led to recurring delays and data inconsistencies, particularly when the person in charge was absent. To address these issues, a draft standardized technical guideline was developed; however, it has not yet been formally implemented or tested. The presence of this guideline is expected to improve workflow efficiency, ensure data consistency, facilitate effective knowledge transfer, and ultimately contribute to increased operational safety and regulatory compliance in Indonesian aviation.

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INTRODUCTION

The availability of accurate and reliable Digital Terrain Model (DTM) data is fundamental to the design of safe and efficient flight procedures, as mandated by international standards and aviation regulations [1], [2]. In Indonesia, AirNav Indonesia, through its Aeronautical Information Cartography Unit, is responsible for providing DTM data to support the development and review of flight procedures. In practice, several flight procedure projects in Indonesia—such as updates to Standard Instrument Departure (SID) and Standard Terminal Arrival Route (STAR) procedures for airports in Sumatra and Eastern Indonesia—have experienced delays and inconsistencies due to the absence of standardized DTM data provision. These issues underscore the importance of a clear technical guideline for DTM management at the national level.

Despite the strategic role of DTM data, the current provision process lacks documented technical guidelines and formal standard operating procedures. This situation has resulted in a heavy dependence on a single key individual, increasing the risk of inconsistent outputs, delays, and non-compliance with both national and international standards such as ICAO Annex 15 and Doc 10066 PANS-AIM [2], [3]. ICAO Annex 15 sets forth requirements for Aeronautical Information Services (AIS), emphasizing the quality, integrity, and timely provision of aeronautical data—including DTM—for safety-critical operations. Meanwhile, ICAO Doc 10066 (PANS-AIM) provides comprehensive procedures for the digital management and exchange of aeronautical information, directly supporting the functions of Aeronautical Information Management (AIM) units in Indonesia. These documents serve as key references to ensure that DTM data provision by the Aeronautical Information Cartography Unit aligns with global best practices as well as national regulatory needs.

While previous studies have examined technical aspects of DTM generation, data accuracy, and application in various contexts [4], [5], most of the existing literature focuses on international standards and technological advancements. Previous studies also in Indonesia have demonstrated the importance of Digital Terrain Model (DTM) optimization for accurate three-dimensional physiographic and geomorphological mapping, particularly in complex terrain environments such as geopark areas [9]. However, these studies primarily focus on geospatial and mapping applications, with limited discussion on the operational integration of DTM data within aeronautical information management and flight procedure development processes. There remains a significant gap in research addressing the specific challenges and operational realities of DTM data provision within the Indonesian aviation environment. National references and documented case studies from Indonesian AIM operations are still limited, highlighting the need for studies that bridge the gap between international guidelines and local implementation challenges. While existing studies in Indonesia have explored the technical and cartographic aspects of DTM generation and accuracy [9], [10], limited attention has been given to the operational and procedural dimensions of DTM data provision within aeronautical information management systems.

This study aims to comprehensively analyze the current process of DTM data provision, identify operational challenges, and develop a standardized technical guideline. The outcomes are expected to improve workflow efficiency, promote consistency, and provide a solid foundation for future audit and training processes within the Aeronautical Information Cartography Unit.

METHODS

This study employed a qualitative research design to gain an in-depth understanding of the Digital Terrain Model (DTM) data provision process in the Aeronautical Information Cartography Unit of AirNav Indonesia. Data collection took place from January to July 2025 and involved six informants, consisting of key personnel responsible for DTM data processing, verification, and delivery. The informants were selected using purposive sampling, focusing on individuals directly involved in the technical and operational aspects of DTM provision.

Data were gathered through a combination of semi-structured interviews, direct observation of operational procedures, and document analysis [6], [7]. Sample interview questions included: “Can you describe the step-by-step process of DTM data provision?” and “What challenges do you encounter in the absence of formal guidelines?” The observation checklist included aspects such as: (1) the sequence

of data provision steps, (2) software used (QGIS, Global Mapper), (3) division of responsibilities, and (4) adherence to existing informal practices.

Observations were conducted on-site throughout the six-month period, with each session lasting between two and four hours, to assess the actual workflow, software utilization, and communication patterns among staff. Relevant documentation, including output files, configuration records, and internal communications, were also analyzed to validate and triangulate findings [7].

The collected data were analyzed using a descriptive qualitative approach, involving data reduction, data display, and conclusion drawing as outlined by Miles and Huberman [8]. Triangulation of sources and methods was applied to ensure the credibility and validity of the findings. For enhanced transparency, the research steps are summarized in Table 1, and the methodological workflow is visualized in Figure 1. The study was conducted at the Aeronautical Information Cartography Unit between January and July 2025.

RESULT AND DISCUSSION

The analysis of the DTM data provision process at the Aeronautical Information Cartography Unit reveals a systematic workflow, starting from requests by the Flight Procedure Design Unit and culminating in the delivery of processed DTM data in various digital formats. The operational steps include formal request reception, data collection (such as ARP coordinates and SRTM elevation data), spatial data processing using QGIS and Global Mapper software, output validation, and final data delivery. However, the process heavily relies on a single key personnel (Person in Charge or PIC), with no formal technical guidelines in place. Interviews with six-unit staff confirmed that, in the absence of the PIC, data provision activities were frequently delayed or interrupted. One respondent stated, “If the PIC is unavailable, the rest of the team is often unsure how to proceed, especially with configuration settings.” Document analysis further showed inconsistencies in exported data formats, with 67% of reviewed outputs displaying different configuration standards.

The absence of a documented standard operating procedure also led to inconsistent data outputs and a high risk of errors, particularly during periods when the PIC was unavailable. Additionally, field observations noted that the division of responsibilities among staff was unclear, and there was no structured training for new team members. The lack of configuration standards for data export and software usage further exacerbated the risk of non-compliance with both national and international requirements [2], as evidenced by instances where exported DTM files did not meet the formatting guidelines stipulated in ICAO Doc 10066.

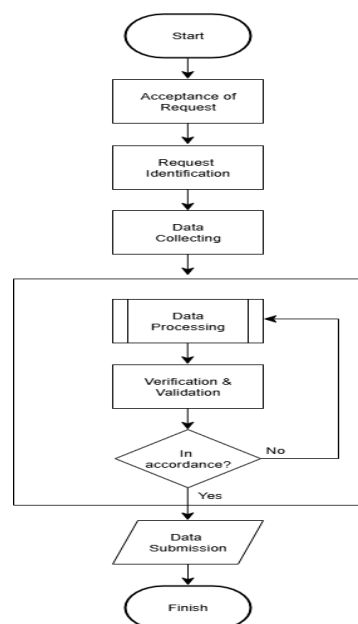


Figure 1 Flowchart of the DTM Data Provision Process.

Table 1 Gap Analysis Table

Aspect	Current Condition	Main Issue
Workflow	No written SOP. informal knowledge transfer	Inconsistent process. risk of error
Human Resources	Only one PIC with complete expertise	Workflow interruptions. Dependency
Data Output	Varied formatting. inconsistent configuration	Unreliable data quality. risk for users

The results highlight several gaps that have significant implications for the safety and efficiency of flight procedure design. According to ICAO Annex 15 and Doc 10066, aeronautical data, including DTM, must be provided with guaranteed integrity, standardization, and traceability. The lack of a formalized guideline in the Unit is not only contrary to these international standards but also increases the risk of operational errors such as inaccurate obstacle assessment or incorrect calculation of minimum sector altitude, which could compromise flight safety.

Comparative analysis with international best practices reveals that many leading AIM units adopt comprehensive, step-by-step technical guidelines, periodic staff training, and robust quality control systems to ensure workflow resilience even in the absence of key individuals. In contrast, the heavy reliance on informal knowledge transfer in the current process at AirNav Indonesia's Cartography Unit exposes vulnerabilities in knowledge continuity and regulatory compliance. The draft guideline developed in this study, which documents each stage of the DTM data provision process with clear instructions and configuration standards, is therefore a critical step toward bridging this gap.

By adopting these guidelines, it is expected that workflow efficiency will improve, dependence on individual expertise will decrease, and effective knowledge transfer will occur among personnel. In turn, this will enhance compliance with regulatory standards and improve the reliability and timeliness of DTM data provision for flight procedure design in Indonesia, reducing the risk of errors that could affect operational safety.

CONCLUSION

This study highlights the crucial role of a standardized and well-documented technical guideline in the provision of Digital Terrain Model (DTM) data for flight procedure design within AirNav Indonesia. The analysis reveals that the existing workflow, though technically functional, suffers from a lack of formal guidelines and an over-reliance on individual expertise, resulting in inconsistent outputs and operational delays. The proposed technical guideline addresses these issues by providing a structured and replicable workflow, supporting knowledge transfer, and ensuring compliance with international standards.

To ensure the effective implementation of these guidelines, a follow-up plan is recommended that includes pilot testing the guidelines on selected DTM data provision projects, followed by structured feedback and internal validation. Regular training sessions and workshops should be organized for all relevant personnel to familiarize them with the new procedures and to strengthen technical capacity. The effectiveness of the guidelines should be periodically evaluated through audits, feedback mechanisms, and performance metrics, allowing for continuous improvement and refinement. By following these implementation steps, it is expected that the guidelines will not only enhance workflow efficiency and data reliability, but also support sustainable operational performance and improved aviation safety.

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