# Case Study: Analysis of ATC Tower Infrastructure at Nicolau Lobato International Airport, Timor-Leste

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**ABSTRACT**
This study aims to analyze the feasibility of the Air Traffic Control (ATC) Tower infrastructure at Presidente Nicolau Lobato International Airport, Timor-Leste. A qualitative approach with a case study method was employed, involving in-depth interviews with three sources consisting of ATC personnel and supervisors, as well as direct on-site observation. The findings indicate that the ATC Tower infrastructure does not fully meet the required standards, particularly in terms of visibility, ventilation, lighting, and the absence of an emergency evacuation route. Supporting work facilities remain limited, including rest areas and safety equipment. Additionally, some communication and navigation systems are not yet integrated with modern technology, affecting operational efficiency. Therefore, comprehensive improvements are needed ranging from physical building renovations and the provision of adequate support facilities to the modernization of work systems to enhance safety and the effectiveness of ATC personnel in the future.

***Keywords:*** *Infrastructure, ATC Tower, ICAO, Flight Safety, Timor-Leste.*

## 3.1 INTRODUCTION

Air transportation plays a strategic role in connecting regions around the world with speed and efficiency unmatched by other modes of transport. As a system that integrates advanced technology with significant risks, aviation safety is a top priority for states, institutions, and stakeholders in the sector (Susanto & Keke, 2019). Within this context, Air Traffic Services (ATS) encompass essential functions such as flight information, alerting, advisory, and air traffic control services, including area, approach, and aerodrome control. Air Traffic Controllers (ATC) are professionals responsible for ensuring the safety and efficiency of operations through continuous communication and guidance to pilots.

In Timor-Leste, civil aviation relies heavily on Nicolau Lobato International Airport in Dili, which serves as the nation's only international airport and primary gateway for regional and international connectivity. Since its independence in 2002, Timor-Leste has faced numerous challenges in transportation infrastructure development, including limited financial resources, inadequate technology, and human resource constraints. These challenges are further compounded by the country's geographical conditions, characterized by mountainous terrain and earthquake-prone zones, which add complexity to aviation infrastructure development.

Airport and navigation services in Timor-Leste are managed by the Air Navigation Administration of Timor-Leste (ANATL) under the Ministry of Transport and Communications (MTC). However, ANATL continues to face significant limitations, particularly regarding infrastructure and supporting facilities. One of the most critical elements in aviation safety is the Air Traffic Control Tower (ATC Tower), which functions as the central hub for communication between controllers and pilots, managing aircraft movements during takeoff, landing, and ground operations (Umar et al., 2017).

Adequate ATC Tower infrastructure involves not only the physical building but also integrated systems for communication, information, navigation, and operational support. The International Civil Aviation Organization (ICAO) provides global standards and guidelines through Annex 14 – Aerodromes and the Air Traffic Services Planning Manual (Doc 9426), which detail the design, equipment, and operational procedures

necessary for ATC facilities. Despite these standards, several limitations remain at Nicolau Lobato International Airport, particularly the absence of supporting facilities such as dedicated rest areas and emergency exits, which are crucial for ensuring personnel safety and comfort.

Given these challenges, the main research problem addressed in this study is: *What is the condition of ATC Tower infrastructure at Nicolau Lobato International Airport, Timor-Leste?* The scope of the research is limited to the analysis of infrastructure conditions, especially the availability and adequacy of supporting facilities related to safety and operational efficiency. The objective is to evaluate the current state of ATC Tower infrastructure and identify gaps in compliance with ICAO standards. The working hypothesis suggests that the infrastructure of the ATC Tower has not yet fully met ICAO requirements, thereby posing potential operational risks.

The expected contribution of this study is twofold. First, it aims to provide strategic recommendations for ANATL and the Ministry of Transport and Communications of Timor-Leste to improve ATC Tower infrastructure in alignment with ICAO standards. Second, it seeks to enrich academic knowledge in the fields of aviation safety and air navigation infrastructure management, particularly regarding international standards for ATC facilities.

In this regard, the research titled "Case Study: Analysis of ATC Tower Infrastructure at Nicolau Lobato International Airport, Timor-Leste" is expected to support efforts to enhance safety and efficiency in Timor-Leste's aviation sector while providing practical insights for infrastructure development in emerging aviation markets.

## 3.2 LITERATURE REVIEW

### *2.1 Case Study*

Case study research is widely recognized as an approach that explores "a bounded system" or "a case/multiple cases" through in-depth data collection over time, involving multiple rich sources of information within a specific context (Assyakurrohim et al., 2022). The bounded system is defined by time and place, while cases may include programs, events, activities, or individuals. Merriam and Tisdell (2015) describe case studies as detailed descriptions and analyses of a bounded system in which its parts work in an integrated and patterned manner with other elements of the overall system. Similarly, Rahardjo (2017) defines case studies as a series of intensive, detailed, and in-depth scientific activities conducted on programs, events, or activities at the level of individuals, groups, institutions, or organizations with the aim of obtaining comprehensive knowledge of the phenomena under investigation. Typically, case study research addresses real-life and unique cases rather than past or obsolete events.

Stake (1995) emphasizes that the purpose of case study research is to reveal the uniqueness or specific characteristics of the studied case, as the case itself becomes the central reason for conducting such research. Therefore, all aspects related to the case—including its natural characteristics, functions, historical background, environmental conditions, and influencing factors—must be examined to provide a holistic and comprehensive understanding. Additionally, case studies aim to understand individuals in depth, particularly their development and adaptation within their environment, as well as their interactions with groups, institutions, and society (Assyakurrohim et al., 2022). Yin (2017) further explains that case studies function as a research strategy that allows researchers to gain a thorough understanding of the dynamics of complex events or conditions by utilizing various relevant data sources.

### *2.2 Standards for Air Traffic Control Towers*

International standards for air traffic control (ATC) towers are established in ICAO Annex 14, Volume I – Aerodrome Design and Operations, ICAO Doc 9426 – Air Traffic Services Planning Manual, and ICAO Circular 241 – Digest No. 8 on Workplace Conditions in Air Traffic Services Units. Although Annex 14 does not provide a dedicated chapter for ATC towers, it emphasizes their role as essential facilities at controlled aerodromes. Requirements include the provision of a signal lamp as a backup means of visual communication, tower placement in accordance with operational safety and frangibility principles, and sufficient height to ensure unobstructed visibility over aircraft movement areas (ICAO Annex 14, Chapters 5 & 9).

Further specifications are provided in ICAO Doc 9426 and ICAO Circular 241, which outline technical guidance on workspace design, lighting, acoustics, temperature, ventilation, and safety. The layout of the control tower should meet the operational needs of ATS units (Doc 9426 Part III, Section 2, Chapter 1). Lighting must be uniform, adjustable in intensity, and free from glare (Circular 241, Paragraphs 2.20–2.24; Doc 9426, Chapter 2). Noise levels are recommended not to exceed 55 dB to maintain clear communication (Circular 241, Paragraph 2.28), while the ideal temperature ranges from 21–25°C with relative humidity of around 50% (Circular 241, Paragraphs 2.25–2.27). Ventilation and air conditioning systems must also ensure comfort without adding excessive noise (Doc 9426 Part III, Section 2, Chapter 1, Point 1.2).

ICAO standards further address safety and emergency requirements, including evacuation routes, lightning protection, fire alarms, emergency lighting, and supervision of emergency exits (Doc 9426, Part III, Section 2, Chapters 1 & 2; Annex 14, Chapter 9). Supporting facilities such as rest areas, dining spaces, and communication and navigation equipment (VOR, NDB, radar, ILS, VDF) are also recognized as critical elements in ensuring effective ATC operations (Doc 9426 Part III, Section 1).

In summary, ICAO emphasizes that ATC towers are not merely physical structures but integrated systems combining operational safety, air traffic control efficiency, and the well-being of personnel working within them.

## *2.3 Profile of Nicolau Lobato International Airport, Timor-Leste*

### *2.3.1 Historical Background*

Dili Airport (IATA: DIL, ICAO: WPDL), officially named Presidente Nicolau Lobato International Airport (Portuguese: *Aeroporto Internacional Presidente Nicolau Lobato*; Tetun: *Aeroportu Internasional Presidente Nicolau Lobato*), and formerly known as Comoro Airport, is located in Dili, the capital city of Timor-Leste. Since 2002, the airport has been named after Nicolau dos Reis Lobato (1946–1978), a national hero and political leader of Timor-Leste. The airport is situated in Suco Madohi, part of the Dom Aleixo administrative post, on the western outskirts of Dili. It is bordered by the Ombai Strait to the north and west, and the Comoro River to the east, with nearby settlements, agricultural areas, a school, a church, and a cemetery located between the runway and the Ombai Strait.

The airport has historically served as the main gateway for both domestic and international flights. In 1999–2000, it suffered severe damage due to lack of maintenance, destruction of equipment, and overuse. The United Nations Transitional Administration in East Timor (UNTAET) initiated rehabilitation programs for the airport and seaport infrastructure, supported by INTERFET operations. By late 2000, the airport had resumed full operations, with airlines such as Airnorth, Merpati, and Qantas' subsidiary Airlink operating regular commercial services. Upon Timor-Leste's independence in 2002, management of the airport was transferred to the new government, which renamed it in honor of Nicolau Lobato.

In March 2005, Timor-Leste launched its first post-independence commercial airline service, operating the Dili–Kupang route with a CASA C-212 Aviocar leased from Merpati. Currently, the airport provides international connections to neighboring countries, primarily Indonesia and Australia. However, the facility continues to face challenges related to limited infrastructure, particularly runway length and supporting systems, which affect overall operational effectiveness and safety.

### *2.3.2 Airport Data*

| | | |
|---|---|---|
| *ARP coordinates and site at AD* | : | S08° 32' 47.1" E125° 31' 29.4". *Rwy center.* |
| *Direction and distance from Dili city* | : | 6.2Km *west of* Dili *city* |
| *Elevation/reference temperature* | : | 25ft/33.8° *Celsius* |
| *Geoid undulation at AD ELEV position* | : | *Not available* |
| *MAG Variation/Annual change* | : | 3° E/*Not available* |
| *Administration and contact details* | : | *Civil Aviation Division*<br>*Ministry of Transport, Communications and Public Transport, Dili, Timor Leste*<br>Tel: +670 390 317 110<br>Fax: +670 390 371 111 WPDLYDYX<br>*Mon-Fri:* 2300-0800 *excluding public holidays* |
| *Types of traffic permitted* | : | IFR/VFR |
| *Remarks* | : | AD *Reference Code* 3C |

*1. Aerodrome Geographical and Administrative Data*

| | | |
|---|---|---|
| *Hotels* | : | *Near the AD and in Dili city* |
| *Restaurants* | : | *Cafeteria in terminal bldg. Restaurants in city* |
| *Transportation* | : | *Taxi services available* |
| *Medical* | : | *General Hospital about 8Km in city* |
| *Bank and Post office* | : | *Bank in terminal bldg (AD hours) and in city. Post Office in city* |
| *Tourist office* | : | *In city* |
| *Remarks* | : | *Nil* |

*2. Passenger Facilities*

3. *Aprons, Taxiways and Check Location Data*

| | | |
|---|---|---|
| *Apron Surface and strength* | : | *Apron* D (*Main apron*) 215 x 87 m. *Surface*: |
| | | *Asphalt*. PCN: 32/F/B/X/U. *Capacity limited. Aprons* A, B & C *are generally for* UN *aircraft*. |
| *Width, Surface and strength of taxiway* | : | *Single central taxiway* 110m x 23m *connects runway to Apron* D. |
| PCN | : | 32/F/B/X/U. *Aprons* A, B & C *connected to runway via connecting taxiways.* |
| *Altimeter location and elevation check point* | : | *Nil* |
| *VOR/DME Check point* | : | *Holding Position taxiway* D. |
| *INS Check point* | : | *Nil* |
| *Remarks* | : | PPR *from* AD Ops *for engine tests at aprons.* |

Table 1 *Aprons, Taxiways and Check Location Data*

4. *Runway Physical Characteristics*

| WPDL *Runway Physical Characteristics* | | | | |
|---|---|---|---|---|
| 1. *Designation* | 08/26 | | 7. *Slope* | 0.1% |
| 2. *Bearing* | 073°/253° Mag. | | 8. *Stopway* | Nil |
| 3. *Dimension* | 1850m x 30m | | 9. *Clearway* | Nil |
| 4. PCN | 32/F/B/X/U. *Asphalt* | | 10. *Flight Strip* | 1970m x 150m |
| 5. THR *Coords* | THR 08: S08°32' 53.7" E125°31' 01.1" THR 26: S08° 32' 40.5" E125° 31' 57.7" | | 11. Obs. *Zone* | Nil |
| 6. THR elev. | THR 08/26: 17/25ft | | | |
| 12. *Remarks* | *Aircraft with MTOW greater than 7,000Kg must roll to runway end after landing and backtrack to prevent damage to runway surface.* | | | |

*Table 2 Runway Physical Characteristics*

5. *Declared Distances*

*Table 3 Declared Distances*

| | TORA | TODA | ASDA | LDA |
|---|---|---|---|---|
| Rwy 08 | 1850 | 1850 | 1850 | 1790 |
| Rwy 26 | 1790 | 1850 | 1850 | 1790 |
| *Remarks* | Rwy 08 THR *displaced* 60m *permanently*. *Declared Distance reduced due to no* RESA at Rwy 08. | | | |

6. *Air Traffic Services Airspace*

*Table 4 Air Traffic Services Airspace*

| | |
|---|---|
| *Designation and lateral limits* | Dili CTR. Arc radius 25NM *centred on* DIL VOR/DME *from* 265R *through north to the* 080R *joining arc radius* 15NM DIL VOR/DME *from* 081R *through south to the* 264R. |
| *Vertical limits* | *Surface level* to 11,000ft amsl. |
| *Airspace classification* | *Class C* |
| *ATS unit callsign and language* | *Comoro Approach/Comoro Ground. English* |
| *Transition altitude* | 11,000ft |
| *Remarks* | *Nil* |

7. *Airport Layout*

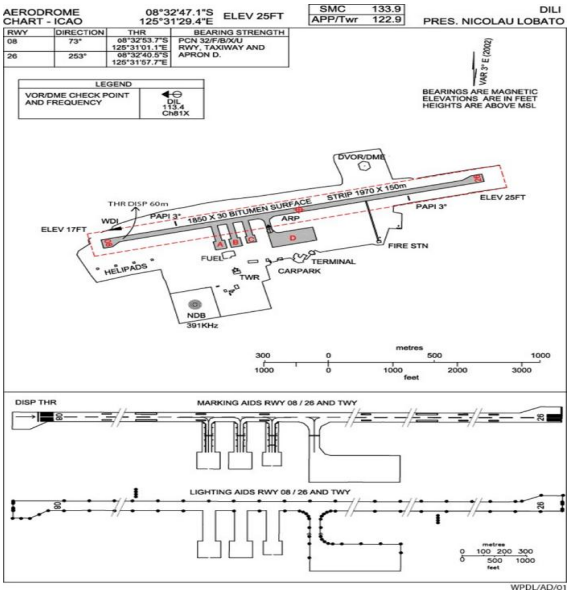


*Figure 1 Airport Layout*

## 3.3 METHOD

### *3.1 Research Design*

This study employs qualitative research design, defined by McMillan in Hadjar (1996) as a plan and structure of investigation to obtain empirical evidence in answering research questions. In this approach, the researcher acts as the primary instrument for collecting and analyzing data. The research is carried out in a natural setting to provide a holistic understanding of processes, values, and meanings within the studied phenomenon. The design is flexible, allowing adjustments at each stage, from topic selection and question formulation to data analysis and reporting, based on field conditions. The main objective is not to test hypotheses but to explore meanings and achieve a deeper understanding of the phenomenon.

The implementation of qualitative research involves several stages:


*Figure 2 Research Design*

#### *3.1.1 Topic Selection*

Topic selection in qualitative research is a crucial step that defines the research direction. Creswell (2022) emphasizes that topics should be based on research interest, problem urgency, and social relevance. This study was informed by literature, field observation at Nicolau Lobato International Airport, and discussions with aviation practitioners. The research focuses on the infrastructure of the Air Traffic Control (ATC) Tower, which plays a vital role in flight safety. Initial findings indicate challenges such as limited rest facilities, lack of emergency evacuation routes, and suboptimal visibility.

#### *3.1.2 Data Collection*

Qualitative data collection aims to obtain in-depth insights into the studied phenomenon. Yin (2017) highlights that case study methods involve multiple techniques, including in-depth interviews, direct observation, and document or archive review, to build a comprehensive understanding of the context. Similarly, Sugiyono (2013) notes that qualitative research relies on words, actions, and documents as primary data sources.

In this study, in-depth interviews were conducted with air traffic controllers, airport safety officers, and operational management at Nicolau Lobato International Airport. These interviews explored perspectives, experiences, and knowledge regarding the infrastructure and feasibility of the Air Traffic Control (ATC) Tower. Such an approach provided valuable insights into both physical and operational aspects of the facility.

### 3.1.3 Data Analysis

In qualitative research, data analysis is conducted systematically to uncover meaning from the collected information. Creswell (2016) emphasizes thematic analysis, which involves organizing, coding, and grouping data into relevant themes to develop an interpretative narrative reflecting participants' experiences and perspectives. Similarly, Sugiyono (2013) highlights that qualitative analysis is an ongoing, interactive process that includes data reduction, data presentation, and conclusion drawing with verification. This approach enables researchers to identify patterns, relationships, and underlying meanings within the findings.

### 3.1.4 Report Writing

According to Creswell (2016), qualitative research reports are written in a flexible, narrative structure. Researchers are encouraged to present findings using direct quotations from participants to strengthen data validity. The writing style is descriptive and reflective, enabling readers to gain a deeper understanding of the context and meaning of participants' experiences. The main goal is to highlight participants' voices and illustrate how the researcher interprets data within its social context. Similarly, Sugiyono (2013) explains that qualitative reports should be written in a descriptive-narrative form, systematically and logically presenting the research process from background and problem formulation to theoretical foundation and data analysis. The report must also demonstrate how the researcher interprets the meaning of data from participants' perspectives.

## 3.2 Research Variables

According to Salladien (2016), qualitative research does not require predetermined variables, hypothesis testing, or statistical analysis. Instead, the focus lies on exploring meanings, processes, and contexts without measuring or controlling variables.

## 3.3 Population, Sample, and Research Object

### 3.3.1 Population

In qualitative research, population refers not to statistical counts but to social situations comprising *place, actors, and activities* (Nasution, 2003; Sugiyono, 2013). In this study, the population includes personnel directly involved in air traffic control operations at the ATC Tower of Presidente Nicolau Lobato International Airport, namely three air traffic controllers (ATC officers and supervisor).

### 3.3.2 Sample

Samples in qualitative research are better understood as *informants* selected purposively (Sugiyono, 2013; Moleong, 2012). This study involves three key informants—two ATC officers and one ATC supervisor—chosen for their direct involvement in ATC Tower operations. Their insights on infrastructure conditions, equipment reliability, and operational challenges provide in-depth perspectives aligned with the research objectives.

### 3.3.3 Research Object

The research object is the ATC Tower infrastructure at Presidente Nicolau Lobato International Airport. The study examines how the tower supports air traffic operations, compliance with navigation service standards, and the role of ATC personnel in ensuring safety and efficiency (Arikunto, 2010).

## 3.4 Data Collection Techniques and Research Instruments

This research employs a case study approach with triangulation (Sugiyono, 2017).

a. Interviews, Semi-structured interviews with two ATC officers and one supervisor were conducted to gather insights into tower conditions, equipment functionality, and operational challenges. The interview guide was adapted from *ICAO ATS Planning Manual (Doc 9426)*.

b. Observation, due to access limitations, indirect observation was conducted using visual documentation (photos, safety training videos, audit reports) and assisted by an ATC staff observer. This provided contextual understanding of tower facilities and operational issues.

c. Document Analysis, Relevant documents, including SOPs, technical inspection reports, and maintenance records, were analyzed to complement interview and observation data. Document study strengthens data triangulation and historical understanding of ATC infrastructure.

## 3.5 Data Analysis Techniques

Data analysis followed the interactive model of Miles, Huberman, and Saldaña (2020), consisting of:

a. Data Reduction – selecting and categorizing relevant data from interviews, observations, and documents.

b. Data Display – presenting findings in descriptive narratives, tables, and thematic matrices to identify patterns.

c. Conclusion Drawing and Verification – interpreting findings and validating them through triangulation across data sources.

### *3.6 Research Location and Time*

The research was conducted at Presidente Nicolau Lobato International Airport (IATA: DIL; ICAO: WPDL), Dili, Timor-Leste. The location was selected due to its relevance, uniqueness, and alignment with the research topic (Al Muchtar, 2015). Data collection was carried out over four months, from November 2024 to April 2025, through observations, interviews, and document analysis (Sugiyono, 2017).

| NO. | ACTIVITY TYPE | MONTH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | NOV | DES | JAN | FEB | MAR | APR | MAY | JUNE | JULY |
| 1 | Observation and Literature Review | | | | | | | | | |
| 2 | Thesis Title Submission | | | | | | | | | |
| 3 | Thesis Proposal Consultation | | | | | | | | | |
| 4 | Thesis Proposal Writing | | | | | | | | | |
| 5 | Thesis Proposal Defense | | | | | | | | | |
| 6 | Thesis Proposal Submission | | | | | | | | | |

*Table 5 Research Timeline*

## 4. RESULTS AND DISCUSSION

### *4.1 Research Results*

The data collection instruments were reviewed by Air Traffic Control (ATC) experts to ensure technical accuracy and relevance. Validation focused on the feasibility of questionnaire items and analytical indicators, aligned with the study objectives and ICAO standards. Suggested improvements from the review were incorporated, resulting in instruments deemed suitable for systematic and direct data collection.

#### *4.1.1 Validation Results*

Dr. Dimas Arya Soeadyfa F., M.M., an ATC expert at Surabaya Aviation Polytechnic, reviewed the instruments on July 4, 2025. The instruments were confirmed valid in terms of language clarity, content relevance, and contextual appropriateness, and are therefore suitable for use in collecting accurate and research-relevant data. Detailed validation results are provided in the Appendix.

#### *4.1.2 Observation Results*

In 2023, the researcher conducted field observations at Presidente Nicolau Lobato International Airport, Timor-Leste, to assess the ATC Tower. Due to limited on-site access, ATC personnel in Dili assisted as an observer, providing detailed insights into infrastructure, operational procedures, and challenges. This collaboration enabled comprehensive data collection for evaluating the ATC Tower's compliance with ICAO standards, using a checklist adapted from the ATS Planning Manual 9426.

The table below presents the observation results conducted by the observer as part of the data collection process.

*Table 6 Observer Results*

| NO | ITEM | Availability | |
|---|---|---|---|
| | | Yes | No |
| 1 | Headset | ✓ | |
| 2 | Microphone | ✓ | |
| 3 | Transceiver | ✓ | |
| 4 | Speakers | ✓ | |
| 5 | Radio Selector Panel | ✓ | |
| 6 | Telephone selector panel/handset | ✓ | |
| 7 | Intercom | ✓ | |
| 8 | Auto Switch headset/Speaker | ✓ | |
| 9 | Recorder (radio and telephone) | ✓ | |
| 10 | Power | ✓ | |
| 11 | Back –up Power | ✓ | |
| 12 | Signal Lamp and Reel | | ✓ |
| 13 | Wind speed and direction display | ✓ | |
| 14 | Barometric altimeter | ✓ | |
| 15 | Alrimeter Settng Indicator | ✓ | |
| 16 | Clock | ✓ | |
| 17 | Aerodrome Lighting Panel | ✓ | |
| 18 | Navaid(s)monitor panel | ✓ | |
| 19 | Lighting, including emergency lights | ✓ | |
| 20 | Daylight radar/display consoles | ✓ | |
| 21 | Flight data panel | ✓ | |
| 22 | Clipboards/displays (NOTAM etc.) | ✓ | |
| 23 | Fire alarm and extinguishers | ✓ | |
| 24 | Desks/consoles/shelves | ✓ | |
| 25 | Chairs | ✓ | |
| 26 | Shades | ✓ | |
| 27 | Air conditioning, heating/cooling | ✓ | |
| 28 | Convenience group (hot plate/water, etc.) | | ✓ |
| 29 | Water fountain | | ✓ |
| 30 | Bookcases | ✓ | |
| 31 | Binoculars | ✓ | |
| 32 | Sound-absorbing coverings(floor/wall) | ✓ | |

Based on the observer's evaluation of facility availability at the Air Traffic Control (ATC) Tower, the majority of primary and supporting equipment were found to be adequately provided. Nonetheless, certain facilities remain unavailable, including the signal lamp and reel, the convenience group (hot plate/water, etc.), and the water fountain. The signal lamp and reel are critical for conveying ICAO-standard light signals to aircraft in the event of radio failure, with the reel ensuring organized and ready deployment of cables for

emergency or backup communication. The convenience group supports ATC personnel in preparing hot beverages and drinking water, contributing to operational comfort and reducing the need to leave the control room. The water fountain provides accessible hydration, maintaining personnel focus and operational continuity. Addressing these deficiencies would enhance work efficiency, safety, and comfort within the ATC Tower.

During the 2023 field visit to Presidente Nicolau Lobato International Airport, the researcher conducted direct observations of the ATC Tower infrastructure. Despite limited observation time, the findings revealed several potential operational and safety concerns, including the absence of standard-compliant emergency exits and a dedicated rest area for ATC personnel. Tower access currently relies solely on the main staircase, which may impede emergency evacuation in cases of fire or severe technical malfunctions. Furthermore, several existing facilities and equipment exhibited signs of aging and require refurbishment or replacement to ensure optimal functionality. These observations indicate that maintenance and facility upgrades have not been fully implemented. Failure to address these issues could adversely affect personnel comfort, operational efficiency, and, most importantly, flight safety.

### *4.1.3 Interview Results*

In the in-depth interviews, the researcher engaged three informants working at Presidente Nicolau Lobato International Airport in June 2025:

1. Mr. Elias De Deus – ATC Supervisor
2. Ms. Isabel Fatima de Jesus – ATC Personnel
3. Mr. Edmond Brian – ATC Personnel

The interviews were conducted online via Zoom Meeting and supplemented with written communication through WhatsApp, according to the availability of each informant. The informants provided insights based on their direct experiences regarding the ATC Tower infrastructure, covering aspects such as workspace comfort, operational visibility, supporting facilities, and challenges encountered in daily operations. These interviews served as a primary source for obtaining qualitative data on the compliance of tower facilities with International Civil Aviation Organization (ICAO) standards. The information obtained was analyzed and compared with field observations, providing a comprehensive understanding of the actual conditions of the ATC Tower infrastructure. This approach allowed the researcher to identify gaps between existing conditions and ICAO's ideal standards, as well as factors affecting operational performance and safety. The interview results also formed the basis for formulating relevant recommendations to improve operations at Presidente Nicolau Lobato International Airport.

The data were then reduced by summarizing and filtering relevant information to highlight the core aspects of ATC Tower infrastructure, supporting facilities, and operational challenges. This process focused the data on points critical to the study objectives.

a. Infrastructure Condition
   The ATC Tower at Presidente Nicolau Lobato International Airport shows signs of aging, with some areas receiving only repainting. The current tower location limits optimal visibility of the entire runway area. Routine maintenance ensures cleanliness, but damage remains, such as leaks during the rainy season and malfunctions of outdoor CCTV systems.
b. Personnel Facilities
   The tower lacks a dedicated rest area for ATC personnel. Toilets are available but often experience water supply disruptions. Furthermore, first aid kits are absent, workspace organization is suboptimal, and electrical cables are scattered.
c. Safety and Emergency
   The tower does not have standard emergency exits; evacuation procedures rely solely on the main staircase.
d. Visibility and Lighting
   Operational visibility is not fully adequate, particularly at Runway 26 thresholds. Natural lighting during daytime is sufficient, but artificial lighting inside the tower is suboptimal due to aging lamps.
e. Communication and Navigation Equipment
   Some communication and navigation equipment remains conventional and is not fully integrated. While certain devices function properly, modernization is necessary to support optimal performance.
f. Informants' Expectations and Suggestions
   The informants expressed the need for a new tower that addresses not only structural conditions but also equipment modernization, additional rest areas, emergency exits, and improved occupational safety facilities for ATC personnel.

Based on these in-depth interviews, the ATC Tower at Presidente Nicolau Lobato International Airport still requires improvements in both infrastructure and supporting facilities. Structurally, parts of the tower are aging and receive only repainting, while the tower's position limits visibility across the runway. Maintenance routines maintain cleanliness, but damages such as leaks and faulty outdoor CCTV persist. Personnel facilities are inadequate, lacking a dedicated rest area, and emergency evacuation relies solely on the main staircase. Informants emphasized that a new tower should combine physical improvements, supporting facility enhancements, equipment modernization, provision of

emergency exits, and improved safety and comfort standards for ATC personnel.

### *4.1.4 Documentation Study*

During data collection, the researcher conducted a direct visit to the Air Traffic Control (ATC) Tower at Presidente Nicolau Lobato International Airport, Timor-Leste, albeit within a limited timeframe. The visit provided an initial overview of the general condition of available facilities. To complement the limited direct observation, the researcher obtained detailed explanations from ATC personnel, who provided in-depth information on infrastructure conditions, operational procedures, and field challenges.

This documentation study aimed to identify discrepancies between the existing infrastructure and International Civil Aviation Organization (ICAO) standards, particularly Annex 14 and Doc 9426 (Air Traffic Services Planning Manual). The results of observations and information from ATC personnel are presented in tabular form, including physical evidence, descriptions of non-compliance, ICAO references, recommended improvements, and are supplemented with visual documentation provided in the appendices.

*Table 7 Documentation Study Results*

| No | ATC Tower Infrastructure at Timor-Leste Airport | Non-Compliance | Explanation | Relevant ICAO Document | Resolution |
|---|---|---|---|---|---|
| 1 |  Control Room | The work facilities have not been modernized, and a portion of the equipment remains outdated. | The control room equipment remains based on outdated systems, potentially impacting operational efficiency and personnel comfort. | *ICAO Doc 9426 – Air Traffic Services Planning Manual, Part III, Section 2, Chapter 1, Point 1.3.* | Undertake phased modernization of work facilities and equipment, in accordance with ICAO technical standards and contemporary operational needs. |
| 2 |  Access Staircase to the ATC Control Room | The evacuation route does not comply with established standards and is inadequately equipped with safety signage. | Access relies solely on the main staircase, with no emergency exit provided in accordance with standards. | *ICAO Doc 9426 Part III, Section 2, Chapter 1, Point 1.3.6 dan ICAO Doc 9426 Part III, Section 2, Chapter 2, Point 2.2.4 dan poin 2.3.10. b* | Plan and implement a standard-compliant emergency exit following ICAO guidelines, accompanied by the installation of proper evacuation signage. |
| 3 |  ATC Tower Exterior | The building lacks a dedicated rest or breaks room for ATC personnel on duty. | The ATC Tower lacks a dedicated rest area for personnel, requiring them to rest within the operational workspace. This arrangement could potentially compromise concentration and performance, especially during shift transitions. | *ICAO Doc 9426 – Air Traffic Services Planning Manual, Part III, Section 2, Chapter 3, Point 3.2.9* | Establish a dedicated restroom separate from the operational workspace, furnished with facilities compliant with ICAO standards. |

Based on direct observations and interviews with personnel at the ATC Tower of Presidente Nicolau Lobato International Airport, Timor-Leste, several key findings regarding the current infrastructure were identified. Some aspects do not fully comply with ICAO Doc 9426 – *Air Traffic Services Planning Manual*, particularly Part III, Section 2, Chapter 1 on structural and operational requirements for ATS facilities.

Non-compliances include the use of conventional or outdated work facilities, which may affect efficiency and comfort, especially during shift rotations or high air traffic periods. Emergency evacuation routes are absent, with the main staircase serving as the sole access and lacking adequate safety signage and emergency lighting, posing safety risks. The overall tower structure and design are suboptimal for operational and ergonomic needs, as they are not fully based on functional or long-term comfort considerations.

These findings indicate the need for gradual, planned improvements, including updating work facilities, constructing standard-compliant emergency exits, and redesigning the tower layout to maximize operational efficiency and personnel safety. All improvements should follow ICAO standards to ensure a safe, comfortable, and professional working environment within the air traffic services facility.

## *4.2 Discussion of Research Results*

This discussion aims to address the research question regarding the condition of the Air Traffic Control (ATC) Tower infrastructure at Presidente Nicolau Lobato International Airport, Timor-Leste, in relation to compliance with International Civil Aviation Organization (ICAO) standards.

Interviews with three informants—a supervisor and two ATC personnel—revealed that the tower's infrastructure does not fully meet the expected standards, such as those outlined in ICAO Doc 9426 (*Air Traffic Services Planning Manual*). Regarding the physical structure, the building is relatively old, with certain areas requiring renovation. A key issue is limited visibility towards the Runway 26 threshold, due to the tower's suboptimal location and obstruction by hangar buildings.

Supporting facilities for ATC personnel, including rest areas and toilets, remain inadequate. Complaints included disorganized workspaces, absence of first aid kits, and intermittent water supply issues. While ergonomic chairs are provided, there is no dedicated rest

area, which may affect comfort and performance during monitoring duties.

In terms of safety and emergency preparedness, the tower lacks emergency exits or staircases, relying solely on the main staircase, which poses significant risks during emergencies such as fires or natural disasters.

Communication and navigation equipment are functional but not fully modernized or integrated. Some devices, including computers, are outdated and inefficient for rapid and accurate decision-making. Routine evaluations and maintenance, such as logbook updates and daily checks, are conducted; however, follow-up on personnel-reported issues is often delayed or insufficient.

Informants recommended comprehensive tower renovation, modernization of navigation aids, provision of adequate supporting facilities, and periodic emergency training and SOP updates to enhance operational efficiency, safety, and a professional work environment.

In conclusion, the discussion indicates that the ATC Tower infrastructure at Presidente Nicolau Lobato International Airport requires significant improvements to meet ICAO standards and support safe, efficient air navigation services in Timor-Leste.

## 5. CONCLUSION AND RECOMMENDATIONS

### *5.1 Conclusion*

The research results indicate that the ATC Tower infrastructure at Presidente Nicolau Lobato International Airport, Timor-Leste, does not fully comply with the standards set by ICAO. Deficiencies include limited visibility, inadequate ventilation and lighting systems, absence of emergency evacuation routes, insufficient supporting facilities such as rest areas, and communication and navigation equipment that is not integrated with modern technology. These conditions may reduce the efficiency and effectiveness of ATC personnel. Therefore, comprehensive improvements are required, including physical building upgrades, provision of adequate supporting facilities, and modernization of operational systems to ensure the safety and smooth operation of air traffic at the airport.

### *5.2 Recommendations*

Based on the study findings, the following recommendations are proposed to support ATC Tower operations:

1. ATC Tower Infrastructure Enhancement
   It is recommended that ANATL or the Government of Timor-Leste improve the ATC Tower infrastructure in accordance with ICAO standards to ensure operational safety and efficiency. Supporting facilities, including rest areas, air conditioning systems, first aid kits, and emergency evacuation routes, should also be upgraded to enhance both comfort and safety for personnel.
2. Operational Equipment Modernization
   Modernization of operational equipment at the airport/ATC should involve technological updates and improvements in workplace facilities to create an integrated, advanced, and representative system. This includes implementing electronic and automatic Flight Progress Strips (FPS) and upgrading computer systems to current specifications. Renovation of the ATC Tower building in Dili is essential to meet at least minimum standards.
3. Scheduled Evaluation and Maintenance
   ANATL or the Government of Timor-Leste should establish policies for routine maintenance and scheduled evaluations of infrastructure and equipment to detect potential failures early and ensure all facilities remain in optimal condition in compliance with ICAO standards.

## REFERENCES


[1] Adji, G. P., Valguna, P. A., & Soegiri, H. (2018). Pengaruh kebisingan terhadap kualitas pemberian pelayanan lalu lintas penerbangan di Bandar Udara Banyuwangi. *Prosiding SNITP (Seminar Nasional Inovasi Teknologi Penerbangan)*, 2(2).

[2] Afif, D. (2016). *Perencanaan struktur baja bangunan atas Gedung Air Traffic Control Tower Bandara Samarinda Baru*. Institut Teknologi Malang.

[3] Al Muchtar, S. (2015). *Dasar penelitian kualitatif*. Bandung: Gelar Pustaka Mandiri.

[4] Arikunto, S. (2010). *Metode penelitian*. Bumi Aksara.

[5] Assyakurrohim, D., Ikhram, D., Sirodj, R. A., & Afgani, M. W. (2022). Metode studi kasus dalam penelitian kualitatif. *Jurnal Pendidikan Sains dan Komputer*, 3(01), 1–9.

[6] Creswell, J. W. (2015). *Penelitian kualitatif dan desain riset*. Pustaka Pelajar.

[7] Creswell, J. W. (2016). *Research design: Pendekatan metode kualitatif, kuantitatif, dan campuran*. Yogyakarta: Pustaka Pelajar.

[8] Creswell, J. W. (2022). *Research design: Qualitative, quantitative, and mixed methods approach* (5th ed.). Sage Publications.

[9] Hadjar, I. (1996). *Dasar-dasar metodologi penelitian kuantitatif dalam pendidikan*. Jakarta: Raja Grafindo Persada.

[10] Huberman, A. (2020). *Qualitative data analysis: A methods sourcebook*.

[11] International Civil Aviation Organization. (1993). *Human factors digest No. 8: Workplace conditions*

*in air traffic services units* (ICAO Circular 241-AN/145).
[12] International Civil Aviation Organization. (2016). *Air traffic services planning manual* (Doc 9426, 3rd ed.).
[13] International Civil Aviation Organization. (2020). *Annex 14 to the convention on international civil aviation: Aerodromes — Volume I, Aerodrome design and operations* (5th ed.).
[14] Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation* (4th ed.). Jossey-Bass.
[15] Moleong, L. J. (2012). *Metodologi penelitian kualitatif*.
[16] Nasution, S. (2003). *Metode penelitian naturalistik kualitatif*. Bandung: Tarsito.
[17] Pariyan, V. O., Gunawan, I., & Fahriani, F. (2018). Analisis ulang struktur bangunan Air Traffic Control (ATC) di Bandara Depati Amir Pangkalpinang. *FROPIL (Forum Profesional Teknik Sipil)*, 6(2), 113–125.
[18] Prof. Dr. Drs. Salladien, Bs. (2016). Memahami penelitian. *Journal Social*.
[19] Rahardjo, M. (2017). *Studi kasus dalam penelitian kualitatif: Konsep dan prosedurnya*. Malang: UIN Maliki Malang.
[20] Sisilia, Y. (2011). Implementasi sistem manajemen keselamatan sebagai standar keselamatan pelayanan lalu lintas udara. *Bisnis & Birokrasi: Jurnal Ilmu Administrasi dan Organisasi*, 16(3), 140–146.
[21] Soares, J. da R. F. (2018). Analisis pengembangan sisi udara dan alat bantu pendaratan di Bandara Internasional Nicolau Lobato Dili Timor-Leste. Institut Teknologi Dirgantara Adisutjipto.
[22] Stake, R. E. (1995). *The art of case study research*. Sage Publications.
[23] Sucipto, W., Tanijaya, J., & Kalangi, H. T. (2023). Analisis kinerja seismik struktur beton bertulang (Studi kasus: Tower A Gedung Ciputra School of Business Makassar). *Jurnal Media Teknik Sipil*, 1(1), 16–26.
[24] Sugiyono. (2014). *Penelitian pendidikan: Pendekatan kuantitatif, kualitatif, R&D* (Ke-19). Bandung: Alfabeta.
[25] Sugiyono. (2017). *Metode penelitian pendidikan: Pendekatan kuantitatif, kualitatif, R&D* (Cetakan ke-25). Bandung: CV Alfabeta.
[26] Sugiyono, S. (2013). *Metodologi penelitian kuantitatif, kualitatif, dan R&D*. Bandung: Alfabeta.
[27] Susanto, P. C., & Keke, Y. (2019). Implementasi regulasi International Civil Aviation Organization (ICAO) pada penerbangan Indonesia. *Aviasi: Jurnal Ilmiah Kedirgantaraan*, 16(1), 53–65.
[28] Triadmojo, A., & Haryati, E. S. (2022). Penerapan sistem manajemen keselamatan (safety management system) di Bandar Udara Rahadi Oesman Ketapang Kalimantan Barat. *Jurnal Kewarganegaraan*, 6(3), 5872–5880.
[29] Umar, S. H., Hodi, H., & Nurmakkie, P. K. (2017). Evaluasi sistem manajemen keselamatan (safety management system) di Bandar Udara Internasional Adi Soemarmo Boyolali. *Jurnal Manajemen Dirgantara*, 10(1), 5–15.
[30] Wells, A. T., & Young, S. B. (2004). *Airport planning & management* (5th ed.). McGraw-Hill.
[31] Yin, R. K. (2017). *Case study research and applications: Design and methods* (6th ed.). Sage Publications.