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Optimizing the Safety and Efficiency of Ngurah Rai Airport Runway, Bali through the Implementation of Stopbar Light

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***Abstract*—Ngurah Rai Airport is one of the airports with the busiest traffic in Indonesia. Maintaining runway safety and operational efficiency is crucial to the continuous growth of air traffic. Ensuring the safety and efficiency of airport runway operations is paramount in the aviation industry. This study investigates the implementation of Stopbar Lights as a measure to optimize the safety and efficiency of runway activities at Ngurah Rai Airport in Bali. Stopbar Lights serve as a visual aid to pilots, indicating the precise location where they should stop on the runway, contributing to the prevention of runway incursions, and enhancing overall safety protocols. The research method used is a descriptive qualitative method with data collection techniques in the form of observation, unstructured interviews, literature study, and documentation. Results indicate a notable enhancement in runway safety and efficiency following the introduction of Stopbar Lights. The technology not only reduces the risk of runway incursions but also streamlines ground movements, leading to improved operational timelines. Insights from this study provide valuable considerations for airport authorities and aviation professionals seeking to enhance runway management systems.**

Keywords— *Aviation Safety, Operational Efficiency, Stopbar Light, Technology Implementation.*

I. INTRODUCTION

An airport is an area on land and/or water with certain boundaries used as a place for aircraft to land and take off, up and down passengers, loading and unloading goods, and a place for intra and intermodal transportation movements, which is equipped with aviation safety and security facilities, as well as basic facilities and other supporting facilities[1]. Ngurah Rai Airport, located on the island of Bali, is one of the busiest airports in Indonesia with a significant volume of air traffic. Flight safety and operational efficiency are the main focus in maintaining reliable flight services. In this context, the application of Stopbar Light technology is an important debate to improve vehicle and aircraft control on the runway.

One of the main focal points in maintaining flight safety and operations at Ngurah Rai Airport is the runway area. A runway is a pavement path used by aircraft to land or take off[2]. Runways that function as places where aircraft take off and land, as well as where various ground vehicles interact with aircraft, require careful management and advanced technology to minimize the risk of incidents. In the world of aviation, safety is the top priority, the highest, and the only thing that cannot be tolerated[3].

It is estimated that for every 350.000 surface traffic one severe runway incursion occurs and for every 66 million movements one accident is caused by runway incursion. With 18 million movements on the ECAC airports per year, this results in one runway incursion-related accident every 3.7 years[4]. When pilots or vehicle drivers can navigate on the airport surface but visibility is not sufficient to avoid collision, controllers switch over to procedural control. Therefore, on most airports aircraft or vehicles will only move in one defined section of the airport at a time and will be controlled as such. An aircraft or vehicle will only be permitted to enter a clearly defined airport section (taxiway segment separated by stop bars) after this section has been cleared by all other traffic[5]. Runways are one of the most critical infrastructures at airports that require careful and innovative management to avoid incidents that could jeopardize flight safety. Amidst the complexity of airport operations, phenomena such as "runway incursion" have emerged as a serious issue affecting airport safety and efficiency. Flight safety is a top priority in the aviation industry. A runway incursion is an important aspect that must be considered to maintain such safety.

Runway Incursion is any incident at an airport involving the improper presence of aircraft, vehicles, or persons in a protected area on a surface intended for landing and taking off aircraft[6]. Runway incursion refers to a situation where an unauthorized vehicle or aircraft enters or moves on the runway, which may interfere with the operations of aircraft taking off or landing. Such events can result in collision risks and potential hazards for passengers, flight crews, and airport personnel. To prevent runway incursions, efforts are made to address pilot familiarity with airports, navigation and communications improvements, pilot/controller memory and attention, controller training and procedures, and airport surface markings and lighting[7]. Some of the factors that can lead to runway incursion include poor coordination, unclear communication, and lack of use of advanced technology. The consequences of a runway incursion can range from minor delays to serious accidents. Even if runway incursions do not result in accidents, the potentially catastrophic consequences of runway incursions place them high on the agendas of aviation safety[8].

One solution that has been proposed to address the risk of runway incursion is the implementation of Stopbar Light technology. This technology uses a system of signal lights on

the runway that provides visual warnings to pilots and ground vehicle drivers regarding when they should stop and when they can resume movement. The application of this technology aims to increase awareness and coordination among all parties involved in airport operations, as well as minimize the possibility of runway incursion. Runway Stop Bars are considered a valuable line of defense against aircraft and vehicles mistakenly entering the runway without ATC clearance[9]. Runway incursion incidents result from pilots and drivers who are aware of the short runway hold instructions but then proceed beyond the runway hold position markings. Stop Bars are intended to provide additional protection at runway intersections to protect against runway incursions. Aircraft taxiing in the maneuvering area must stop and hold at all lighted stop bars and may proceed further when the lights are turned off[10]. Finally, to reduce runway incursion threats, Stop Bar Lights works. This light is identical to In-Ground Centreline Lights, but they are illuminated in red, meaning that pilots are not permitted to cross the holding point line on the runway. Pilots must receive verbal take-off clearance from the ATC officer, and the lights will be shut off before they can continue to cross it. [11]

The implementation of Stopbar Light technology has emerged as a promising solution. Pilots should not cross red stop bars when lining up on, or crossing, a runway unless emergency procedures specifically permit this[12]. This technology can significantly improve the control and management of aircraft movements on the runway, by providing clear guidance to pilots and operational personnel. The red stop bar light is switched off as verbal instruction is given to reinforce that an aircraft or vehicle is cleared to enter the runway[13]. By using various types of lights, you can assist and serve the pilot visually during the take-off and landing process as well as during taxiing so that the aircraft can move safely during bad weather (low visibility) and at night[14]. Along with the development of aviation technology, the implementation of the Stopbar Light at Ngurah Rai Airport has received serious attention to improve safety and efficiency.

The application of advanced technology in airport operations has opened new avenues in minimizing collision risks and improving coordination between aircraft and ground vehicles on runways. The more sophisticated technology causes convenience, but in its development, what is striking is the ease of access to information in terms of knowledge, communication, and easy access to stakeholders in their activities[15]. Against this background, this article will investigate in greater depth the need for the implementation of Stopbar Light at Ngurah Rai Airport, describe its expected benefits, and review its potential impact on flight safety and operational efficiency. When considering safety risks (a combination of frequency of occurrence and severity of consequences), safety experts, based on observations and interviews, also hope that new solutions will lead to a reduction in safety risks.[16]

In this context, this study aims to investigate the potential for optimizing the runway safety and efficiency of Ngurah Rai Airport, Bali, through the implementation of Stopbar Light technology. With a focus on the issue of runway incursion, this study will analyze the impact of using this technology on incident frequency, and operational efficiency, as well as the perceptions and responses of pilots, ground vehicle drivers, and airport personnel to the implementation of Stopbar Light. Three factors influence innovation in the aviation sector, namely human resource capability, technological advancement, and the prominence of clean energy. These three factors have a positive influence so that they can encourage the aviation sector to continue to innovate[17]. Through a thorough analysis of relevant data and information, this research is expected to provide an in-depth view of how this technology can be an effective solution in reducing the risk of runway incursion and improving safety and efficiency at Ngurah Rai Airport, Bali.

II. METHODOLOGY

This type of research is descriptive qualitative, which is a technique that describes and interprets the meaning of the data that has been collected by paying attention to and recording as many aspects as possible of the situation under study at that time, to obtain a general and comprehensive picture of the actual situation (Kriyantono, 2007). According to Moleong (2010) using descriptive methods means that researchers analyze the data collected in the form of words, pictures, and not numbers. The data may come from interview scripts, field notes, photos, videotapes, personal documents, notes or memos, and other official documents.

The data collection technique that the author uses is the documentation study method. Documentation review is a data collection method that does not directly point to the subject of investigation. The documents studied vary, not necessarily official, but can be diaries, personal letters, reports, meeting minutes, case histories, and others. (Aminarno: 2019). The documents studied in this research are taxiway data documents that require the application of a stop bar light.

This study aims to present the results of a descriptive qualitative analysis of the impact of Stopbar Light implementation on runway safety and efficiency at Ngurah Rai Airport, Bali. The discussion outlines the key findings resulting from the research and provides a broader view of the implications of the changes to airport and aviation operations. Overall, the discussion concludes that the implementation of Stopbar Light at Ngurah Rai Airport has made positive changes in terms of flight safety and operational efficiency. However, challenges and opportunities for further development must continue to be addressed for the benefits of this technology to be enjoyed in the long term.

III. RESULT

The results of the analysis show that the implementation of Stopbar Light significantly improves flight safety at Ngurah Rai Airport. Pilots report that the visual illumination provided by the Stopbar Light makes it easier to navigate aircraft on the runway, especially in adverse weather conditions. Potential incidents related to aircraft movement on the runway can be prevented more effectively. In addition, operational efficiency is also improved with the implementation of Stopbar Light. Better coordination between air traffic controllers and pilots results in more efficient use of the runway and a reduction in delay time. The application of this technology helps optimize the aircraft movement process in the runway area.

This study aims to investigate the impact of the implementation of Stopbar Light technology on the optimization of runway safety and efficiency at Ngurah Rai Airport, Bali, with a particular focus on the issue of runway incursion. Based on the analysis of the collected data and information, the results of this study show several significant findings regarding the positive effects of implementing Stopbar Light technology in addressing the risk of runway incursion and improving the safety and efficiency of airport operations.

1. Reduction of Runway Incursion Incidents:
   The results of this study indicate that the implementation of Stopbar Light technology significantly reduces the frequency of runway incursion incidents at Ngurah Rai Airport, Bali. This signal light system provides clear visual guidance to aircraft pilots and ground vehicle drivers as to when to stop and when to resume movement. This has helped reduce confusion and human error in understanding priority rights and the appropriate time to move on the runway.
2. Improved Awareness and Coordination:

   The implementation of the Stopbar Light has also improved awareness and coordination among all parties involved in airport operations. Pilots, ground vehicle drivers, as well as airport personnel have become more aware of the visual signals provided by the Stopbar Light. This reduces the risk of miscommunication or interpretation that could lead to runway incursion.
3. Improved Operational Efficiency:

   In addition to increased safety, the implementation of Stopbar Light has also made a positive contribution to airport operational efficiency. The use of this technology reduces waiting time and confusion on the runway, allowing aircraft to move more smoothly and on time. This has resulted in an increase in runway capacity and the efficiency of landing, take-off, and aircraft movements in the airport area.
4. Positive Response from Involved Parties:

   Survey and interview data showed that pilots, ground vehicle drivers, and airport personnel responded positively to the implementation of Stopbar Light. They feel that this technology helps reduce stress and uncertainty in runway operations, and increases confidence in the decisions made.

Providing flight information services in the form of Information Service and Alerting Services to aircraft must guarantee air traffic safety and smooth flow within its territory. This is also to achieve the goal of the flight information service itself, namely, to prevent collisions between aircraft, aircraft in a maneuvering area, or between aircraft and obstacles in that area, and accelerate and maintain the smooth flow of air traffic[18].

IV. DISCUSSION

Safety Challenges at Ngurah Rai Airport: The high traffic levels and complexity of operations on Ngurah Rai Airport's runways pose potential safety risks. Effective implementation of stopbars can reduce the risk of aircraft and ground vehicle collisions, as well as provide clear instructions to personnel operating in the area. However, implementing new technology also involves several challenges. During the transition process, adaptation to Stopbar Light technology requires intensive training for airport personnel. In addition, the maintenance and care of this technology became a critical factor in ensuring optimal performance. Discussions with technical personnel and airport officials underscored the importance of regular maintenance to maintain lighting quality and prevent potential breakdowns.

Stop Bars are a series of unidirectional lights embedded in the runway surface at an angle perpendicular to the taxiway centerline at the associated runway detention point. These lights are located at 3-meter intervals along the taxiway and are located at points where traffic should stop. Typically, this location is near the runway detention line. Stop Bars show red lights in the direction of approach to the Stop Bar from the taxiway and must be controlled or operated by ATC. When lit, they indicate where ATC requires aircraft and vehicles to stop. Stop Bars should be installed in conjunction with taxiway centerline lights along the taxiway after the Stop Bar, which guide aircraft towards the runway centerline. When provided, they are operated in conjunction with the Stop Bar so that when the Stop Bar is red, the taxiway centerline lights leading to the Stop Bar are also on, and the taxiway centerline lights for a minimum distance of 90 Meters after the Stop Bar are off. When ATC gives clearance to proceed, the controller turns off the Stop Bar lights, and the portion of the taxiway lights that are locked highlights the taxi route to the runway. Stop bars are intended to be an additional barrier if an aircraft mistakenly thinks they are receiving a clearance intended for another aircraft. The stop bar must have been visible[19].

Stop Bars on runways are considered a valuable line of defense against aircraft and vehicles entering the runway without permission from ATC (Air Traffic Control). Many Runway Encroachment incidents occur because pilots and drivers recognize the instruction to hold in front of the runway but then proceed past the runway hold sign anyway.

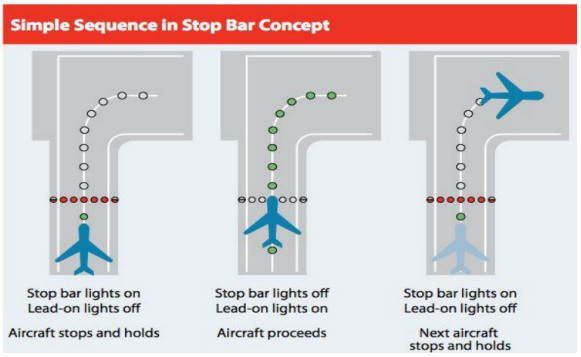

Fig 1. Simple Sequence in Sop Bar Concept

Based on the investigation of the incidents, the Safety Board concludes that an acceptable ground movement safety system should be able to provide direct warnings to flight crews and other vehicle operators of potential incursions through means such as runway edge lights and stop bars located at all runway/taxiway intersections, or by other means, such as a data-link[20]. Stop Bars are intended to

provide additional protection at runway intersections to prevent runway incursions in the following ways:

1. Increasing the visibility of the detention point.
2. Strengthen ATC control of aircraft and vehicles in the vicinity of the runway.
3. Improves defense against ATC errors in identifying aircraft or vehicles.

Stop Bar operation does not require any special equipment on the aircraft or vehicle, but only requires the pilot or driver to stop and hold in front of an illuminated Stop Bar and only resume travel when ATC gives appropriate verbal instructions and turns off the Stop Bar. Once the aircraft or vehicle crosses the Stop Bar, all lights will be automatically or manually reset by ATC. In places where Stop Bars are automatically reset, this may be done by sensors (on the runway surface) or a backup timer (typically 60 seconds for the timer, but may vary based on local operating conditions). Furthermore, it is also suggested to implement stop bars at every entry to a runway in all airports. These are not only visual aids, they can also confirm the clearance given to the pilots. For example, they get de-activated by ATC when pilots are given clearance to line up on the runway[21].

The use of a Stopbar Light will provide several significant benefits. First, it will improve the pilot's and ground vehicle driver's view of the stopping point indicated by the lights. Second, this technology can be integrated with air traffic control systems to manage aircraft movements on the runway more efficiently and safely. runway incursions have occurred in many airports, and related institutions have also paid more attention to the use of technical means to prevent runway intrusion. Some airports have had the technology of stop bars through technical renovation and expansion[22].

The implementation of Stopbar Lights is expected to provide Positive Implications to Flight Operations such as collision incidents or potential collisions between aircraft and ground vehicles can be significantly reduced. This will create a safer environment for aviation and airport operations. In addition, operational efficiency will increase as the process of aircraft movement on the runway will be more coordinated. With the help of this technology, coordination between airport personnel and pilots has improved significantly. The process of aircraft navigation and traffic management around the runway has become more structured and effective. The result is increased runway utilization, reduced delay time, and better overall operational efficiency. Further development requires observation and analysis during the research process to make this stopbar light application better to the needs and adjustments with the evolving technology[23]. This research contributes to the ongoing discourse on runway safety, offering practical insights into the positive outcomes of implementing Stopbar Lights at Ngurah Rai Airport. The findings underscore the importance of adopting advanced technologies to address safety concerns and optimize operational procedures within airport environments.

V. CONCLUSION

This research describes the results of a descriptive qualitative analysis of the implementation of Stopbar Light at Ngurah Rai Airport, Bali, and its impact on optimizing runway safety and efficiency. Based on in-depth interviews with various stakeholders as well as participatory observation during the implementation period, this research presents an in-depth understanding of the changes in the airport's operational environment and the responses of the stakeholders.

The analysis shows that the implementation of Stopbar Light has contributed significantly to flight safety at Ngurah Rai Airport. Clear and controlled visual illumination has reduced the potential for accidents associated with aircraft navigation on the runway. Stopbar Light technology has helped minimize the risk of collisions and incidents during aircraft movements in the runway area, especially in poor weather or low visibility conditions. Runway incursion can occur under any visibility or weather conditions. The provision of Stop Bars at runway restraint positions and their use at night and in visibility conditions greater than 550 m of runway visibility can be part of an effective runway incursion prevention effort.

In addition, operational efficiency has also been improved by the application of this technology. Navigation procedures and aircraft traffic control around the runway have become more coordinated and timelier. Air traffic controllers report improved communication with pilots and airport management, reducing delays and increasing more effective runway utilization.

This improved safety and efficiency has also received positive support from pilots, technical personnel, and airport management. This even-handed response demonstrates that the implementation of Stopbar Light not only affects the technical aspects of operations but also provides confidence to all parties involved in the flight process.

However, the successful implementation of Stopbar Light also faced some challenges. The adaptation process to the new technology requires intensive training for airport personnel. In addition, regular care and maintenance of this technology is an important factor in maintaining its performance and ensuring continued flight safety. To optimize the effectiveness of Stopbar Light technology, continuous efforts in training, maintenance, and communication between relevant parties are required. This research recommends that implementing new technology in an airport operational environment should be supported by a collaborative approach and the active involvement of all relevant parties.

Overall, this research has provided an in-depth overview of how the implementation of Stopbar Light has successfully optimized runway safety and efficiency at Ngurah Rai Airport, Bali. The findings are an important contribution to the overall improvement of aviation safety and airport operations and a basis for further development in this field.

REFERENCE

[1] "UNDANG-UNDANG REPUBLIK INDONESIA NOMOR 1," 2009.

[2] A. Utami, "ANALISIS PENGEMBANGAN RUNWAY DAN FASILITAS ALATBANTU PENDARATAN DI BANDAR UDARA DEPATI AMIR BANGKA," 2012.

[3] F. Anwar, G. Marausna, and F. Jayadi, "ANALISIS HEAT TRANSFER PADA STRAIGHT TUBE TWISTED TAPEINSERT ANTI ICING HEATER DENGAN MEMANFAATKAN THERMALGAS BUANG ENGINE," 2021.

[4] "Ting Ding Advanced Surface Movement Guidance and Control System Investigation and Implementation in Simulation," 2010.

[5] J. Teutsch and V. Mollwitz, "Executive summary A-SMGCS Airport Block Control Separation Bubbles Low Visibility Procedures Virtual Block Control and Separation Bubbles in ATC Low Visibility Operations Results of Tower Control Real-time Simulations Tower Controller Working Position during Rotterdam Evaluation Sessions," 2009. [Online]. Available: www.nlr.nl

[6] "HARMONISING THE USE & MANAGEMENT OF STOP BARS AT AIRPORTS," 2014.

[7] "RUNWAY INCURSION PREVENTION PROGRAM," 2002.

[8] M. Avenue, "RUNWAY INCURSIONS: A Call for Action," 2007.

[9] "ICAO Doc 4444 Air Traffic Management," 2016.

[10] "ICAO Annex 2 Rules of the Air," 2005.

[11] M. Syafiq, A. Law, and A. H. Ariffin, "A Review on the Aerodrome Standard in the Aviation Industry," *Journal of Aviation and Aerospace Technology Journal homepage*, vol. 2, no. 2, pp. 1–4, 2020, [Online]. Available: www.fazpublishing.com/jaat

[12] C. KnowHow, S. AENA -Aeropuertos Españoles Navegación Aérea, C. Juan, S. Adeco-Editions van Diermen, and M. Richard Van Diermen, "Manual on the Prevention of Runway Incursions," 2007.

[13] Connecting Australian Aviation, "Stop Bars."

[14] J. Teknik, K. Transportasi, R. P. Simanjuntak, R. Aulia, S. Diriyanti, and P. P. Medan, "Sistem Monitoring Runway Guard Light Menggunakan Power Line Carier di Bandara Kualanamu Deli Serdang Runway Guard Light Monitoring System Using Power Line Carier at Kualanamu Airport Deli Serdang," 2022.

[15] Y. Damayanti, H. Krisnani, and M. Budiarti Santoso, "KEBERADAAN MASYARAKAT PENDATANG DI DESA SUKAKERTA (PERUBAHAN SOSIAL BUDAYA MASYARAKAT TERKAIT PEMBANGUNAN BANDARA INTERNASIONAL JAWA BARAT DI KECAMATAN KERTAJATI, KABUPATEN MAJALENGKA)".

[16] Teutsch, Stegeman, and GB, "NLR-Netherlands Aerospace Centre Virtual Stop Bars: from Block Control towards Low Visibility Automation Support," 2017. [Online]. Available: www.nlr.nl

[17] D. Supardam and R. Raza Bunahri, "Faktor-Faktor yang Mempengaruhi Inovasi dalam Sektor Penerbangan: Kapabilitas Sumber Daya Manusia, Kemajuan Teknologi, dan Prominensi Energi Bersih," 2023, doi: 10.31933/jemsi.v4i4.

[18] A. Susanto and A. Sutrisno, "ANALISASTANDAR KEAMANAN TERHADAP KESELAMATAN PENERBANGANDIBANDAR UDARA KOMODO LABUAN BAJO," 2018.

[19] J. EID and P. B. JENSEN, "RUNWAY INCURSIONS IN NORWAY 2009-2019: A CASE STUDY OF EXTENDED INVESTIGATION REPORTS," *The Polish Journal of Aviation Medicine, Bioengineering and Psychology*, vol. 25, no. 3, pp. 5–14, Aug. 2021, doi: 10.13174/pjambp.19.05.2021.01.

[20] G. K. Singh and C. Meier, "Preventing runway incursions and conflicts," *Aerosp Sci Technol*, vol. 8, no. 7, pp. 653–670, Oct. 2004, doi: 10.1016/j.ast.2004.08.001.

[21] J. M. Carl, S. Handledare, V. Polishchuk, E. Tobias, and A. Granberg, "Investigation of Runway Incursion Examensarbete utfört i Logistik vid Tekniska högskolan vid Linköpings universitet," 2013. [Online]. Available: http://www.ep.liu.se/

[22] L. Jiang, P. Yang, X. Ma, H. Yang, T. Li, and J. H. Yang, "Comparison of Detection Technology for Runway Incursion Prevention in Airport Hot Spot," in *Journal of Physics: Conference Series*, Institute of Physics Publishing, Jun. 2020. doi: 10.1088/1742-6596/1570/1/012052.

[23] A. B. Rahmah, A. Setiawan, and T. Warsito, "PENGEMBANGAN SISTEM INFORMASI APLIKASI PETA BANDARA BERBASIS WEBSITE UNTUK MENINGKATKAN PELAYANAN PENGGUNA JASA DI BANDARA INTERNASIONAL JUANDA SURABAYA," 2021.