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Influence of Building Layout and Weather Conditions on Air Traffic Services

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***Abstract*— I Gusti Ngurah Rai International Airport is one of the busiest airports in Indonesia that serves a variety of flights, ranging from scheduled, unscheduled, cargo, and military, to recreational flights. All flights are regulated by the Air Traffic Controller which is divided into two units, namely the Aerodrome Control Tower and Approach Control Surveillance. The Aerodrome Control Tower has the responsibility of regulating flight traffic in the "vicinity of aerodrome" area. From the tower, ATC must be able to monitor all movements of flight operations in the area of responsibility. However, at the Airport tower, several things can affect ATC's view in monitoring the movement of flight operations, namely airport buildings that block several parking stands, dark night conditions in the maneuvering area, and extreme weather. Of course, these problems will also affect the performance of ATC in providing flight traffic services. In addition, it can cause doubts in ATC in making decisions for aircraft that are being handled. This research aims to analyze the problem of ATC's limited view in monitoring the movement of flight operations in its area of responsibility. The research method used is qualitative with data collection techniques in the form of observation, literature study, interviews, and documentation. The development of Advanced Surface Movement Guidance and Control System that can monitor the movement of flight operations in various conditions can be one solution to the problem. In addition, the installation of CCTV in several areas that are not visible from the tower can also assist ATC in monitoring the movement of flight operations in the area. The results of this study are expected to assist ATC in monitoring the movement of flight operations both in dark night conditions and extreme weather. The author also hopes that the results of this study can be useful in improving organized and efficient flight traffic services at I Gusti Ngurah Rai International Airport.**

Keywords—view, tower, layout, weather, ASMGCS

I. INTRODUCTION (*HEADING 1*)

Aerodrome Control Tower is one part of the Air Traffic Controller Unit. Aerodrome Control Tower works in towers throughout the airport. One of them is the I Gusti Ngurah Rai International Airport Tower located on the island of Bali.

At I Gusti Ngurah Rai International Airport, the Aerodrome Control Tower has the task of providing instructions, permits, and information to aircraft within its area of responsibility to ensure safety, order, and smooth flight traffic at I Gusti Ngurah Rai International Airport, to prevent collisions between aircraft: [1]

- Aircraft flying within the aerodrome traffic zone of I Gusti Ngurah Rai International Airport and its movement area, including the traffic circuit;
- Aircraft operating in the maneuvering area;
- Aircraft landing and taking off;
- Aircraft and vehicles in the maneuvering area;
- Aircraft and obstacles in the maneuvering area.

Based on ICAO Document 4444 Air Traffic Management and ICAO Annex 14 Air Traffic Services [2][3], the definition of a Maneuvering Area is part of the airport used for aircraft take-off, landing, and taxiing, excluding the apron. Unlike the Movement Area, which means part of the airport used for take-off, landing, and taxiing of aircraft, which consists of the Maneuvering Area and Apron. From this understanding, more briefly, it can be explained again that the Manoeuvring area consists of taxiways and runways. Meanwhile, the Movement Area consists of a taxiway, runway, and apron.

In carrying out their duties, an ATC at the Aerodrome Control Tower must continuously monitor all movements of flight operations in the vicinity of the aerodrome, including vehicles and flight personnel in the maneuvering area [4]. This is in accordance with what is stated in ICAO Document 4444 Air Traffic Management, Chapter 7 Procedures of Aerodrome Control Tower, point 7.1 Function of Aerodrome Control Tower, which states: [2]

"Aerodrome controllers shall maintain a continuous watch on all flight operations on and in the vicinity of an aerodrome as well as vehicles and personnel on the manoeuvring area. ..."

In the Aerodrome Control Tower unit, the author found a problem that can affect the performance of ATC in providing flight traffic services due to several factors that hinder an ATC in monitoring the movement of flight operations continuously. Some of these factors include:

- Parking stands that are not visible to ATC from the Tower;
- Conditions at night in the dark maneuvering area;
- Extreme weather, such as rain, storms, and fog

These three things have the potential to obstruct the ATC's view when monitoring the movement of flight operations in providing flight traffic services. On the other hand, an ATC at the Aerodrome Control Tower unit is required to always apply "visual separation" to every flight in his area of responsibility [5].

II. RESEARCH OF METHOD

The research method is a scientific method with a rational and systematic basis to obtain valid data with specific purposes and uses. This research uses qualitative research

methods, namely research that uses a method of study or comparison between theories, laws, provisions, and procedures that apply to the conditions that occur in the field at that time. Qualitative research method according to Sugiyono, is a research that makes people as instruments who must have theoretical provisions and broad insights, so that they are able to ask, analyze, photograph, and project the situation or situation being studied. [6]

Qualitative methods rely on text and image data, have unique steps in data analysis, and use diverse designs. In his book entitled Reseacrh Design, Creswell explains that qualitative research partly requires educating the reader about the purpose of the research, mentioning the specific design, reflecting carefully on the role played in the research, drawing from an ever-expanding variety of data sources, using specific rules for recording data, analyzing information through several steps of analysis, and mentioning approaches to document the methodological integrity or accuracy (validity) of the data collected. [7]

Furthermore, the author collected data using several methods, as follows: [8]

A. Observation

The author makes observations at the I Gusti Ngurah Rai International Airport Tower, by observing what happens in the field directly to get the original data and in accordance with the actual situation.

B. Literature

The author conducts a literature study by studying the procedures and SOPs that apply to flight operations, especially in the Aerodrome Control Tower unit of Perum LPPNPI Denpasar.

C. Interview

The author also conducted unstructured interviews with several ATC personnel in the Aerodrome Control Tower unit of Perum LPPNPI Denpasar to find out the obstacles and difficulties experienced while serving as an ATC.

D. Documentation

The author also conducts documentation on several conditions in the field that show problems so that they can be presented as evidence in the research report.

III. Analysis and Discussion

The Air Traffic Control (ATC) tower is one of the most strategic and vital building structures for the operational functions of each airport because the functionality of each airport directly depends on the operation of the ATC tower [9]. Based on ICAO Document 9426 Air Traffic Services Planning Manual explains that the requirements of an Air Traffic Control (ATC) Tower must have the required height and must have sufficient space to ensure an optimal working environment for personnel and equipment (including expansion capabilities), energy efficient, durable, and aesthetically pleasing all within an affordable cost [10].

Tower towers at each airport have different heights. The height specification of the tower at an airport depends on the type and needs of the airport. In general, the wider the airport and the longer the runway, the higher the tower at the airport [11]. However, the height of a tower cannot guarantee that an ATC can see and monitor all movements in the vicinity of the aerodrome [5]. Several things or factors at an airport can cause an ATC's view to be obstructed and limited [12]. An ATC in the Aerodrome Control Tower unit is required to monitor continuously all movements of flight operations, as discussed in the previous point in accordance with ICAO Document 4444 Air Traffic Management, Chapter 7 Procedure of Aerodrome Control Tower [2]. If this happens, it can hinder an ATC in providing flight traffic services and can reduce the level of safety in the world of aviation [13].

Based on the EuroControl Operational Safety Study Document: Controller Detection of Potential Runway and Manoeuvring Area Conflict, the following are the biggest factors that can affect the effectiveness of safety levels: [14]

A. Surveillance Information

The availability of surveillance data can affect the detection of runway incursion and movement errors in the manoeuvring area.

B. Visibility Condition from the Tower

Visibility from the Cabin Tower and the ability to recognize potential conflicts can be limited due to:

a) Day/Night
b) Fog/Smoke
c) Low clouds affecting the Tower height
d) Daytime sunlight and glare
e) Rainwater on Tower windows (precipitation)
f) Airport floodlights at night, especially temporary *repair worksementara*

C. Runway Configuration

Runway configuration can impact the complexity and performance of an ATC.

D. Line of Sight

An ATC's view of the tower may vary. The position, height, design, materials, and distance from the tower can limit an ATC's direct line of sight to parts of the runway and manoeuvring area.

E. ATC Safety Net Alerts

The availability of ATC Safety Net Alerts can have an impact on the timeliness of harassing a conflict.

Of all the factors above, some of them can be found in the Aerodrome Control Tower unit at Perum LPPNPI Denpasar Branch Office. This can hamper ATC in providing flight traffic services [13]. The following is an analysis of the problem:

A. The existence of parking stands that cannot be seen by the Tower Controller

At I Gusti Ngurah Rai International Airport, the north apron section, has 2 parking stands that cannot be seen by ATC from the tower. The parking stands are A39 and A40. These two parking stands cannot be seen by ATC from the tower because they are covered by airport buildings. The airport building is enough to prevent ATC from seeing the position of the aircraft in the parking stand. Therefore, in giving pushback clearance to aircraft in the two parking

stands, ATC cannot fully ensure that the taxiway area behind the parking stands is free from obstruction [15].

Fig. 1. ATC's view from the tower of Parking Stands A39 and A40

For parking stand A40, the engine pushback and start-up procedures are different from the other parking stands. In accordance with the Letter of Coordination and Agreement between Tower and AMC, the pushback and start-up procedures for parking stand A40 are as follows: [16]

" For parking stand A40, aircraft are only allowed to start engines when they are at taxiway centerline A39 (pushback and towed to the A39 boundary); in case the aircraft cannot start engines and requires GPU (Ground Power Unit) assistance, the ground handling pulls the GPU to the taxiway and is supervised by AMC with the permission of ATC after prior coordination (pushback and towed to A39 and assisted by GPU to start engines)."

In the pushback procedure at parking stand A40, after pushback, the aircraft will be pulled to the back of parking stand A39. This is so that the nose of the aircraft can be seen by ATC from the tower. At this position, the new aircraft is permitted to perform engine start-up. If the aircraft requires an external Ground Power Unit (GPU), the GPU will be towed to the aircraft's position on the center line taxiway with permission from ATC.

When ATC permits the ground handling to enter the taxiway and carry the GPU, ATC also cannot ensure that the area to be entered by the ground handling is completely safe because in that position only the tip of the aircraft (nose) can be seen by ATC from the tower [17].

In addition, the invisibility of parking stand A40 raises doubts for ATC when providing parking stand information to arriving aircraft that will enter parking stand A40. Sometimes, ATC must contact the AMC unit first to ensure that the parking stand is empty and there are no aircraft parked there.

B. Dark conditions at night in the manoeuvring area

At night, conditions in the manoeuvring area of I Gusti Ngurah Rai Airport appear quite dark, especially in the taxiway N1 and N7 areas associated with the ends of runways 27 and 09. The considerable distance from the tower to taxiways N1 and N7 also reduces the clarity of ATC's view of the taxiway at night. This makes it difficult for ATC to identify the position of aircraft that have reached taxiways N1 and N7. Often, pilots report that they have reached on short runway 27 or runway 09. However, due to the dark conditions and long distances, ATC has difficulty determining whether the aircraft is at the holding point or not. Especially when the aircraft had stopped, the light of the aircraft seemed to merge with the surrounding lights. Thus, ATC had difficulty identifying where the aircraft was. [15] [18] [19]

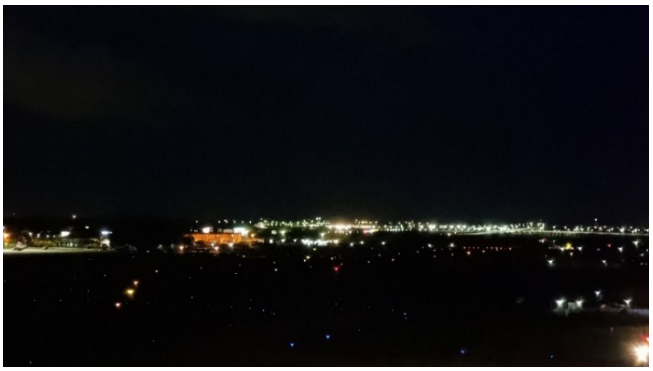

Fig. 2. ATC's view from the tower of the dark N1 taxiway area at night

In low-traffic conditions, this is not a problem. However, in busy traffic conditions, it will cause doubts for ATC, as in the following conditions:

- Entering a departure aircraft when there is an arrival aircraft that has approached but the separation distance is still possible for the departure aircraft, and
- Tucking a departure aircraft between two arrival aircraft with a separation distance that still allows for the departure aircraft.

(*) Notes: The separation distance between the arrival aircraft and the departure aircraft is 8 NM. If the arrival aircraft is still more than 8 NM away from the runway, the departure aircraft is still allowed to fly. [20]

In both conditions, the pilot reports that the departure aircraft has reached "on short runway" and is "ready for departure". Meanwhile, there is an arrival aircraft that starts to approach for landing with a distance of more than 8 NM. If this condition occurs at night, it will cause ATC to doubt when entering the departure aircraft onto the runway. ATC cannot be sure whether the position of the departure aircraft is right at the holding point or not.

The consideration when entering the departure aircraft is that if the departure aircraft has indeed reached the holding point, the runway line-up process and take-off can be done quickly. So that the separation between the departure aircraft and the arrival aircraft can be maintained. Meanwhile, if the departure aircraft has not reached the runway holding point, the line-up process will take longer until the take-off. While the arrival aircraft continues to approach the final area, this can cause the separation between the departure aircraft and the arrival aircraft to be reduced. The worst possibility that can occur if the separation is reduced is runway incursion and the arrival aircraft must go around because the runway is not yet empty from the departure traffic. [21]

In addition, at night conditions, it is often difficult for ATC to ensure that the runway is empty of arriving aircraft. The conditions are quite dark, making it difficult for ATC to identify the position of the arrival aircraft, whether it has completely exited the runway or not. Thus, ATC often has to wait longer to ensure that the arrival aircraft has exited the

runway. Another option is for ATC to ask the pilot to report that the arrival aircraft has exited the runway. [17]

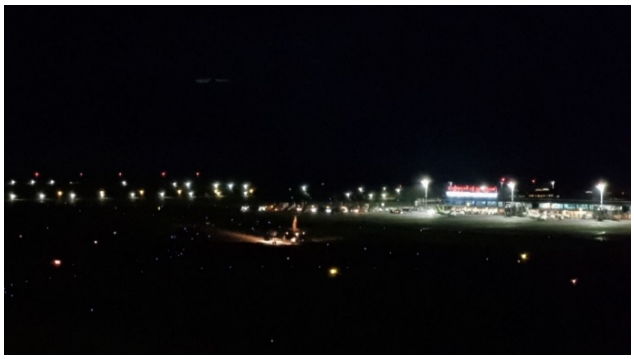

Fig. 3. ATC's view from the tower of aircraft arriving vacating runway via taxiway N5 at night

In low-traffic conditions, this is not a big problem. However, in busy traffic conditions, it can reduce the effectiveness and efficiency of runway use, and cause a load of communication. This is related to the granting of clearance by ATC to the next runway user. If ATC still has doubts about the certainty that the runway is clear of traffic, then clearance cannot be given to the next runway user. The worst possibility of ATC's difficulty in confirming the runway's emptiness is the occurrence of runway incursion [21].

IV. Extreme Weather, such as Rain, Storms and Fog

When conducting research at I Gusti Ngurah Rai International Airport, it coincided with the rainy season period. Thus, the author often experiences extreme weather when providing flight traffic services. The extreme weather included rain, storms, and fog. Moreover, the position of the runway near the beach causes the wind to blow quite strongly.

Several times, the author experienced conditions where the manoeuvring area was covered by fog. This caused visibility in the manoeuvring area from the tower to be very low and ATC could not monitor the movement of flight operations in the area, even during the day. Similarly, at night, the fog makes it difficult for ATC to determine the position of the aircraft either on the taxiway or about to exit the runway. In foggy conditions like this, it will be very dangerous and can reduce the level of flight safety at the airport. [19] [22]

During rain and storms, rainwater often covers the tower's window glass. This causes the towering glass to become blurred and obstructs the ATC's view in monitoring movements in the manoeuvring area. Here are some documentations during extreme weather and foggy conditions:

Fig. 4. Occurrence on Friday, January 28th, 2022

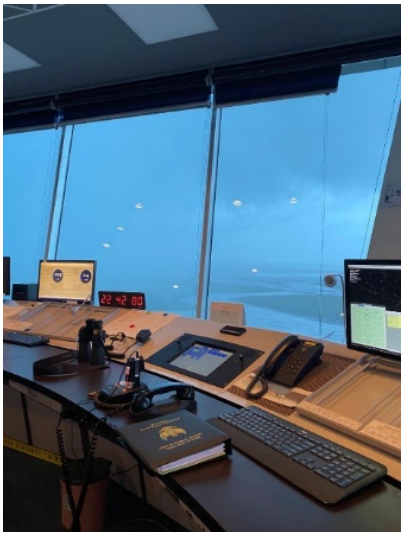

Fig. 5. Occurrence on Thursday, January 27th, 2022

Fig. 6. Occurrence Saturday, January 15th, 2022

From the analysis above, all three are problems that can occur in the Aerodrome Control Tower unit, which can cause limited ATC views in monitoring the movement of flight operations in the manoeuvring area. The author also notes that I Gusti Ngurah Rai International Airport is one of the busiest airports in Indonesia [23]. So, the existence of the above problems can hamper ATC in providing flight traffic services. In addition, these problems can also reduce the effectiveness and efficiency in realizing flight safety at I Gusti Ngurah Rai International Airport [17].

V. Results

From several problems that occur in the Aerodrome Control Tower unit of Perum LPPNPI Denpasar, the author takes several documents and reference sources that can be used as a reference in solving these problems.

Based on ICAO Document 4444, Air Traffic Management, Chapter 7 Procedure for Aerodrome Control Tower, point 7.1 Function of Aerodrome Control Tower, it is explained that the Aerodrome Control Tower must monitor continuously all movements of flight operations in the vicinity of the aerodrome. This monitoring can be done by visual observation, or assisted by the ATS Surveillance system [2].

"*7.1.1.2 ... Watch shall be maintained by visual observation, augmented when available by an ATS surveillance system. ...*

7.1.1.2.1 Visual observation shall be achieved through direct out-of-the-window observation, or through indirect observation utilizing a visual surveillance system which is specifically approved for the purpose by the appropriate ATS authority."

In Ministerial Regulation (PM) Number 65 of 2017 concerning CASR 170 on Aviation Traffic Regulations, point 3.11 Use of Surface Movement Radar (SMR) is also explained that: [24]

" *In conditions where all or part of the manoeuvring area cannot be seen visually, SMR can be used as stated in the regulations, or other suitable sensing equipment must be used ...*"

According to the document EuroControl Operational Safety Study: Controller Detection of Potential Runway and Manoeuvring Area Conflict, there are two sets of barriers that can reduce the risk of runway incursions, namely: [14]

- Prevention of Runway Incursion and Ground Conflicts
- These barriers, when used and applied correctly, are capable of providing timely warnings to ATC to prevent runway incursions and ground conflicts.
- Mitigation the effect of Runway Incursions and Ground Conflicts

These barriers, when properly used and applied, are capable of alerting ATC when runway incursions or ground conflicts occur in sufficient time for ATC to act to prevent ground collisions.

TABLE 1. PREVENTION AND MITIGATION BARRIERS TABLE

Prevention Barriers	Mitigation Barriers
ATCO memory aids for issued (not issued) clearances by standardized flight data displays including dedicated runway bays, blocking strips, etc	ATCO detection after alert from airport ground systems that detect entry onto the runway (e.g. magnetic loops or lasers).
ATCO direct visual detection	ATCO direct visual detection
ATCO visual detection using remote camera displays	ATCO visual detection using remote camera displays
ATCO resolution following pilot/driver report	ATCO detection following pilot/driver report
ATCO detection of the occupied runway by use of basic Surface Movement Radar	ATCO detection using basic SMR
A-SMGCS level 1 surveillance with vehicles, in addition to aircraft, equipped with transponders in order to enhance surveillance	ATCO detection it using A-SMGCS level 1
A-SMGCS level 2 conflict alerts	ATCO detection it after alert from A-SMGCS level 2
Use of input and display of the ATC clearances that enable the use of “early warning” surveillance and data (Integrated Tower Working Position (ITWP) to highlight any non-conformance to clearance	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

The EuroControl document also explains the methods of indicating the availability of a runway. There are three methods of indicating runway availability, namely: [14]

1. Controller Memory Aids
   - Runway Occupied Strip
   - Runway Occupied Box
   - Runway Occupansy Plate
2. Surveillance System
   - Surface Movement Radar
   - Advanced Surface Movement Guidance and Control System (A-SMGCS) Level 1 or 2
3. Integrated Tower Working Position (ITWP)

The documents and references above explain the solutions related to the problems found by the author during the research at Perum LPPNPI Denpasar Branch Office. Thus, the author can propose several solutions that can be considered as solutions and minimize the occurrence of ATC errors in providing flight traffic services. All of the above solutions are good to implement and can be applied at I Gusti Ngurah Rai International Airport. However, here the author wants to provide the main alternative solution with consideration of I Gusti Ngurah Rai International Airport as one of the airports with the third most traffic in Indonesia [23]. This solution is also a long-term solution that can be a profitable investment for the airport in the future in improving the quality of flight traffic services, with an expected increase in the number of flight traffic after the COVID-19 pandemic ends.

The solution provided by the author, namely the development and procurement of the Advanced Surface Movement Guidance and Control System (A-SMGCS). Based on ICAO Document 9830 on Advanced Surface Movement Guidance and Control System (A-SMGCS) Manual, the definition of A-SMGCS is a system that provides routing, guidance, surveillance, and control functions for aircraft and ground vehicles to maintain the level of movement in a weather condition within the Aerodrome Visibility Operational Level (AVOL) while maintaining the required level of safety. [25] [26] [27]

As an initial introduction, A-SMGCS is derived from SMGCS or Surface Movement Guidance and Control System. Based on ICAO Document 9476 on the Manual of Surface Movement Guidance and Control System (SMGCS), SMGCS consists of providing guidance and controlling or regulating all aircraft, vehicles, and personnel movement in the airport area. SMGCS is applied to a system of aids, facilities, procedures, and regulations designed to meet the specific requirements of guidance, and control or regulation, of traffic on the aerodrome surface in accordance with the operational needs of an aerodrome. SMGCS can be in the form of markings, lightings, signs, charts, services, signaling lamps, and other equipment. [28]

Current SMGCS procedures are based on the main principle of "see and be seen" to maintain separation between aircraft and vehicles in the movement area of the aerodrome. However, the number of incidents and accidents during movement in the movement area, including runway incursions, continues to increase [21]. Some of the contributing factors are operating in low visibility

conditions, the increase in the amount of traffic, the complexity of the airport layout, and the capacity to improve techniques and procedures at an airport. Therefore, more sophisticated capabilities are needed to ensure separation when visual means are inadequate and to maintain airport capacity in all weather conditions. [25]

A-SMGCS is an enhancement of SMGCS that is useful in supporting movement operations on the aerodrome surface. The purpose of this SMGCS upgrade, is so that ATC, pilots, and vehicle drivers have a system with the same level of performance. In addition, it is also to improve situation awareness for ATC, pilots, and vehicle drivers with consideration of visibility conditions, flight traffic density, and airport layout. The upgrade of SMGCS to A-SMGCS can also improve visual vision assistance for ATC in monitoring movements on the aerodrome surface with an integrated system. [25] [19]

I Gusti Ngurah Rai International Airport itself has been equipped with various SMGCS equipment such as markings, lighting, signs, charts, services, and adequate signaling lamps. Thus, the procurement of A-SMGCS should already be realized [28]. In addition, it is also with the consideration that I Gusti Ngurah Rai International Airport has a large amount of flight traffic, outside of the current COVID-19 pandemic conditions [23].

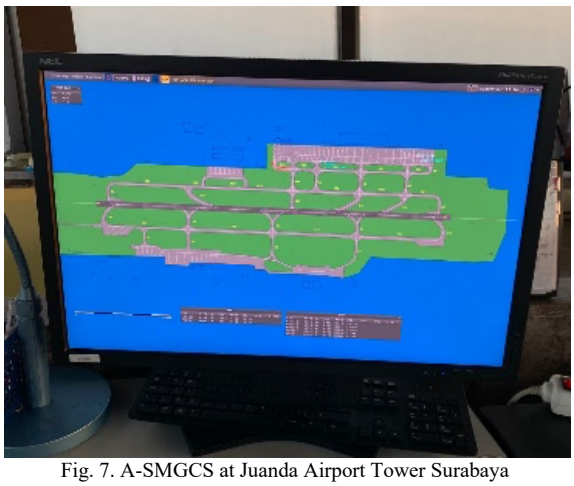

Fig. 7. A-SMGCS at Juanda Airport Tower Surabaya

The A-SMGCS is capable of providing full service under various weather conditions, traffic densities, and airport layouts. The use of A-SMGCS provides visual surveillance capabilities for ATC, even pilots with automation functions. The main advantage of using A-SMGCS is related to movement operations on the aerodrome surface in low visibility conditions. In low visibility conditions, the A-SMGCS can provide ATC with a projection of movements on the aerodrome surface. Meanwhile, in good visibility conditions, A-SMGCS can significantly increase the capacity of the airport. [25] [26] [27]

With the A-SMGCS, an ATC can confirm the presence of an aircraft in parking stand A40. A-SMGCS can eliminate ATC doubts regarding the vacancy of the parking stand when providing information to arriving aircraft that will enter parking stand A40 [29]. This can also reduce the load of communication, if previously ATC had to first confirm the vacancy of parking stand A40 to AMC. A-SMGCS can also assist ATC in monitoring the pushback movement of aircraft in parking stands A39 and A40 through the A-SMGCS display screen in the tower. This can also reduce the special pushback procedure for parking stand A40. Previously, aircraft at parking stand A40 had to push back and pull up to the centerline of parking stand A39 taxiway to be seen by ATC from the tower. Then with the help of A-SMGCS, aircraft at parking stand A40 can pushback normally without having to be pulled because ATC can already confirm the presence and movement of aircraft at the parking stand. Thus, the pushback procedure can be more efficient and the aircraft can save more time. [29]

To improve the quality of monitoring, the author also suggests adding CCTV installation in the A39 and A40 parking stand areas. This CCTV will be placed in such a way that all movement activities in the parking stand area can be monitored by ATC from the tower. This CCTV installation must also be equipped with a CCTV display screen placed in the cabin tower as a reference for ATC in monitoring the area. The purpose of this CCTV installation, is so that ATC can monitor the movement of vehicles (ground movement) in the parking stand area. CCTV can also assist ATC in ensuring the safety of the taxiway area that will be passed by the aircraft when it makes a pushback. Thus, when giving pushback clearance, ATC can guarantee that the area is free from any disturbance. In addition, ATC can also monitor the movement of ground handling that will enter the apron taxiway area during the engine start-up procedure of parking stand A40 aircraft with the help of an external GPU. So that in permitting ground handling to enter the apron taxiway, ATC can ensure that the area is safe. [30] [31]

In other research, related to surveillance technology in monitoring the movement of flight operations on the ground, several other technologies have been developed such as Forward Looking Infrared (FLIR). FLIR can be useful to assist ATC in monitoring aircraft movements on the ground in various weather conditions [32]. In addition, other studies have also discussed the improvement of Airport Surface Traffic Control (ASTC) Surveillance which is a form of monitoring of traffic on the ground [33]. Both of these have the same background, namely the occurrence of conditions where the ATC Tower cannot monitor the movement of flight operations on the ground so there is a need for a tool that can provide images of aircraft movements in various conditions.

In Indonesia, CCTV has only been applied to several airports, one of which is Soekarno Hatta International Airport, precisely in Terminal 3. This is because Terminal 3 has a taxiway that cannot be seen from the Tower so the installation of CCTV aims to monitor aircraft movements in the Terminal 3 taxiway area. Based on existing research, several airports also need this CCTV tool, such as Juanda Airport Surabaya, Domine Eduard Osok Airport Sorong, and Sentani Airport Jayapura. [34] [35] [36] [37]

If this A-SMGCS is implemented at I Gusti Ngurah Rai International Airport, it can assist ATC in providing flight traffic services during extreme weather conditions that cause low visibility, such as fog, rain, and storms. In extreme weather conditions, ATC often cannot monitor the movement of flight operations on the surface of the aerodrome, because it is covered by fog or the condition of

the tower window glass is blurred by rainwater. With this A-SMGCS, ATC can still monitor aircraft movements in the maneuvering area from the A-SMGCS display screen. Thus, the process of "maintaining continuous watch" can still be done by ATC in any weather condition. [38]

A-SMGCS can also assist ATC in confirming the position of aircraft in the manoeuvring area at night, especially to identify the position of aircraft in the N1 and N7 taxiway areas and confirm the position of arriving aircraft that are exiting the runway (vacating runway). At night with dark conditions in the manoeuvring area, ATC can confirm the exact position of the aircraft from the A-SMGCS display screen. This eliminates ATC's hesitation in confirming the position of aircraft that have reached short runway taxiways N1 and N7. In addition, ATC can also ensure that the arrival aircraft has completely exited the runway without the need to wait too long and ask the pilot to report its position when it has exited the runway. With this, the process of identifying the position of the aircraft by ATC can run faster and more effectively, and can increase the capacity of runway usage in busy traffic conditions at I Gusti Ngurah Rai Airport. [39]

VI. Conclusion

From the discussion above, the author can conclude that I Gusti Ngurah Rai International Airport has an airport layout that can affect ATC performance, namely the invisibility of parking stands A39 and A40 which are covered by airport buildings. In addition, dark conditions at night and extreme weather often make visibility on the aerodrome surface low. This causes ATC to be unable to monitor the movement of flight operations on the aerodrome surface continuously. In addition, this condition can also reduce the level of effectiveness and efficiency in providing flight traffic services, creating the potential for runway incursion, and not achieving safety in flight. [21]

So, it is necessary to have a supporting facility that can assist ATC in monitoring the movement of flight operations across the surface of the aerodrome with various conditions. Among them, namely the installation of CCTV in the A39 and A40 parking stand areas, as well as the development of the Advanced Surface Movement Guidance and Control System (A-SMGCS). These two tools can provide visual surveillance for ATC in any condition. Thus, ATC can provide services effectively, efficiently, and without hesitation.

In addition, the author also realizes the importance of always maintaining a good working environment for an ATC who works under pressure. An uncomfortable working environment can affect the stress level of an ATC which can be a hazard for the ATC in providing flight traffic services. Therefore, supporting facilities that can help ATC performance can support safe and orderly flight traffic services. [33]

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