PILOT TRUST ANALYSIS ON AUTOLAND SYSTEMS IN BOEING 737 CLASSIC AIRCRAFT: A CASE STUDY AT SULTAN HASANUDDIN INTERNATIONAL AIRPORT MAKASSAR

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ABSTRACT *This study aims to analyze the level of pilot confidence in the Autoland system when operating at Sultan Hasanuddin International Airport. The development of flight automation technology is designed to enhance aviation safety and reduce pilot workload, particularly during the critical landing phase. The Boeing 737 Classic (B737 CL) aircraft is equipped with an Autoland system (Autopilot Flight Director System) that enables automatic landings under low-visibility conditions. This study aims to analyze the level of pilot trust toward the Autoland system when operating at Sultan Hasanuddin International Airport (UPG/WAAA), Makassar, which is renowned for its dynamic weather characteristics and strong crosswinds. This study employs a descriptive quantitative method by distributing questionnaires to 50 active B737 CL pilot respondents. Based on the data analysis using Human Factors principles, the pilot trust level falls into the "High" category with an aggregate mean score of 4.12 out of 5.00. However, this trust is highly conditional and significantly influenced by situational awareness and the crosswind operational limitations of the B737 CL. Pilots consistently maintain high vigilance (avoiding complacency) because the B737 CL system represents legacy technology requiring more stringent monitoring compared to modern Fly-by-Wire aircraft.*

Keywords: *Autoland System, Boeing 737 Classic, Pilot Trust, Human Factors, Sultan Hasanuddin Airport, Flight Automation.*

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1. INTRODUCTION

Air transportation is one of the most crucial modes of transport in Indonesia, serving as the artery of national connectivity by linking thousands of islands in a relatively short time. Along with economic growth and public mobility, the volume of flights in national airspace continues to experience significant year-over-year increases. This linear rise in traffic intensity heightens operational risks in the air, making aviation safety and risk management an absolute priority for all stakeholders. To mitigate these potential hazards, the modern commercial aviation industry relies heavily on the implementation of cockpit automa tion systems to reduce pilot cognitive workload and minimize the potential for human error in every phase of flight. Among the various automated techno logies embedded in modern aircraft, one system that plays a highly vital role in maintaining safety during critical phases is

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the automatic landing capability, or Autoland. This system is designed to guide the aircraft through the approach, flare, and touchdown phases autonomously, without direct manual intervention on the primary flight controls by the pilot. The presence of Autoland serves as a crucial fail-safe instrument supporting Low Visi bility Operations (LVO), particularly when the aircraft must penetrate severe weather, dense fog, or extreme rain precipitation that restricts the pilot's visual range below standard minimums. These operational challenges are highly evident at Sultan Hasanuddin International Airport Makassar (UPG/WAAA), which serves as the primary gateway and aviation hub for eastern Indonesia. Geographically, the airport is surrounded by a highly dynamic coastal topography that periodically triggers extreme weather shifts and sudden atmos pheric anomalies. Phenome na such as windshear, boundary layer turbulence, and high-intensity crosswinds remain latent hazards frequently encountered by avia tors when appro aching runways 03/21 and 13/31. Under these highly uncertain envi ronmental conditions, the pilot's deci sion to either maintain manual flight mode or delegate full control authority to the Auto land system becomes an operational dilemma heavily dependent on their level of trust in the reliability of the aircraft's mechanical and electronic systems. However, global aviation history notes that even advanced automation systems are never entirely immune to the risks of automation malfunctions. Several cases of systemic failure indicate that electronic anomalies such as air data sensor discrepancies, steering servo motor failu res, glideslope/ localizer beam bends, and uncommanded autopilot disenga gement can occur during crucial phases. When one of the Flight Control Computer (FCC) channels experiences sudden functional degrada tion below the decision height (DH), the hybrid system may produce an unstable mechanical res ponse, which, if not rapidly anticipated, can place the aircraft in a dangerous flight attitude in close proximity to the terrain. Such techni cal failure risks are often exacerbated by the pilots' failure to fully comprehend the dynamics and operational logic of the automation systems them selves. A psy chological phenomenon known as auto mation surprise frequently emerges when aircraft systems execute a silent mode transition without the flight crew's full awareness. The pilot's inability to interpret the rationale behind the actions or corrections being taken by the flight computer can trigger a drastic loss of situational awareness. When there is a discrepancy between the pilot's mental expectations and the actual behavior of the aircraft, this lack of understanding often leads to cognitive overload and fatal delays in executing an emergency manual takeover.The condition of this Human-Machine Interface becomes a far more complex challenge when dealing with the characteristics of legacy aircraft fleets, such as the Boeing 737 Classic (series -300, -400, -500), which remain actively operational in Indonesian airspace, particularly for strategic cargo transport and pioneer logistics routes. Unlike modern Fly-by-Wire (FBW) aircraft equipped with multi-layered automatic flight envelope protection capable of autonomously restricting hazardous inputs, the B737 Classic utilizes a conven tional Autopilot Flight Director System (AFDS) with limited mechanical feedback. These characteristics demand significantly stricter active monitoring from the aviators, as the vulnerability to automation compla cency or, conversely, extreme automation distrust is highly prevalent within this legacy technology platform. Based on this background of technical and psychological urgency, this scientific research is conduc ted compre hensively to analyze and measure the level of pilot trust in the performance of the Autoland system on the Boeing 737 Classic, utilizing a specific case study in the operational environment of Sultan Hasanuddin International Airport Maka ssar. By collecting empirical primary data from 50 active B737 CL pilot respon dents who routinely fly this aircraft type in Indonesia, this research aims to dissect

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the interaction among aircraft aerodynamic limitations, ground guidance infrastructure stability, and human factors dynamics to formulate an ideal trust calibration pattern, ultimately ensuring the sustainability of national aviation safety.

1.1. Literature Review

1.1 Architecture and Mechanism of the Autoland System on the Boeing 737 Classic

The Autoland system on the Boeing 737 Classic (comprising the -300, -400, and -500 variants) represents an advanced flight automation capability managed by the Autopilot Flight Director System (AFDS). Unlike modern aircraft built with pure Fly-by-Wire (FBW) architectures that utilize full electronic control laws, the 737 Classic relies on a hybrid mechanical-hydraulic system driven electronically by two independent Flight Control Computers (FCC), designated as FCC A and FCC B.

To execute an Autoland operation legally and safely, dual-channel engagement is mandatory, requiring both autopilot chan nels (Command A and Command B) to be armed simultaneously. This integra tion provides a fail-passive redundancy capa city. If an autopilot channel malfunctions below the critical decision height, the system will not execute any hazardous flight maneuvers but will instead automa tically disengage, accompa nied by immediate visual and aural warnings. This leaves the aircraft in trim and provides the pilot with sufficient time to safely execute a manual takeover (Federal Aviation Administration [FAA]. Technically, the Autoland system synchronizes input data from several critical flight instruments: the Radio Altimeter (RA), which provides abso lute altitude above terrain below 2,500 feet and dictates the automatic flare maneuver at approximately 50 feet; the Inertial Reference System (IRS), providing attitude (pitch, roll, yaw) and acceleration data; and the Air Data Computer (ADC), measuring airspeed and barometric pres sure. The operational limitations of the 737 Classic Autoland system are significantly more restrictive than those of the Next Generation (NG) or MAX variants. For instance, the maximum crosswind capability for automated landings is gene rally limited to 15–20 knots, Excee ding these thresholds can overwhelm the authority of the autopilot servo motors, causing horizontal deviations from the runway centerline.

1.2. Ground Station Infrastructure: Instrument Landing System (ILS)

The capability of an aircraft to perform an automatic landing is completely dependent on the quality and continuity of the guidance signals transmitted by the airport's ground station infrastructure, specifically the Instrument Landing System (ILS). The ground station emits highly precise radio frequency beams that are captured by airborne receiver antennas to construct a precision approach path (Muir, 1994). This infrastructure comprises three primary subsystems:

- *Localizer (LOC): Located at the far end of the runway, emitting two modulating frequencies (90 Hz and 150 Hz) to provide lateral (horizontal) guidance relative to the runway centerline.*
- *Glide Slope (GS): Positioned adjacent to the touchdown zone, transmitting vertical guidance signals to establish a standard 3-degree descent glidepath.*
- *Distance Measuring Equipment (DME) or Marker Beacons: Providing distance verification relative to the runway threshold.*

To support Autoland, the airport ground equipment must comply with rigorous International Civil Aviation Organization Category (CAT) classifications. Sultan Hasanuddin International Airport in Makassar features ILS equipment calibrated periodically to support precision approaches. However, the performance of these ground transmissions is vulnerable to environmental interferences. The topo graphy surrounding Makassar is exposed to seasonal wind patterns from the Makassar Strait, causing rapid moisture transitions. Heavy precipitation and high humidity attenuate electromag netic wave

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amplitudes, risking fluctuations in glide slope and localizer indications in the cockpit. Furthermore, vehicular or aircraft movements within the ILS Critical and Sensitive Areas can cause beam reflec tions, leading to hazardous beam bends.

1.3. Psychological Aspects of Aviators and Levels of Trust in Automation

Pilot trust in cockpit automation is a complex psychological phenomenon that shapes the human-machine interface. Trust is defined as an aviator's subjective expectation that an automated system will operate safely, consistently, and effectively within a context characterized by risk and uncertainty (Lee & See, 2004). According to Muir's framework of trust in automation (1994), trust is not a binary construct but is composed of three evolving dimensions:

- *Predictability: The foundational level where trust is built upon the pilot's ability to anticipate the system's future behaviors based on operational consistency.*
- *Dependability: A higher tier where the pilot trusts the system's structural capacity to absorb environmental distur bances (e.g., light turbulence) without experiencing failure.*
- *Faith: The highest psychological tier, representing the pilot's willingness to delegate full control to automation under critical future conditions, even in the face of incomplete information.*

Aligning the actual capability of the machine with the pilot's psychological perception is known as Trust Calibration. Failures in this calibration process can trigger two types of safety-critical behavioral anomalies (Parasuraman & Riley, 1997). First, Automation Bias or Complacency (over-trust) occurs when a pilot places excessive reliance on the machine, resulting in passive monitoring, degraded situational awareness, and a delayed response to sudden system failures. Second, Automation Distrust (under-trust) leads to pilot anxiety and premature manual intervention on a system that is functioning correctly, causing unnecessary cognitive overload during critical landing phases. For legacy aircraft like the 737 Classic, maintaining appropriate trust calibration is a pronounced challenge due to the lack of modern graphical and visual flight path feedback typical of full glass cockpits.

2. METHODOLOGY

This study implements a quantitative descriptive research method using an analytical survey approach (Sugiyono, 2022). The target sample consists of 50 active pilots (Captains and First Officers) holding a valid Boeing 737 Classic type rating who regularly execute flight operations and landing procedures at Sultan Hasanuddin International Airport, Makassar. The primary research instru ment is a structured Likert-scale question naire (1 to 5) adapting Muir's trust scales. The evaluation encompasses parameters of Predictability, Dependability under normal conditions, Reliability in crosswind scenarios, and overall Faith in task delegation. Primary data gathered from the 50 pilot respondents were processed via IBM SPSS software to verify statistical validity, reliability, and to generate descriptive tabulations.

3. RESEARCH RESULTS AND DISCUSSION

3.1. Respondent Demographics

Among the 50 active B737 Classic pilot respondents, 60% hold the rank of Captain (Pilot in Command) and 40% serve as First Officers. In terms of experience, 70% of the respondents have accumulated over 5,000 total flight hours. This demographic distribution indicates a high level of opera tional maturity, rendering their empirical assessments of aircraft automa tion highly robust and credible.

3.2. Pilot Trust Levels Toward the B737 CL Autoland System

Statistical computation of the question naire data indicates that the aggregate mean score for pilot trust is 4.12 out of

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5.00, which corresponds to the "High" trust category. Table 1 outlines the detailed breakdown across the evaluated trust dimensions.

Trust Dimension	Mean Score (Scale 1-5)	Category
Predictability (System Behavior Anticipation)	4.25	Very High
Dependability (Standard Weather Operations)	4.40	Very High
Reliability in Crosswinds (Environmental Limits)	3.65	Moderate to High
Faith (Willingness to Delegate Control)	4.20	High

3.3. Operatioal Analysis at Sultan Hasanuddin Airport

While the overall pilot trust is high, a visible contraction is evident within the crosswind reliability dimension, which registered a lower mean score of 3.65. Sultan Hasanuddin International Airport (Run ways 03/21 and 13/31) features an open coastal geography susceptible to intense wind rushes from the Makassar Strait. The B737 Classic maintains strict aerodynamic crosswind limits for automated flight, which are lower than those of modern Next Generation (NG) variants. Respondents indicated that as crosswinds approach 15–20 knots, their trust in the automation declines pro-actively, prompting them to manually take over the aircraft control before any unstable flight path deviation occurs. This finding underscores that B737 Classic pilots in Indonesia exhibit excellent situational awareness and are highly resilient to automation complacency. Instead of blindly trusting the legacy machine, they actively cross-check environ mental constraints, validating a mature model of calibrated trust in human-machine integration.

4. CONCLUSION AND RECOMMENDATION

4.1. Conclusion

- *Based on the empirical data collected from 50 active pilot respondents, it is concluded that the level of pilot trust toward the Autoland system on the Boeing 737 Classic at Sultan Hasa nuddin International Airport Makassar falls into the "High" category (Mean: 4.12). The system is deemed highly predictable and dependable under standard instrument meteoro logical conditions.*
- *However, this trust is highly conditional and dynamic. Environmental factors, specifically the severe crosswinds typical of the Makassar region, repre sent a critical pivot that signifi cantly reduces control delegation to the machine. The human factors interac tion on the B737 Classic dictates that pilots maintain rigorous active monito ring, demonstrating that they are free from automation complacency by inter vening manually whenever wind limits threaten the legacy flight envelope.*

4.2. Recommendations

- *Operational Compliance: Flight crews must strictly enforce crosswind limita tions for the B737 CL Autoland system, preferring manual takeovers whenever coastal winds exceed 15 knots at Sultan Hasanuddin Airport.*
- *CRM and Training Focus: Airline operators should enhance Crew Resource Management (CRM) training, specifically focusing on managing "automation surprises" and silent mode transitions on legacy avionics suites.*
- *Simulator-Based Trust Calibration: Periodic flight simulator training must include scenarios with unstable ground ILS signal propagation and crosswind shear to continuously calibrate pilot trust profiles and manual intervention reflexes.*

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