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An Examination of Serious Runway Incursion Incidents Resulting from Air Traffic Control Services

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Abstract

With the development of aviation transportation in the world, the number of aircraft accidents has also increased numerically. Although as a result of technological advances the equipment and reliability of aircraft have increased technically, errors and violations caused by human factors involving air traffic controllers and pilots as the main actors of aviation, continue to exist as serious causes of accidents. When serious aviation incidents resulting from the execution of air traffic control services are examined, factors such as lack of communication, lack of teamwork, lack of positive safety culture, organizational functioning, stress/chronic fatigue, situational awareness and inadequate supervision appear to be of serious importance in causing accidents/incidents. The study aims to determine the factors that are likely to cause accidents/ incidents by examining the serious aviation incidents caused by air traffic that occurred and recorded in the world between 2012 and 2022, and to offer suggestions to reduce risks to an acceptable level by taking precautions before accidents/ incidents occur in accordance with a proactive approach.

1. Introduction

It is possible to describe the concept of safety which is encountered wherever humans are present as the state of being free from danger resulting from natural forces or human error (Nas, 2015). ICAO (International Civil Aviation Organization) describes safety in terms of air traffic control services as the state where risks related to aviation activities are reduced and controlled by decreasing them to an acceptable level, and the main purpose of safety culture is described as reducing the unsafe behaviors of the workers to an acceptable level by the support of the management (ICAO, 2016).

There is always the potential of making mistakes if there is human involvement; therefore, it is inevitable to have the of safety policies in order to minimize the errors. The concept of safety is always important for reducing errors in every sector, however; since the scale of the danger and human related risks can lead more severe consequences, it becomes more crucial in some sectors. Aviation sector is among the leading sectors where human errors can cause serious consequences. ICAO has stated that human factor has a steadily increasing effect on the occurrence of unsafe incidents in aviation (ICAO, 2018).

Along with developing technological possibilities, human related factors have substituted technological causes in factors leading accidents and incidents, the examination of the place of air traffic controllers in human factors has become more significant.

The importance of safety in air traffic services has made it necessary to establish a safety system for air traffic controllers Even though all the precautions are tried to be provided in order to eliminate risks, it is not completely possible to purify a system, where there is 'human', from danger and operational errors. What is essential is that to control the risks in the system and maintain them in a reasonable level by managing them. A system with reasonable level risks is accepted as 'safe' (SHGM, 2022).

It is known that a lot of undesirable incidents happening in aviation sector is directly and indirectly related to human factors. Considering the significance of human factor in unsafe incidents, a close examination of human factors is critically important for pilots and air traffic controllers, who play the most significant roles within the aviation community related to aircraft operations (Moon et al., 2011).

In this study, runway incursions in air traffic control services which lead serious aviation incidents resulting from human factor are going to be discussed. A runway incursions occur when an aircraft, ground vehicle or a person enters a runway or runways. Runway incursions are incidents that are very difficult or dependent to luck to resolve for the cabin crew or the pilot of an aircraft that is in motion on the ground or landing.

2. Materials and Methods

The main purpose of the study is to determine factors that cause undesirable serious incidents in aviation, to prevent risk factors that lead the occurrence of accidents/incidents before they even occur as required to proactive approach or to reduce risks to an acceptable level.

In this study, content analysis as one of the qualitative research techniques is employed in order to determine factors that can lead severe aviation incidents. Content research is a research approach that meticulously analyze, study and verify the contents of written data (Cohen et al., 2002).

In compliance with the purpose of the study, serious incidents that occurred worldwide between 2012 and 2022 and whose reports were prepared by aviation authorities of related countries and that cause runway incursions have been analyzed. A total of 225 serious incidents related to runway incursions were encountered over the span of this decade in the world and among these incidents, incidents whose final reports were drawn by relevant civil aviation authorities were collected, similar incidents were eliminated and a total of 16 serious incidents were analyzed. Relevant serious aviation incidents were compiled by comprehensively examining web sites of aviation authorities of the respective countries, sector reports on air traffic control service deficiencies and relevant scientific articles about the incidents.

In the study, content analysis was conducted on 16 serious incidents, examining seven factors. These are organizational functioning and unsafe supervision, as the components of the Human Factors Analysis and Classification System (HFACS), teamwork, situational awareness, stress and chronic fatigue, communication as the components of Team Resource Management (TRM) and positive safety culture as the component of safety culture. These 16 incidents are about the incidents on runway incursions. Since there is no chance to utilize developed technologies such as ACAS X/TCAS (Airborne collision avoidance system/Traffic alert and collision avoidance system) systems that step in as a result of hazardous aircraft proximity and warn pilots, CWP (Controller working position) that effectively generates alerts in situations which require the controller to be aware of dangerous aircraft proximity and STCA (Short term conflict alert), MSAW (Minumum safe altitude warning), APW (Area proximity warning) and APM (Approach path monitor) that are safety nets, human factor in those incidents are at its highest level. While human errors are minimized through systems in other air traffic control services such as approach and area control services, human intervention is essential in runway incursions within the airport control services. When examining accidents and serious incidents based on the phase of flight between 2012 and 2022, it is observed that 70% of the incidents occurred during aircraft approaches/landings, pushbacks, taxiing on the runway, and takeoffs (EASA, 2023).

When aviation incidents occurred between 2012-2022 are evaluated in terms of accidents/incidents and serious incidents, 68% of 366 serious incidents occurred in Eurocontrol region between 2012-2017 were the incidents on runway. When accident/incidents occurred again in Eurocontrol region between 2018-2022 are evaluated, 52 of 122 experienced incidents constitute the incidents occurred in runway. Accidents related to undesirable incidents after runway incursions or incidents occurring after runway excursions or touchdown accounted for 29% of the accidents in which aircraft sustained significant damage in 2020 worldwide (EASA, 2019, EASA, 2023, ICAO, 2021).

In 2020, 66% of serious incidents involving aircraft over 5700 kg occurred due to abnormal runway contact (ARC) and touchdown of landing gears, runway incursions (RI) or runway excursion (RE) and turbulance (TURB) of the plane. Additionally, again in the same year, 75% of aircraft accidents resulting in serious injuries were caused by runway incursions or runway excursions (RI/RE). In serious incidents, the primary cause of aircraft damage was again due to abnormal runway and touchdown contact conditions (ARC), runway incursions (RI), or runway excursions (RE), accounting for 61% of the cases (ICAO, 2021).

Meanwhile, a total of 3103 incidents were reported in Turkey in 2022. 107 of these incidents includde conditions due aerodrome (ADMR), 135 of them were due to incidents in ground handling (RAMP), 127 of them included incidents that were related to runway and runway connection conditions due to abnormal runway and touchdown of landing gears (ARC). Moreover, 1092 of these incidents occurred due to strikes or near strikes with animals such as bird and/or wild animals (BIRD) at ant stage of the flight. Incidents related to runway incursions accounted for 47% of all reported incidents in Turkey in 2022 (SGHM, 2022).

In the study, 225 runway incursions that occurred between 2012-2022 in the world and recorded by being investigated in detail by the aviation authorities of relevant countries were analyzed (Skybrary, 2024). 40 of the analyzed runway incursions were determined as incidents with a potential to cause serious accidents in case of not being prevented at short notice. Of the 40 serious incidents, 16 were examined in detail after filtering out those with similar error factors that caused the incidents.

2.1. An Analysis of Serious Incidents Caused by Air Traffic Control

It is possible to categorize serious incidents caused by air traffic control as vertical and horizontal proximity, runway incursion and excursions of aircraft. In the analysis of serious incidents parts of the study, serious incidents resulting from runway incursions were analyzed since the controllers closely affect the intersectoral interactions. While examining runway incursions which could have resulted in disaster if not prevented at the last moment, in-depth analysis was conducted on the incident contents which were recorded by the aviation authorities of the respective countries and used as educational documents.

2.1.1. Incident 1

The incident occurred on April 27, 2021, when a Boeing 737-400 of TNT Airways (call sign TAY4959), operating a scheduled international cargo flight from Porto airport, noticed a vehicle on the runway just ahead during takeoff under night conditions with good visibility. As soon as TAY4959 sees the vehicle, it took off with a rotation maneuver and at 490 feet above the location of the vehicle, the vehicle was moved to the side of the runway with the instructions of the controller. On the day of the incident, the controller worked for 4 hours continuously without having a break by managing on all the other sectors that are connected to the control tower on a single frequency (GPIA, 2021).

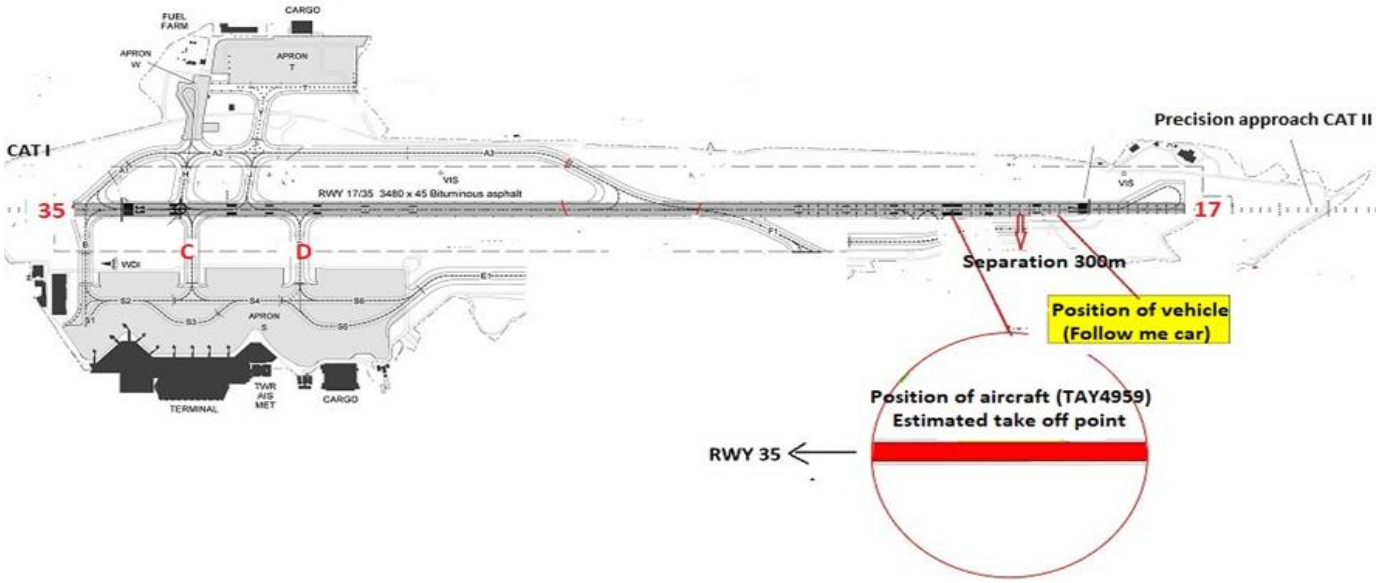

Figure 1. TAY4959, Path followed for Runway 35

On the day of the incident, follow-me vehicle made a call on the handheld radio and asked for permission from the controller to enter Runway 35 from Taxiway 'B' in order for inspection. In the meantime, the controller continued to work under a heavy workload because the frequency clearance for taxi, taxiing and take off were given on the same frequency due to frequency merging. 10 minutes later than the vehicle had entered runway 35 for routine controls, TAY4959 asked for clearance for taxi on runway 35 holding point and an intersection departure from taxiway D and this request was approved by the controller, and TAY4959 was given clearance to take off from Runway 35 at Intersection D. When TAY4959 was given clearance to take off from the D taxiway intersection, the follow-me vehicle had reached the end of Runway 35 and started to turn around to head south and inspect the remaining part of the runway. 15 seconds after TAY4959 had started to take off run, the driver of the follow-me vehicle informed the controller through handheld radio that he was seeing bright lights coming towards him. While the controller and the driver of the follow-me vehicle were communicating, TAY4959 took of moments before reaching the follow-me vehicle as it can be seen in Figure 1. Due to the absence of stopbar lights during the incident also reduced the situational awareness of the controller, pilot and the driver of the vehicle (GPIA, 2021).

Factors that caused the incidents are;

Lack of teamwork:

- On the day of the incident, controller on-duty had been working continuously for four hour managing all frequencies alone and issuing clearance, taxi, and takeoff instructions by himself.
- Planning of the controller involved in the incident as a supervisor and a team leader was based on personal preferences which were far from concepts like tactical management of the team, determining the number of staff and creating risk analysis.

Organizational effects/ Organizational functioning:

- Since there was no audio/visual warning system that could remind the controller that there was a vehicle on the runway reduced the situational awareness.

Unsafe monitoring:

- Not having stopbars on junction points and the entrances on the runways reduced situational awareness.
- Not having an efficient runway incursion monitoring and conflift warning system decreased situational awareness.

Lack of communication:

- The communication of aircraft and follow-me vehicle with the controller occurred at different radio systems (tower frequency and handheld radio) and therefore, this prevented the pilot and the follow-me vehicle from being aware of each other on the runway.

Lack of positive safety culture/ Failure to report previous similar incidents:

- Although there had been similar incidents before, the unsafe incident was not reported to safety management unit officially.
- Unsafe behaviors were triggered because people have different understanding of working and risk culture, organizational culture and safety culture.
- The existence of an individual and organizational culture based on concealment, and the failure to establish a safety system based on risk assessment by the organization to ensure that safety is not compromised, were the effective factors in the occurrence of the incident.

Stress and chronic fatigue:

- Working continuously without sufficient rest time caused excessive fatigue for the controller.

2.1.2. Incident 2

On November 14, 2019, an Air Algerie flight (callsign AH1157), a scheduled international passenger flight from Lyon Saint-Exupéry to Annaba, Algeria, operated by a B738 aircraft, started its takeoff roll on Runway 35L while low visibility procedures (LVP) were in effect. The controller working in the tower position saw that snowplows had entered the active runway and rushed to instruct AH1157 to stop immediately. This serious incident was caused by the ground controller (who manages ground movements and separations) granting the vehicle permission to enter the runway without prior coordination with the tower controller (who grants landing and takeoff clearances). 15 minutes before the incident happened, tower (landing and takeoff service position) and approach (service position for traffic below a certain altitude) services were provided on a single frequency by the same controller, by merging the frequencies. At the moment the ground controller granted pushback and start-up clearance to the AH1157 traffic preparing for takeoff, the leader vehicle with the callsign ELEC8 and another accompanying snowplow requested permission via handheld radio to enter Runway 35L to clear accumulated snow from the runway and taxiways. The ground controller authorized the snowplows to work on Taxiway A3, cautioning them to watch for landing aircraft. Meanwhile, another vehicle was also permitted to be on the runway for brake measurements (BEA, 2022).

The positions of the vehicles are shown in Figure 2.

Figure 2. Lyon Saint-Exupéry Airport 17R/35L Runway and Taxiways

As the ground controller granted taxi clearance to AH1157 to Taxiway A9 CAT III holding point for Runway 35L, the ELEC8 snowplows reported that they would be clearing snow from Taxiway A4 and then intended to clear the A4 and runway intersection. When AH1157 was at A9 holding point on tower frequency, "ELEC8" contacted ground controller and stated that they would continue clearing snow from A4 taxiway and its intersection with the runway. The ground controller instructed ELEC8 to enter Runway 35L and authorized them to clear the area marked as blue zone number 5 in Figure 2. Thirty seconds after the vehicle group led by ELEC8 entered the runway, the tower controller instructed AH1157 to begin takeoff while holding at red point 4 on the runway. Five seconds after AH1157 started its takeoff roll, the tower controller noticed the vehicles at blue point 5 on the runway and urgently instructed AH1157 to abort the takeoff (BEA, 2022).

It is possible to summarize the factors that caused the incident as below.

Lack of teamwork/Workload:

- The conflict of the roles in the tower and high workload.

Lack of communication:

- The controllers had learned that snowplows needed to enter the runway in order to clear the snow on the runway in the middle of the operation.
- Ground controller granted the runway entry permission which should have been given by tower controller without having the necessary communication with the tower controller on his own initiative.

Organizational functioning:

- Not having a clear framework related to the use of frequencies for vehicles during temporary runway closures.
- The rules for organizing and suspending operations that are difficult to implement for people directly involved in traffic management and snow removal.
- Having a snow clearance plan whose description is quite formal and which is partially disconnected from operational realities.
- Incorrect measurements of runway surface conditions that cause high workload and difficulties in implementing the snow clearance strategy.
- Organizational factors such as stopbar configurations that are not compatible the paths followed by snowplow vehicles contributed to the occurrence of this serious incident.

Lack of positive safety culture/Failure to report previous similar incidents:

- Although there had been similar incidents before, the unsafe incident was not reported to safety management unit officially.
- The existence of an individual and organizational culture based on concealment, and the failure to establish a safety system based on risk assessment by the organization to ensure that safety is not compromised, were the effective factors in the occurrence of the incident.

Stress and chronic fatigue:

- Working continuously without sufficient rest time caused excessive fatigue for the controller.

2.1.3. Incident 3

The incident occurred on runway 24R, which was being used for single-runway operations at Palma de Mallorca Airport, where there are two runways known as the north runway (06L-24R) and the south runway (06R-24L). It happened when a Boeing 737-800 of Ryanair (callsign RYR81SN) began its takeoff run and encountered a vehicle on the runway. Due to low traffic flow during the time of the incident, tower control, ground control and clearance services were provided on a single frequency. As it is seen in Figure 3, RYR81SN (B738 type) stated that it is ready to take off from 24R runway and clearance was granted for entry onto runway 24R. At the same time, follow-me vehicle contacted controller to demand entry to north runway from H5 taxiway, however; it mistakenly requested clearance to enter the southern runway instead of the northern runway. Despite "clear" instruction the of the controller, the follow-me vehicle informed the controller that the stopbar lights were on and needed to be turned off. Nevertheless, the controller stated that follow-me vehicle could ignore these lights and repeated the clearance to enter the runway. In the meantime, RYR81SN requested takeoff clearance, and the controller issued a takeoff clearance from runway 24R while the traffic was at position 2. Meanwhile, the Follow-me vehicle driver, who was listening to the frequency, called the tower to inform them that the vehicle was still on the runway. The controller issued an immediate stop instruction to the traffic with the callsign RYR81SN while it was at position 3. Although RYR81SN had reached takeoff speed, the aircraft responded to the call of the controller and managed to stop at position 4 (CIAIAC, 2020).

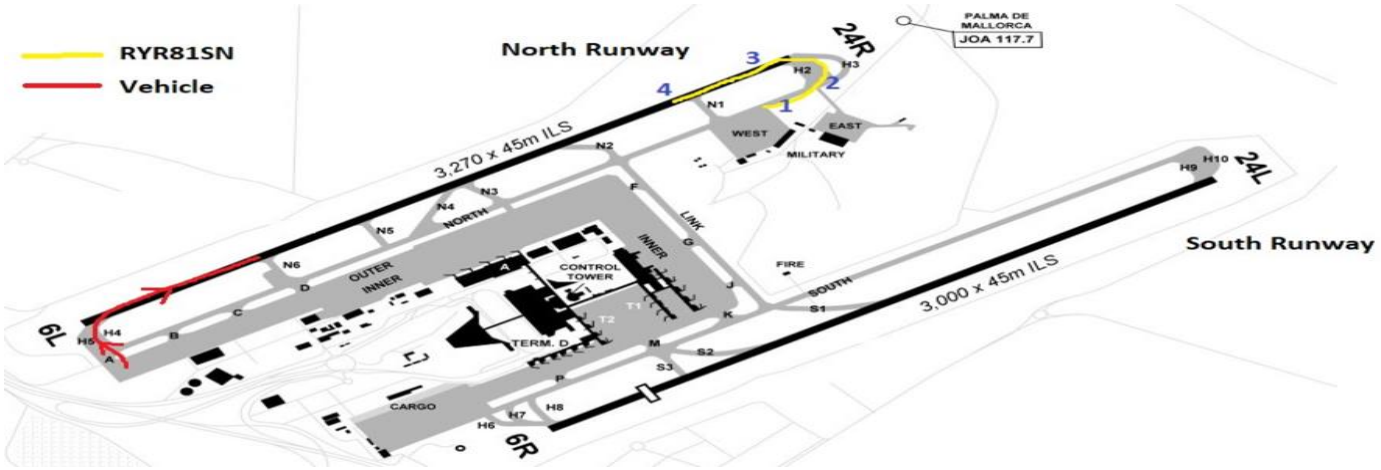

Figure 3. Palma de Mallorca Airport 06R-24L Runway and Taxiway

Factors that caused the incidents are listed below.

Lack of teamwork/ Situational awareness:

- The controller had combined tower/ground/ clearance sectors and working on his own which led lack of team support and resulted in errors.
- The inability of controller to visualize the position of the vehicle affected his control over the traffic negatively.

Lack of communication:

- Although the initial communication between the vehicle driver and the tower controller regarding the position and intent of the vehicle was confusing, the controller made no attempt to prevent the runway incursion. Instead, the controller allowed the vehicle to pass over the illuminated H5 stopbar lights and enter the active runway without any intervention, leading to the serious incident.

Organizational functioning:

- Using north/south in order to describe the runway caused an error in the way the vehicle driver referred to the runway he intended to access. The locational error made by the vehicle driver, requesting access to a runway that couldn't be reached from H5 during their initial communication at H5, went unnoticed by the controller for this reason.

Stress and chronic fatigue:

- Working alone caused the controller to feel mentally tired.

Lack of positive safety culture/ Failure to report previous similar incidents:

- It was confirmed that there had been similar unsafe incidents related to the use of stopbar lights and they were not reported.

2.1.4. Incident 4

On April 10, 2018, an incident occurred between a GOL Aviation B738 (callsign GOL2311) that had started its takeoff roll at night from Brasilia, and a Brazilian Air Force E110 (callsign FAB2345) that had just landed on the same runway and had not yet vacated it. After landing, when the FAB2345 reached taxi speed and, was at position 1 (Figure 4), indicated its intention to vacate the runway via taxiway C. However, the controller, seeing that the FAB2345 had passed taxiway C, instructed the FAB2345 traffic to vacate the runway via taxiway G and to switch to the ground control frequency. However, as it can be seen in figure 4, due to the visual similarity of the names on the signage of G and C taxiways, and the faded condition of signage of taxiway G, the FAB2345 mistook the taxiway G thinking that it is taxiway C. Consequently, at position 2, it continued to position 3 (F taxiway) thinking that the next runway exit was taxiway G and switched to ground control frequency. Since tower controller did not have a comprehensive runway view between G and F taxiways due to the woodland shown in figure 4, the controller granted takeoff clearance to GOL2311 when FAB2345 was at position 3 believing that FAB2345 had exited the runway via taxiway G (CENIPA, 2018).

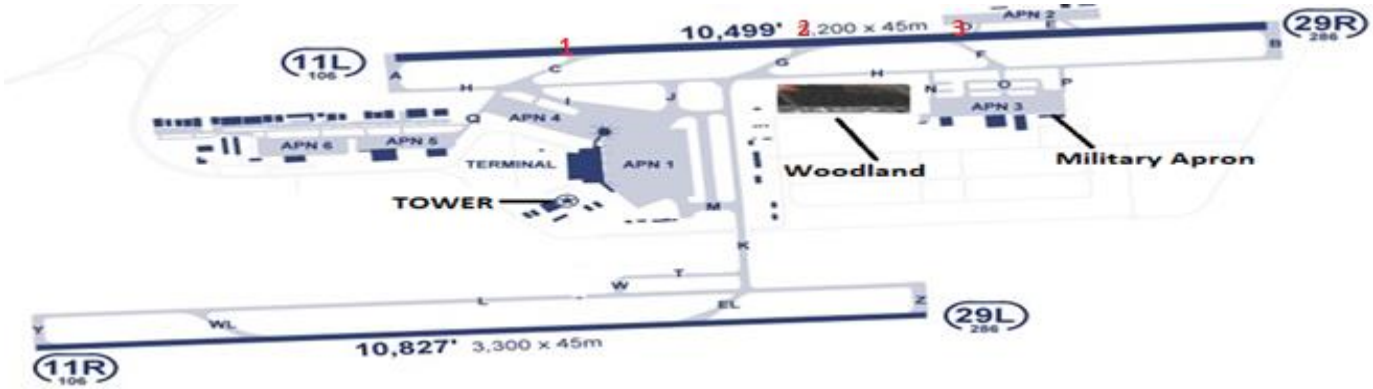

Figure 4. Brasilia Airport 11L/29R Runway and taxiways

It is possible to summarize the factors that caused the incident as below.

Lack of teamwork:

- The working position of the tower controller and external environmental conditions prevented the controller from seeing the aircraft with the FAB2345 callsign, and the ground controller was unable to determine the position of FAB2345 during their initial contact on the frequency. The lack of team work between the tower and ground controllers, and the absence of a third controller monitoring them, were among the latent factors contributing to the incident.

Lack of communication:

- Although the tower controller did not fully understand the initial call from FAB2345 after landing, they did not request a repeat and attempted to analyze the situation based on the location of the aircraft.
- Although FAB2345 had switched ground control frequency before exiting the runway, this situation was nor reported to tower controller by the ground controller.
- Deficiencies occurred in verbal communication between the tower and ground controllers regarding the actual position of FAB2345 after landing.

Organizational factors and / Organizational functioning:

- Not having a ground radar,
- Inability of the tower controller to track traffic effectively due to obstructions that blocked the visual view from the tower,
- Factors such as the lack of a regulatory requirement to define the position at which an aircraft should switch its frequency from tower control to ground control directly contributed to the occurrence of the incident.

Lack of positive safety culture/ Failure to report previous similar incidents:

- It was confirmed that there had been similar communication problems between tower control and ground controls previously, however; no precautions were taken related to this situation.

2.1.5. Incident 5

On July 27, 2018, at Amsterdam Schiphol Airport, the tower controller granted runway entry permission to the E190 aircraft of KLM Royal Dutch Airlines (callsign KLM1289) to runway 18C, as shown in Figure 5. At the same time, the controller permitted the B738 aircraft (callsign KLM1783) to enter the runway via taxiway W4. Approximately one minute later, the tower controller authorized KLM1289 to take off from runway 18C.

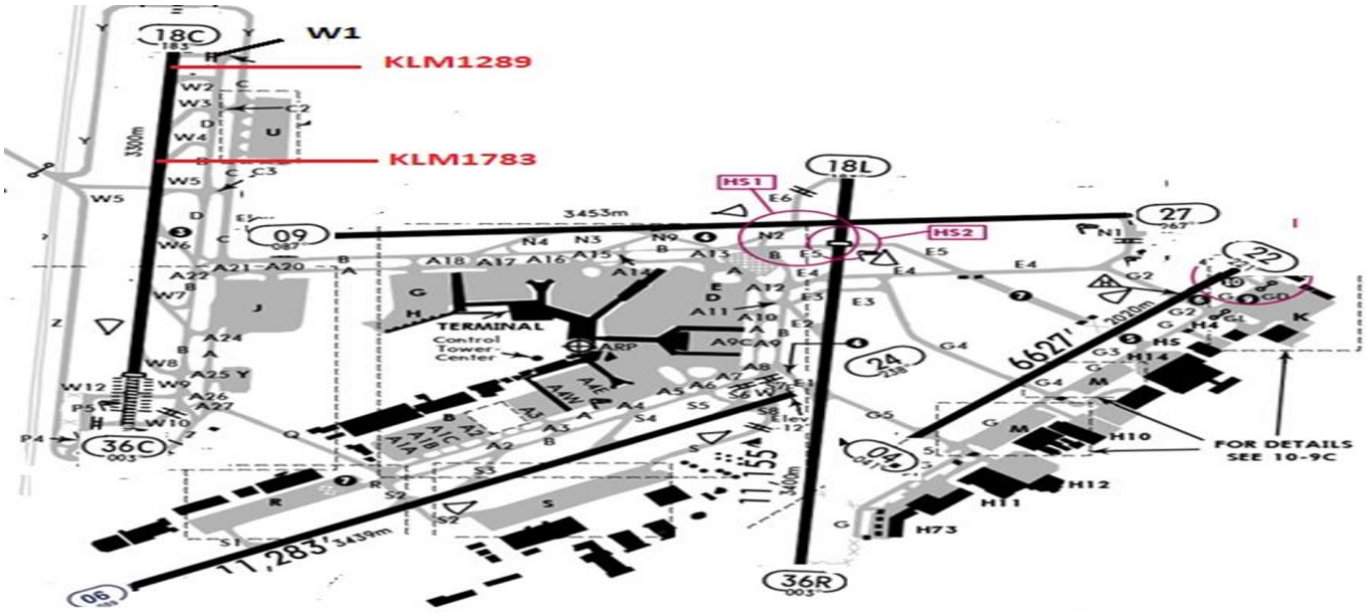

Figure 5. Amsterdam Schiphol Airport 18C/36C Runway and Taxiways

During the incident, while the runway 22 was being used both for takeoff and for landing, the runways 09 and 18C were just being used for takeoffs. Tower controller was providing traffic services for three active runways: 09, 18C and 22. As shown in figure 5, the incident occurred in 18C runway for which the controller provide takeoffs and landing services. At the time of the incident, KLM1289 reached 18C runway start point via W1 taxiway and KLM1783 reached intersection departure point via W4 taxiway. The tower controller had granted takeoff clearance to KLM1783 before the two other aircraft ready for departure, but since KLM1783 was moving slowly while turning onto the W4 intersection, it had not yet begun its takeoff roll. The tower controller, who forgot that he had already granted takeoff clearance to KLM1783, gave takeoff clearance to KLM1289 from the 18C runway heading about 2 minutes later. Upon hearing that KLM1289 was cleared for takeoff, KLM1783, which had passed the W4 holding point, stopped just before entering the 18C runway. KLM1783, which was stopped at the runway intersection, informed the tower controller that they were "on the runway." However, the tower controller, confusing the traffic, issued a takeoff clearance to KLM1783 from the W4 intersection. Hearing that KLM1289 was also cleared for takeoff from the 18C runway heading at the same time, KLM1783 did not proceed with the takeoff clearance and maintained its position. The pilots of KLM1783 could not see the runway threshold 18C due to the angle of the W4 intersection taxiway. Thirty minutes before the incident, two separate events involving the same tower controller were recorded. The first incident involved a light aircraft with VFR clearance that posed a brief risk to traffic taking off from the 18C runway. Then, 20 minutes before the incident, the controller granted takeoff clearance to one aircraft from the 18C runway but also permitted another aircraft to taxi to the 18C runway via the W4 intersection (DSB, 2018).

The factors causing the incidents are below.

Lack of teamwork:

- The absence of controller to assist tower controller during periods of intense workload.
- Absence of an additional controller in the tower to monitor the traffic contributed to the occurrence of the incident in terms of teamwork.

Organizational factors/ Organizational functioning

- Due to the lack of written rules, the controller continued to work despite having experienced two previous incidents before the serious one,
- The incorrect configuration of runways for landing and takeoff,
- The management of 09, 18C and 22 runways by a single controller,
- The fact that KLM1783, which entered the runway from taxiway W4, could not see the traffic on the runway due to the intersection of the taxiway were among the factors that contributed to the occurrence of the incident.

Lack of communication

- In the busy and complex runway structure, the ground controller asking KLM1783 whether it could take off from taxiway W4 to expedite traffic, and increased workload of the tower controller were observed as factors contributing to the communication deficiencies leading to the incident.

Lack of positive safety culture/ Failure to report previous similar incidents

- It was understood that the controllers continued working despite experiencing similar incidents before the serious event, and no regulations were implemented to address the issue of controllers not actively working during such distracting situations.

2.1.6. Incident 6

On September 22, 2017, at Hong Kong International Airport, a runway incursion occurred when an Air Cargo Global aircraft (call sign CCC831), a B744 type, crossed the runway from J6 Taxiway just as a Hong Kong Airlines A333 aircraft (call sign CRK236) began its takeoff roll on Runway 07R. The pilots of CRK236 immediately aborted the takeoff upon noticing another aircraft crossing the runway. At the time of the incident, the controller, who was an instructor at the ground control position, was providing training to a trainee controller. Throughout the roughly one-hour period of ground control operations, the instructor controller occasionally took over the position when traffic increased or the trainee controller struggled, before handing it back to the trainee. After the CCC831 traffic, as indicated in Figure 6, landed on runway 07L, it exited the runway and switched to ground control frequency, where it was instructed by the ground controller to taxi via A, W, J, and J6 holding point. When CCC831 arrived at J6 taxiway, the ground controller, due to not fully understanding the position of the aircraft, did not transfer CCC831 to the frequency of the tower controller for the runway crossing and instead instructed the aircraft to taxi via K and L2 taxiways to its parking stand. At the same time, tower controller, unaware that CCC831 was crossing runway 07R, granted takeoff clearance to CRK236. As CRK236 began its takeoff roll and reached the vicinity of taxiway K2, crossing traffic was spotted the and the takeoff was immediately aborted (AAIA, 2021).

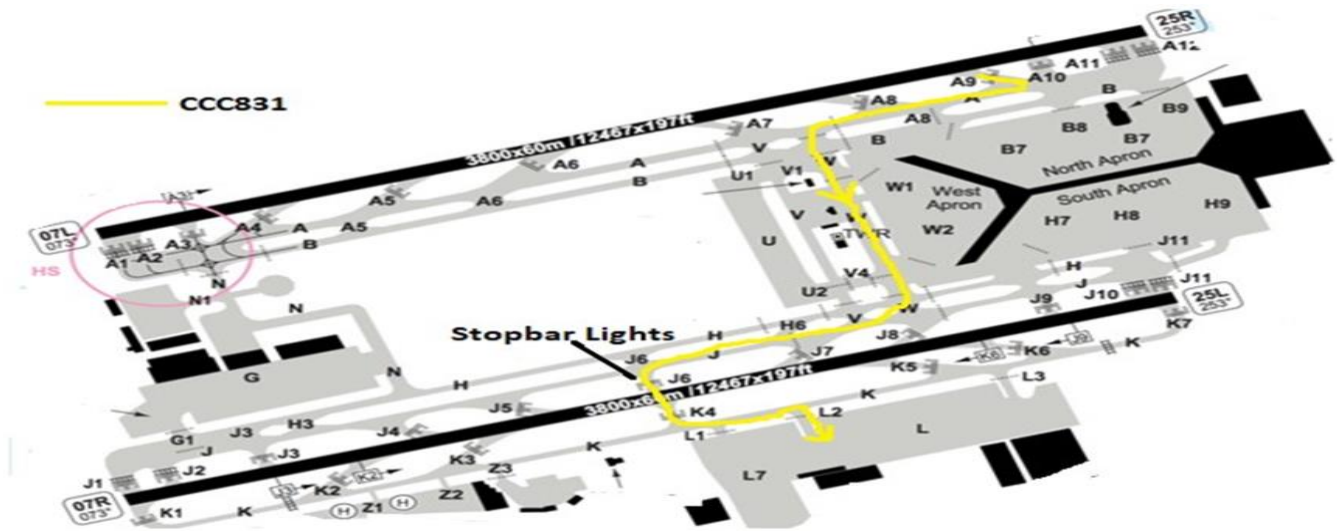

Figure 6. Hong Kong International Airport 07L/25R and 07R/25L Runways and Taxiways

The factors leading the incidents are listed below.

Lack of teamwork/ Situational awareness:

- The frequent handover of the ground control position between the instructor controller and the trainee controller, based on traffic intensity, reduced their situational awareness of the traffic positions.

Unsafe Monitoring:

- At the time of the incident, it was determined that the traffic conflict audio alert on the ground radar was inactive in both the tower control and ground control positions.

Lack of Communication:

- Although runway crossings should be managed on the tower frequency, CCC831 at the J6 holding point was not transferred to the tower frequency
- The ground controller only cleared CCC831 to proceed to the parking area via taxiways K and L12, without using the necessary runway crossing clearance expression, and there was no clear feedback by the pilots.

2.1.7. Incident 7

On March 17, 2017, at Lyon Saint-Exupéry Airport, after landing on runway 35R, the CRJ700 aircraft of Air France Hop (callsign HOP83A) was cleared to cross runway 35L as shown in Figure 7. At the same time, an A319 aircraft of EasyJet (callsign EZY748Z) was cleared for takeoff from runway 35L. During the incident, the tower controller gave the takeoff clearance to EZY748Z from runway 35L in English, as shown at the blue point 2 in Figure 7. Thirty seconds before this, the controller also cleared HOP83A, located at the red point 3, to cross runway 35L in French. As EZY748Z began its takeoff roll from runway 35L, HOP83A, which was crossing the runway, noticed the departing traffic and managed to make an emergency stop at the red point 4 (BEA, 2020).

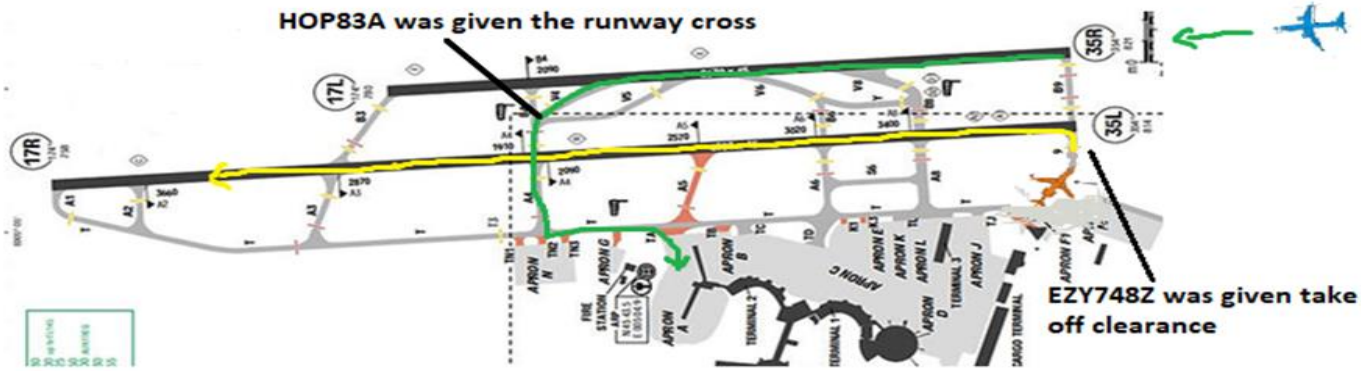

Figure 7. Lyon Saint-Exupéry Airport17L/35R and 17R/35L Runways and Taxiways

The factors leading the incidents are listed below.

Lack of teamwork/ Situational awareness:

- Failure to control the runway by the tower controller and his low situational awareness
- Heavy air traffic led the tower controller to issue instructions quickly and prematurely, and the absence of another controller to observe or share the workload contributed to the occurrence of the serious incident.

Lack of communication:

- The fact that the crossing traffic HOP83A communicated in French and the departing traffic EZY748Z communicated in English resulted in EZY748Z not understanding the position of the crossing traffic.

Organizational factors/ Organizational functioning

The malfunctioning of the stopbar lights on taxiway B4 prevented the controller from realizing his mistake.

Lack of positive safety culture/ Failure to report previous similar incidents:

- It was found that similar misunderstanding had occurred in the past due to speaking French instead of English at times, but no safety measures had been implemented to address this issue.

2.1.8. Incident 8

On December 2, 2016, at Calgary Airport, as shown in Figure 8, an incident occurred when a Fairchild-Swearingen Airlines SA226 (callsign CFGEW) crossed runway 29 from the midpoint, coinciding with an encounter on the runway with an A320 Air Canada aircraft (callsign ACA221) that had just begun its takeoff run.

Figure 8. Calgary Airport Runways and Taxiways

At the time of the incident, runway 29 was in use, but the runways had changed several times throughout the day due to wind conditions. As seen in Figure 8, the tower controller gave ACA221 clearance for takeoff from position 3 (indicated in red) while, simultaneously, the ground controller granted CFGEW clearance to cross the runway. The urgency of the ground controller in clearing the crossing stemmed from the desire to quickly separate CFGEW from another CRJ900 traffic at the intersection of taxiways A and J. The pilots did not have the opportunity to intervene in the situation because ACA221 was on the tower frequency and CFGEW was on the ground control frequency (TSB, 2018).

Factors that caused the incidents are these.

Lack of teamwork/ Situational awareness:

- It is clear that the situational awareness of the two controllers is low because both the ground controller and the tower controller issued instructions to aircrafts without proper environmental monitoring.
- Not having a supervisor at the tower to follow the incidents caused the incident to occur.

Lack of communication:

- Rarely use of runway 29 throughout the day prevented ground controller to transfer CFGEW to tower frequency for clearance to cross the runway. The ground controller laid the groundwork for the incident by granting clearance for crossing without coordinating or transferring the frequency to the tower controller, as it is required for crossings.

Unsafe monitoring:

- The lack of stopbar lights at crossing points 6 and 8 in Figure 8 reduced the awareness of the pilots.

Teamwork/Workload:

- The excessive separations by the ground controller and the absence of a supporting team member led to the ground controller hurrying and making decisions without careful consideration.

Lack of positive safety culture/ Failure to report previous similar incidents:

- In similar past incidents, the fact that traffic was on different frequencies despite needing to be on the same frequency, combined with the lack of established procedures for such situations, was one of the causes of the incident.

2.1.9. Incident 9

On January 7, 2016, at Gran Canaria Airport, a Germania Airlines B737 (call sign GMI6129) began its takeoff from runway 03R with the permission of the tower controller, but the takeoff was canceled by the same controller upon noticing an object on the runway. During the incident, while at position 1, as shown in Figure 9, GMI6129 was instructed by the tower controller to cross runway 03L. When GMI6129 reached position 2, the crew reported that the stop bar lights were illuminated and maintained their position. Despite this, the tower controller granted GMI6129 clearance to enter the runway and take off. Although GMI6129 saw a vehicle on the runway immediately to its right after receiving the takeoff instruction, it continued the takeoff run, thinking the vehicle did not pose an obstacle. When GMI6129 reached position 4, the tower controller noticed another vehicle in the middle of the runway, canceled the take off of GMI6129 and GMI6129 was able to stop at position 5 after it had been instructed to cancel its take off. On the day of the incident, automatic ATIS (Automatic Terminal Information Service) broadcast continuously announced that 03R runway was closed due to construction (CIAIAC, 2016).

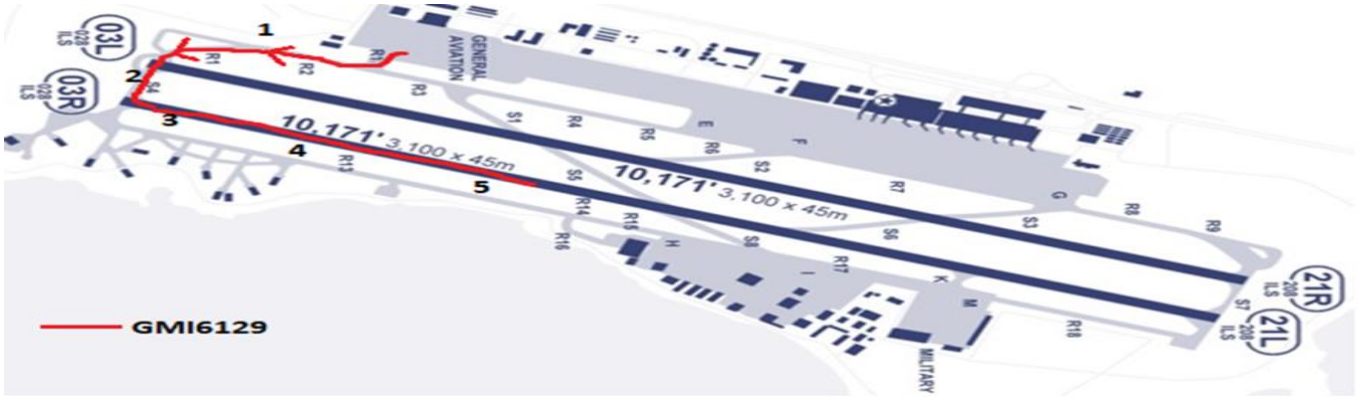

Figure 9. 03L/21R and 03R/21L Runway and Taxiways

Factors leading the incident are listed below.

Lack of teamwork/ Situational awareness:

- Although there were visual aids in the tower to show that the runway was closed, the controller could not perceive that the runway was closed. The inability of the controller and pilots to see the vehicle on runway 03R was attributed to the lack of flashing lights on the vehicle. Despite being in visual contact with the vehicle stopped on the runway strip, GMI6129 began its takeoff roll. Although the situational awareness of the controller was poor, they did not receive sufficient support from their team members.

Lack of communication:

- Although the controller partially heard the report from GMI6129 about the illuminated stop bar lights, they did not ask the pilot to repeat the message and instead instructed GMI6129 to enter runway 03R again. The fact that GMI6129 did not request the controller to turn off the stop bar lights and proceeded onto the runway despite the illuminated lights also contributed to occurrence of the incident.

Organizational functioning:

- The fact that the vehicles operating on the NOTAM (Notice to airman) designated runway did not have lighting and flashing lights at a level that would attract the attention of the pilot and controller indicates an organizational deficiency.

2.1.10. Incident 10

The incident occurred on October 12, 2014, at Addis Ababa Airport when Ethiopian Airlines (flight ET805), a B763 aircraft, started its takeoff roll on runway 07R and spotted a vehicle in the middle of the runway, leading to the cancellation of the takeoff and stopping approximately 100 meters from the vehicle. Air traffic control services at the airport were provided by two controllers, one on the ground frequency and one on the tower frequency, using runway 07R, which is 3,800 meters long and 45 meters wide. There was no supervisor in the tower since it was a Sunday and supervisors were not on duty on weekends. A departing aircraft reported flocks of birds on the parallel runway 07L/25R, and bird activity was also observed by the ground controller on the taxiway and parallel runway. As a result, it was decided to deploy bird dispersal teams to the maneuvering areas. The ground controller wanted to inspect runway 07R, which was in use after 07L/25R, as shown in Figure 10. After verbally obtaining approval from the tower controller, the ground controller allowed the bird dispersal vehicle onto runway 07R. After completing the first section of inspection, the bird dispersal vehicle turned back from the threshold of runway 25L and arrived at the blue position 1, as shown in Figure 10. Meanwhile, the ground controller directed ET805 to the holding point of runway 07R and handed it over to the tower frequency.

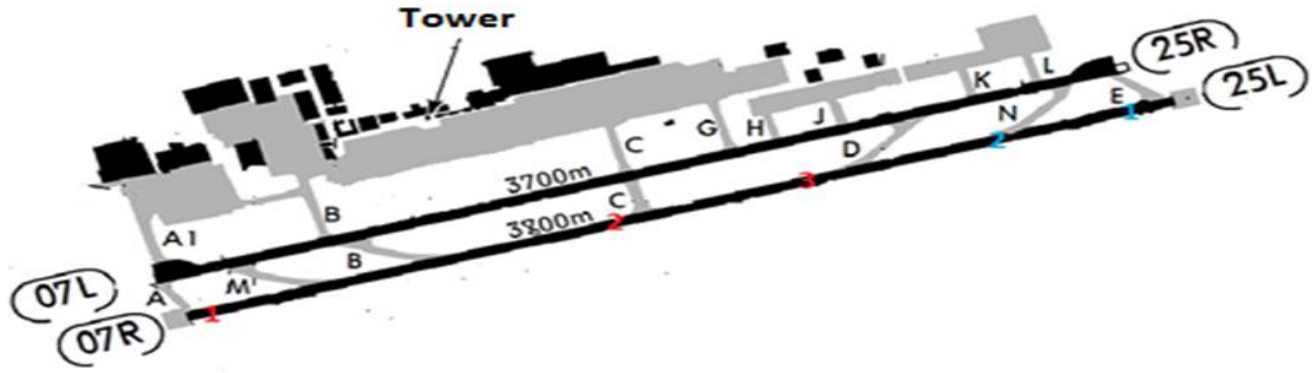

Figure 10. Addis Ababa airport 07L/25 R and 07R/25L Runway and Taxiways

The tower controller granted ET805 clearance for takeoff from runway 07R at the red position 1, and the aircraft began its takeoff roll. When the aircraft reached V1 (138 knots) and arrived at red position 2, the crew noticed a vehicle on the runway at blue point 2. They immediately applied brakes and managed to stop at red point 3. When ET805 stopped, it was 100 meters away from the vehicle. The sudden braking caused the brakes to overheat, resulting in the blowout of four tires, and ET805 had to be towed to the parking area by a tug (ECAA, 2014).

It is possible to summarize the factors that caused the incident as below.

Lack of teamwork/ Situational awareness:

- The tower needed to control the runway before granting clearance for take off and then it should have granted the clearance; however, necessary environmental control was not performed. The incident was caused by the low situational awareness of both ground and tower controllers.
- The absence of a third controller in the tower, who should have been monitoring the situation as part of the team, played a contributed to the failure to prevent the incident.

Lack of communication:

- During the post-incident investigation, the ground controller claimed to have received direct verbal approval from the tower controller for the bird dispersal vehicle to enter the runway, while the tower controller stated that there were errors in communication. The runway inspection clearance, which should have been given by the tower controller, was instead issued by the ground controller (ECAA, 2014).

Lack of positive safety culture/ Failure to report previous similar incidents:

- It was understood that the tower and ground controllers had previously managed traffic flow under the responsibility area of the tower through verbal communication. The failure to report such incidents in accordance with positive safety culture objectives created a basis for the occurrence of this risky event.

2.1.11. Incident 11

On April 4, 2016, at Jakarta Halim Airport, a Batik Air Indonesia Airlines B738 (flight ID7703) began its takeoff roll from runway 24 and noticed an object on the runway, prompting a maneuver to the right of the centerline. Despite veering slightly to the right of the runway centerline, the aircraft could not avoid wing contact with a towed ATR42 being pulled to the parking area from within the runway.

As shown in Figure 11, the ATR 42 was planned to enter from taxiway C, proceed across the runway, and exit via taxiway G to the apron on the other side of the runway. The ATR 42 was to be towed without any engine power, meaning there was no radio communication between the aircraft and the ground controller, and the lighting systems of the aircraft were not operational. Communication between the tow truck driver and the ground controller was maintained via handheld radio, which meant that ID7703, which was taking off, and the ATR 42 tow traffic were on separate channels.

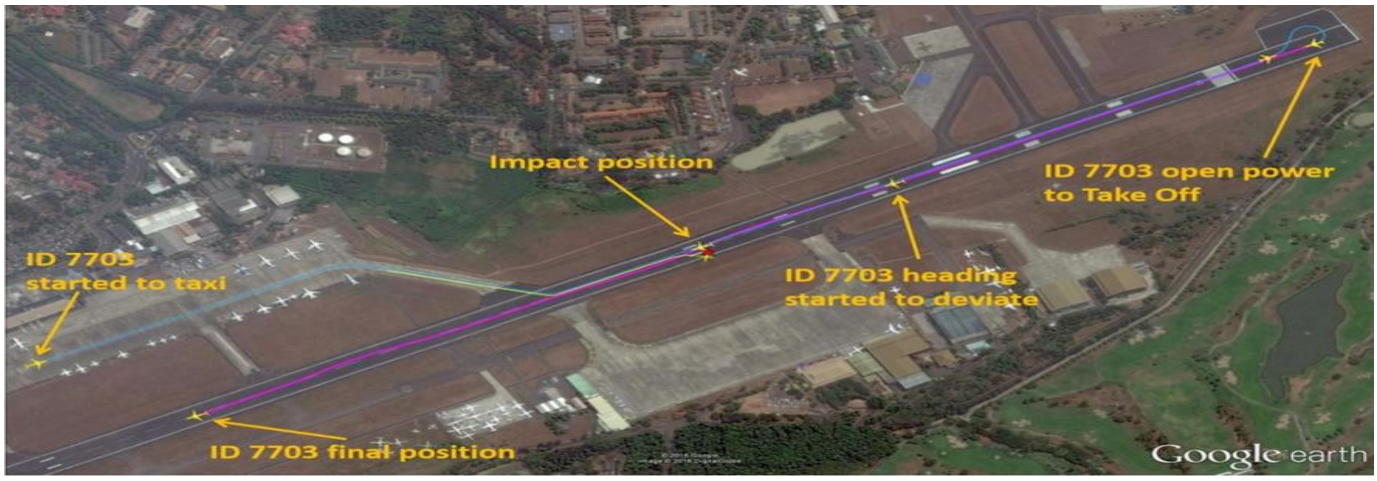

Figure 11. Jakarta Halim Airport 06/24 Runway and Taxiways (ANS, 2016)

After takeoff clearance was given to ID7703 on the tower frequency 118.6 MHz, as determined by the tower controller, permission was also granted by the assistant controller via handheld radio for the ATR 42 to be towed to the southern apron area (KNKT, 2016).

It is possible to summarize the factors that caused the incident are listed below.

Lack of communication:

- Conducting two ground movements in the same area on separate frequencies with different controllers and without proper coordination led to a lack of awareness among the controllers, pilots, and the towing vehicle driver about each other.

Lack of teamwork:

- Although two ground movements were conducted by different controllers on separate frequencies in the same area without proper coordination, the lack of verbal communication and coordination between them contributed to the incident. There was also a communication gap between the assistant controller and the towing vehicle. The misinterpretation of the instruction of assistant controller for the towing vehicle to follow ID7703 led to the towed aircraft entering the runway.

Organizational factors/ Organizational functioning:

- The controllers' ability to track the aircraft was difficult due to poor lighting inside the tower and reflections from the windows.
- The lighting conditions inside the tower cabin and in the turn area of Runway 24 diminished the ability of controllers and pilots to track the towed aircraft.
- The glare from the lighting systems of runway made it difficult to monitor movements on the runway.
- The fact that the AT42 was towed by a tug instead of using its own engine power meant that the lighting systems of the aircraft were not operational, making it difficult to track the aircraft.

2.1.12. Incident 12

On November 25, 2015, under daylight conditions, a B734 aircraft operated by TNT Airways (call sign TAY421J) was cleared to land on runway 02 by the tower controller, while the

ground controller instructed an A321 aircraft operated by Air France (call sign AFR1449) to cross runway 02 via taxiway D2 (as indicated in Figure 12). As shown in Figure 12, when the ground controller granted AFR1449 clearance to cross runway 02, the stopbar lights at taxiway D2 were illuminated. The pilot, noticing the stopbar lights were on, reported the situation to the ground controller, but the ground controller reiterated the clearance to cross. With the awareness created by the stopbar lights, AFR1449, while monitoring its surroundings, reported to the ground controller that it was following traffic that was about to touch down on runway 02. Subsequently, the ground controller instructed AFR1449 to maintain its position. During the incident, TAY421J was on the tower control frequency while AFR1449 remained on the ground control frequency (CIAIAC, 2015).

Figure 12. Barcelona El Prat Airport 07L/25R and 07R/25L Runway and Taxiways

The factors causing the incident are below.

Lack of teamwork:

- Although air traffic control services are based on teamwork, the lack of team intervention regarding the persistent erroneous instructions of the ground controller contributed to the incident.

Lack of communication:

- The responsibility for the crossing traffic, AFR1149, should have been transferred from ground control to tower control at the D2 holding point and the crossing clearance should have been given by the tower controller. However, the crossing was authorized by the ground controller without any communication with the tower controller.

Lack of positive safety culture:

- One of the causes of the incident was the lack of sufficient knowledge about the operational principles of the stopbar lights at the relevant airport, and the fact that similar incidents involving stopbar lights had not been reported.

2.1.13. Incident 13

The incident occurred on July 10, 2014, at Port Elizabeth Airport in South Africa, during daylight conditions. As the South African Airways A320 (call sign SAA410) began its takeoff roll from runway 26, the Expressways CL600 aircraft (call sign EXY336), which was approaching runway 26 and was 1 NM from touchdown, decided to go around and executed a right maneuver to ensure its own separation, as indicated in Figure 13.

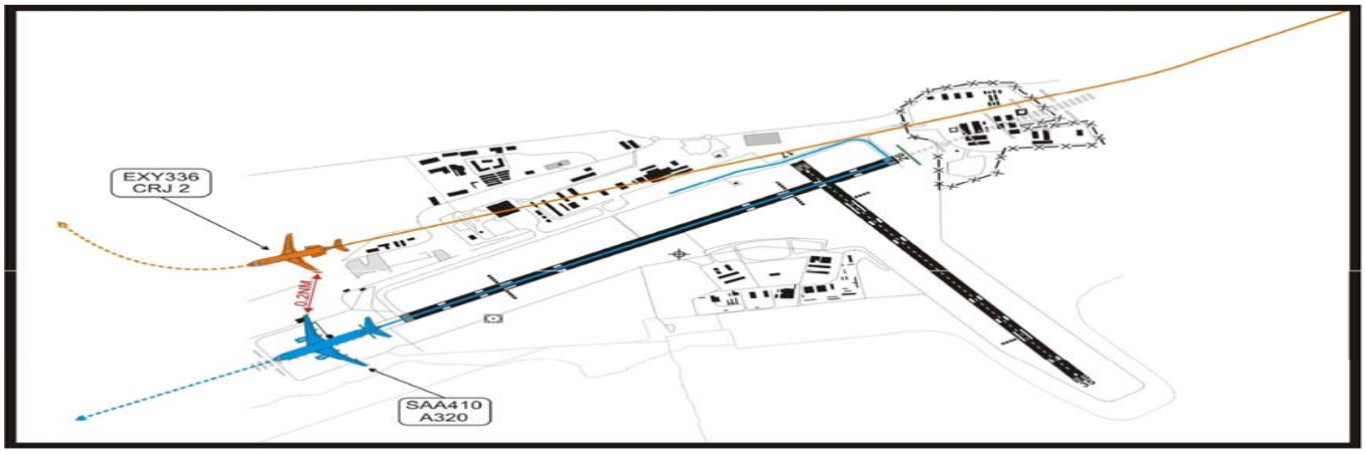

Figure 13. South Africa Port Elizabeth Airport 08/26 and 17/35 Runways and Taxiways (SACAA, 2014)

In addition to not having enough controller at the tower at the time of the incident, there was also a trainee controller on training. EXY336 was approaching Runway 26 visually due to the ILS system being controlled by the flight control aircraft. When SAA410 approached Runway 26, it indicated that it was ready for an immediate departure. Although EXY336, which the tower controller had previously contacted but forgotten, was 2 NM away from the touchdown point, the controller granted SAA410 permission to enter and take off from Runway 26. At the same time, despite EXY336 indicating it was 1.5 NM away, the tower controller did not cancel the departure of SAA410 and instructed EXY336 to continue its approach. As the landing traffic EXY336 passed 1 NM, it decided to go around upon observing that SAA410 was still at the beginning of the runway. The controller instructed EXY336 to turn left and also provided information about the

flight control aircraft waiting in the southern part of the airport. However, both the bypassing EXY336 and the departing SAA410 received a TCAS RA. EXY336, performing a right avoidance maneuver, passed very close to the departing aircraft SAA410 with a horizontal separation of 0.2 NM and a vertical separation of 263 feet (SACAA, 2014).

Factors that caused the incident are below.

Organizational factors/ Organizational functioning:

- The low elevation of the control tower makes it difficult to monitor aircraft on the approach path.
- During clear skies, certain relatively small aircraft types, such as the CRJ series, are less visible compared to others when approaching Runway 26.
- On sunny days, reflections on the windows of the control tower reduce visibility and overall quality of sight.
- Although training for student and trainee controllers during busy periods should be conducted when multiple controllers are on duty, the failure to follow this procedure contributed to the occurrence of the incident as an organizational factor.

Lack of teamwork / Situational awareness:

- Although there was a local radar screen available for tower controllers, the failure to utilize the screen indicates a weakness in situational awareness.
- The statement of the tower controller that they were "busy instructing a student" when the incident occurred indicates a lack of teamwork.

Lack of positive safety culture / Failure to report previous similar incidents:

- The flight inspection aircraft performing ILS calibration flights and the of controller with the maneuvers of the flight inspection aircraft became a contributing factor to the occurrence of the incident. Despite similar incidents occurring previously due to calibration flights, no precautions were taken.

2.1.14. Incident 14

The incident occurred on July 26, 2014, when a QantasLink Airways B717 (call sign QJE1921) had to take off again after seeing a vehicle on runway 24, just six seconds after touching down at Perth Airport, Australia, during daytime and clear visibility conditions. During the incident, intersecting runways 21 and 24 were being used simultaneously for takeoffs and landings. QJE1921 was cleared for an ILS approach to runway 24. Shortly thereafter, a new controller took over the tower position, and soon after, QJE1921 inquired about the wind conditions on the tower frequency. The new controller noticed that the landing strip for the aircraft was marked as 21 on the strip, as shown in Figure 14, and changed it to 24. Subsequently, another A330 aircraft, on final approach to runway 21, was granted landing clearance.

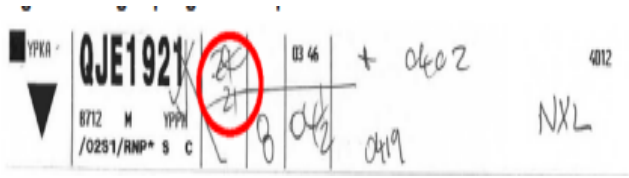

Figure 14. Landing Strip Arrangement for Traffic with Call Sign QJE1921 (ATSB, 2015)

Approximately at the same time, the "follow me" vehicle reported being ready at the holding point of runway 24 to perform a routine runway inspection. The tower controller permitted the vehicle to enter runway 24 but instructed it to hold at position 3, as shown in Figure 15, just before entering runway 21. When the follow me vehicle entered runway 24, QJE1921 was 7.5 NM away from the touchdown point of runway 24. Although communication with the follow me vehicle occurred on the tower frequency, none of the QJE1921 pilots heard the clearance for the vehicle to enter the runway.

The vehicle began to move along runway 24 in the direction of use and eventually held its position at the holding point before the intersection with runway 21. After the A330 landed on runway 21 and vacated it, the tower controller cleared another traffic, an F100, for takeoff from runway 21. Observing the takeoff of F100 from runway 21, the tower controller then cleared QJE1921, which was 1.5 NM away, for landing on runway 24 without seeing the vehicle on the runway. The vehicle driver later stated that they heard this clearance but assumed the aircraft was landing on runway 21.

As shown in Figure 15, when QJE1921 landed on runway 24, approximately 370 meters from the runway threshold, the co-pilot noticed the flashing lights of a vehicle at position 3 on the runway and reported it to the captain. The captain initiated a go-around and, after touching down on the runway and moving approximately 370 meters without slowing down, the aircraft took off again from position 5. Meanwhile, the safety vehicle was positioned on the centerline of runway 24, approximately 1180 meters from the threshold, facing the opposite direction of the approaching QJE1921. The driver of the vehicle did not see the aircraft until it passed about 150 feet over the vehicle (ATSB, 2015).

POINT	INCIDENT EXPLANATION
1	The point where the vehicle waited before entering Runway 24
2	The point where VHNXL got landing clearance
3	The point where the vehicle waited before entering Runway 21
4	The touchdown point of VHNXL
5	The point where VHNXL stated there was a vehicle on the runway
6	The point where VHNXL took off again
7	The point where VHNXL passed over the vehicle at 150 feet

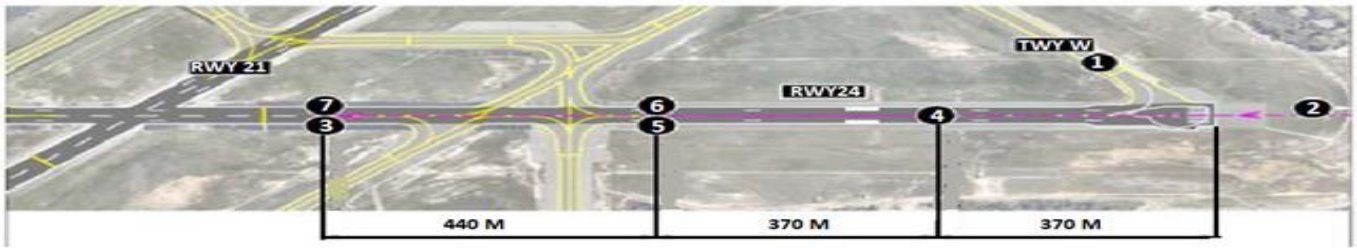

Figure 15. Australia Perth Airport 03/21 and 06/24 Runways and Taxiways (ATSB, 2015)

Factors leading the incident are below.

Organizational factors /Organizational functioning:

- Failure to have a ground radar,
- Insufficient strip arrangement,
- Insufficiency of vehicle lighting for runway operations
- The lack of runway inspections relative to oncoming traffic, resulting in the vehicle driver being unable to see the aircraft, has been observed as organizational factors contributing to the incident.

Lack of communication:

- The lack of handover between controllers and teamwork was one of the factors contributing to the incident.

Situational awareness:

- Low situational awareness of the tower controller was observed as another factor contributing to the incident.

2.1.15. Incident 15

On December 1, 2013, at Ottawa Macdonald airport, under night and normal visibility conditions, a Piaggio 180 aircraft with the call sign CGFOX, taxiing from the police apron to the 07 runway holding point, crossed the center of the 14 runway as Dash 8 aircraft of JAZZ Aviation, with the call sign JZA988, was beginning its takeoff from the 14 runway, as shown in Figure 16.

As shown in Figure 16, after completing the de-icing process, JZA988 requested taxi clearance to runway 07. The ground controller advised JZA988 to take off from runway 14 due to the long taxi route and the need for more space on runway 07, and cleared the aircraft to taxi to the holding point of runway 14, which was accepted by the traffic. At the same time, the aircraft with the call sign CGFOX, requesting taxi clearance from the police apron, was cleared to taxi to the runway 07 threshold via taxiways G, B, and C. Since the ground controller did not enter the details of CGFOX into the ground radar, the traffic could not be observed on the radar. When the tower controller cleared JZA988 for takeoff from runway 14 and the aircraft began its departure, CGFOX, which was taxiing via taxiway C, started crossing runway 14. Because JZA988 was a relatively small aircraft with a capacity of 60 passengers, it lifted off early, and no adverse incidents occurred (TSB, 2013).

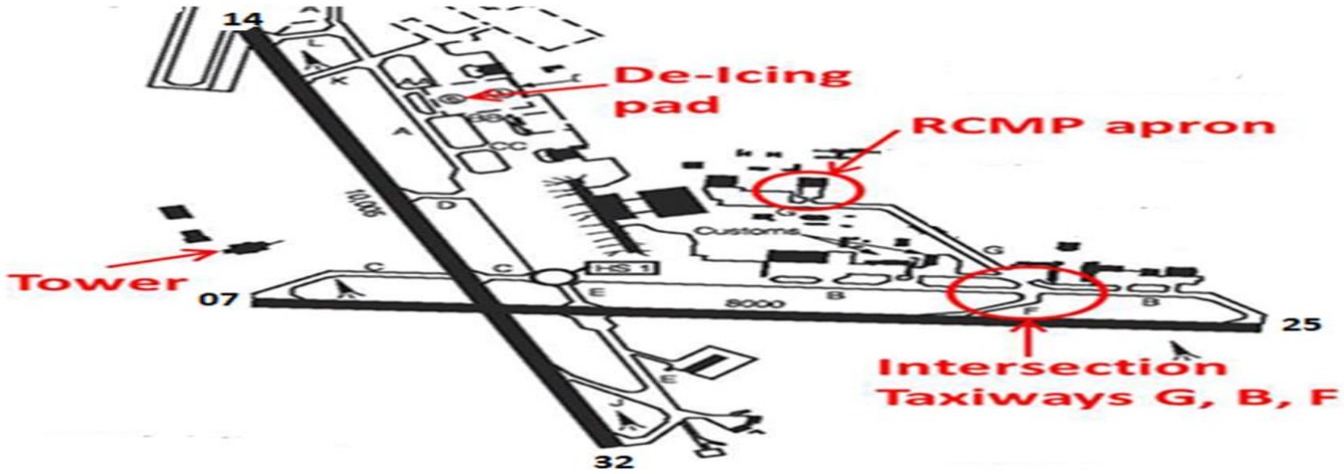

Figure 16. Ottowa Macdonald Airport 07/25 and 14/32 Runways and Taxiways

Factors that caused the incident are below.

Lack of communication:

- The failure of the ground controller to input information of CGFOX into the ground radar prevented the tower controller from tracking the traffic on the ground radar.
- The failure of the ground controller to transfer CGFOX, which crossed runway 14, to the frequency of the tower controller before the runway crossing, and his entry into the responsibility area of the tower controller, led to the runway incursion.
- The ground controller gave permission for the runway crossing, even though it was not their responsibility, and failed to inform the tower controller about the crossing.

Lack of teamwork / Workload:

- The ground controller, burdened by the workload of managing both ground movements and de-icing operations, issued instructions in an effort to quickly reduce their workload.

Lack of positive safety culture/ Failure to report previous similar incidents:

- Due to the failure of the ground controller to grant runway crossing clearance, similar incidents had occurred previously.

2.1.16. Incident 16

On October 3, 2013, under daylight and normal visibility conditions at Singapore Changi Airport, a Singapore Airlines B773 aircraft (call sign SQ371) that had just landed on Runway 20C observed a vehicle on the runway.

The ground controller instructed the vehicle operating under the call sign Rover 39 to proceed to a designated holding point on Runway 02C/20C and wait for three to four minutes, as indicated in Figure 17. Meanwhile, the tower controller was in communication with the ground controller and visually confirmed that the vehicle had reached the holding point. About a minute later, a third controller in a supervisor position, unaware of the previous clearance given by the ground controller but aware that the vehicle needed access to the runway to remove a dead bird, instructed the vehicle to be ready to enter the runway to collect the dead body of the bird. This communication was responded to by ROVER39 with the words "Understood, runway 20, thank you," and this feedback was not challenged by the supervisor. Following this

clearance, the vehicle entered the runway. The stopbar lights, which should have been turned off when aircraft and vehicle crossings were allowed, were illuminated at the time the vehicle entered the runway.

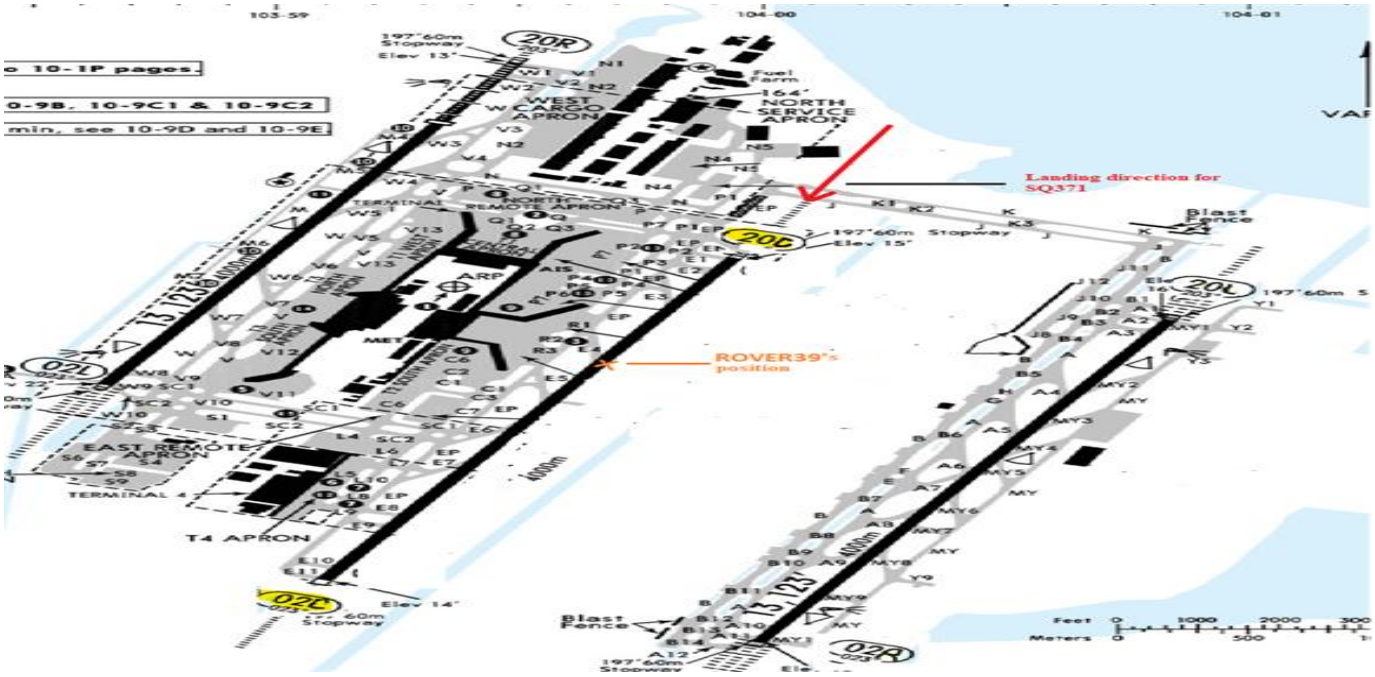

Figure 17. 02L/20R, 02/20C and 02R/20L Runways and Taxiways

Eight seconds after ROVER39 had entered the runway, tower controller granted clearance for landing to SQ371. The tower controller did not visually scan the runway or check the ground radar before granting landing clearance. Additionally, the controllers had frequently turned off the audio alert feature of the ground radar due to the frequent false warnings it gave. After SQ371 landed, the pilots noticed the vehicle on the runway near the E4 taxiway, as shown in Figure 17. They manually applied the brakes and veered slightly to the right of the centerline, allowing the wing of the aircraft to pass over the vehicle. It was found out that the vehicle in question was operated by a runway maintenance company contracted by the airport operator, and at the time, it was being driven by a driver who did not have the proper authorization to use a handheld radio (AAIB, 2013).

The factors contributing to the incident are as follows.

Lack of teamwork/ Situational awareness

- Tower and ground controllers failed to monitor the incident.
- The intervention of the supervisor in the operational position, rather than monitoring the incident by observing errors, was identified as a teamwork deficiency contributing to the incident.

Lack of communication:

- The runway entry permissions should have been granted by the tower controller. However, parts of these permissions were given by the ground controller and the supervisor, and the lack of communication between the tower, ground, and supervisor controllers contributed to the incident.

Organizational factors/ Organizational functioning:

- Although drivers entering the runway should have been sufficiently trained and authorized, the employment of unauthorized drivers for runway inspections revealed deficiencies in organizational procedures.

3. Result and Discussion

As part of the study, 16 serious incidents between 2012-2022 were analyzed by using content analysis. In these incidents, the factors contributing to unwanted events—such as lack of teamwork, communication deficiencies, organizational factors/functioning, lack of a positive safety culture, situational awareness, inadequate supervision, and stress and chronic fatigue—have been evaluated for the weight of their potential to cause accidents/incidents in air traffic control services. The criterion values obtained from the content analysis are tabulated as shown in Table 1.

Table 1. Content Analysis Criteria Weight

Criterion	Criterion Weight	%
Lack of Teamwork	3.68	23
Lack of Communication	3.68	23
Organizational Functioning	2.72	17
Lack of Positive Safety Culture	2.40	15
Situational Awareness	2,24	14
Inadequate Supervision	0.64	4
Stress and Chronic Fatigue	0.64	4
Total Number of Incidents	16	100

Among the 16 events examined through content analysis, the two criteria with the highest weights are teamwork deficiency and communication deficiency, each with a criterion value of 3.68. These are followed by organizational operation with a criterion value of 2.72, positive safety culture deficiency with a criterion value of 2.4, situational awareness with a criterion value of 2.24, and inadequate supervision and stress/chronic fatigue, each with a criterion value of 0.64. The criterion weight is obtained by multiplying the division of the total number of events by 100 by the percentage weight value.

This value for teamwork;

$$x = \frac{16}{100} \times 23 = 3{,}68$$

The scores and percentage values of the criterion weights obtained from the content analysis are shown in Table 2, Content Analysis Score Table and Figure 18, Content Analysis Score Matrix.

Table 2. Content Analysis Score Table

Factors/Incidents	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total	%
Lack of Teamwork	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	15	23
Lack of Communication	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	15	23
Organizational Functioning	●	●	●	●	●		●		●		●		●	●		●	11	17
Lack of Positive Safety Culture	●	●	●	●	●			●		●		●	●		●		10	15
Situational Awareness			●			●	●	●	●	●			●	●		●	9	14
Stress and Chronic Fatigue	●	●	●														3	4
Inadequate Supervision	●					●		●									3	4
Total	6	5	6	4	4	4	4	5	4	4	3	3	4	3	3	4	66	100

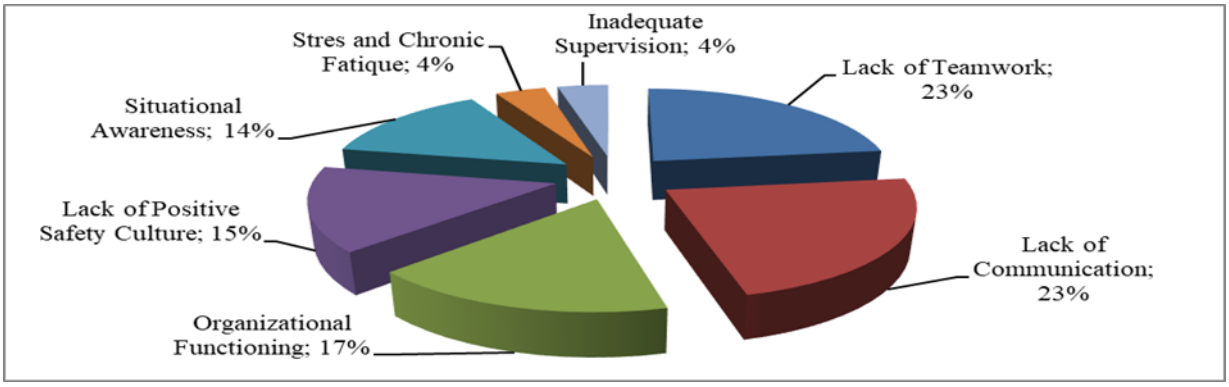

Figure 18. Content Analysis Score Matrix

Among the factors that led to undesirable incidents in the cases examined, the most influential were those stemming from teamwork deficiencies, which accounted for 23%, and communication deficiencies, also at 23%. These were followed by organizational factors/organizational functioning at 17%, lack of a positive safety culture at 15%, situational awareness at 14%, insufficient supervision at 4%, and stress and chronic fatigue at 4%.

According to the content analysis score table, a total of 66 factors were identified as causing the 16 serious incidents, with each incident resulting from more than one factor. Among these, teamwork was a contributing factor in all incidents except for incident 14, and communication deficiency was a contributing factor in all incidents except for incident 13. Organizational functioning was among the factors contributing to 11 incidents; a lack of a positive safety culture contributed to 10 incidents, situational awareness to 9, stress and chronic fatigue to 3, and finally, inadequate supervision contributed to 3 incidents. When examining incidents caused by the most diverse factors, incident 1 occurred due to the influence of all factors except situational awareness, while incident 3 occurred due to the influence of all factors except inadequate supervision. All incidents were caused by more than one factor; the incidents caused by the fewest factors were incident 11, incident 12, incident 14, and incident 15, each of which was limited to being caused by three factors.

4. Conclusion

Among the factors contributing to undesirable aviation incidents identified through content analysis, the relatively higher number of incidents caused by communication and teamwork issues is attributed to the team-based and inter-sector communication nature of air traffic control services. Air traffic control services are carried out by three main sectors: en-route control, approach control, and airport control. These sectors communicate with each other during aircraft handovers. Additionally, the en-route control sector is divided into eastern and western regions, the approach control sector into high altitude and low altitude sectors, and the airport control sector into tower, ground, and clearance delivery sectors. This sectoral division can be further refined in airspaces or airports with higher traffic density. Specifically, in the airport control sector, continuous communication is maintained through both direct verbal interactions between tower and ground control, as well as direct lines with the approach sector, to ensure a smooth traffic flow. The significant 24% impact of teamwork-related factors in undesirable events indicates a vulnerability in this context. Especially in situations where the situational awareness or competence of the controller is low, or when experiencing stress, fatigue, and distraction, teamwork within the team will help reduce the risk of accidents/incidents through effective task distribution. In this context, providing refresher training for air traffic controllers on serious aircraft-to-aircraft and aircraft-to-vehicle near-miss situations, especially in terms of

communication and teamwork, will contribute to reducing the risk of accidents/incidents to an acceptable level. Measures to mitigate risks related to communication and teamwork deficiencies can be summarized as follows;

- Providing training on communication between tower and ground controllers will reduce the occurrence of unwanted incidents.
- Establishing local procedures to define the boundaries of communication between tower/approach and tower/ground control will reduce the risk of accidents/incidents. For runway crossings, conducting clearances on the tower frequency instead of relying on verbal communication between tower and ground control will enhance safety.
- Within the framework of teamwork, having supervisors or standby controllers to monitor dense traffic in the operational sectors will help reduce unwanted incidents.
- Within the framework of teamwork, controllers who have experienced similar incidents before serious events and managed to overcome them without major consequences should be temporarily removed from their working positions and allowed to rest according to established local protocols. This approach ensures that they distance themselves from the effects of the incident and are able to think clearly.

Serious aviation incidents resulting from deficiencies in organizational functioning account for 17% of all serious incidents. To reduce such incidents caused by organizational function deficiencies, it is crucial for air traffic controllers to voluntarily report organizational issues within the system. In this regard, the organization should promote a fair culture and avoid a blame culture to encourage controllers to report deficiencies. Identified deficiencies should be addressed through local procedures and implemented by controllers in operations. The measures to mitigate the risks leading to serious incidents due to organizational function deficiencies are as follows;

- The vehicle performing runway inspections should approach the runway from the opposite direction of the active runway, allowing it to see any approaching or departing aircraft.
- Instead of using a handheld radio, the vehicle performing runway inspections should receive clearance through the tower frequency, which is monitored by all aircraft. This will create awareness for both the vehicle driver and the pilots using the frequency, helping to mitigate factors that could lead to runway incursions.
- Although stopbar lights must be used when visibility is below 550 meters, because of runway incursions can occur in any visibility condition keeping the stopbar lights on at taxiway intersections that are not used for departures will create awareness among pilots (ICAO, 2009). This will ensure that even if a controller gives incorrect instructions, any aircraft entering the runway from the opposite direction for taxiing or takeoff will not execute these incorrect instructions.
- Aircraft or towing vehicles that are about to enter the runway should switch to the tower frequency and obtain clearance from the tower controller before starting their entry. This practice will significantly reduce runway incursions.
- As shown in Figure 19, during intersection departures where the angle between the runway in use and the taxiway connecting to the departure runway is less than 90 degrees, it is possible that the pilots of departing traffic may not see the position of the arriving aircraft. This situation poses a risk of unsafe and undesirable events; therefore, intersection departures should not be conducted in such positions.

Figure 19. Runway Intersection Departure in Use

The lack of a positive safety culture (16%), situational awareness (13%), inadequate supervision (5%), and stress and chronic fatigue (2%) should be carefully examined as factors that can lead to serious incidents in the provision of air traffic control services. As with organizational functioning, establishing a reporting culture that is free from a blame culture is crucial for promoting a positive safety culture. Serious incidents that have occurred in the past should be analyzed for their causes in each sector, and these incidents should be communicated to employees through a learning culture. Within the framework of a positive safety culture, organizational and controller-related errors and violations should be reduced. Additionally, controllers' reporting cultures should be supported in incidents that occur, allowing for preventive measures to be taken before more serious incidents happen.

Undesirable incidents in air traffic control services are not only due to air traffic controllers failing to adopt a positive safety culture but also because the organization is unable to activate a safety culture.

Ethical approval

Not applicable.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

References

AAIB (2013). Final Report, Runway Incursion by Maintenance Vehicle. Singapore: Ministry of Transport Singapore https://www.skybrary.aero/sites/default/files/bookshelf/2988.pdf

AAIA (2021). Air Accident Investigation Authority, Serious Incident Investigation Final Report. Hong Kong: Transport and Housing Bureau https://www.tlb.gov.hk/aaia/doc/Investigation%20Report%2002_2021.pdf

ANS (2016). Jakarta-Halim Perdana Kusuma Airport. https://asn.flightsafety.org/asndb/320102

ATSB (2015). Loss of separation involving a Boeing 717, VH-NXL, and a vehicle. Perth Airport, Western Australia: ATSB https://www.atsb.gov.au/sites/default/files/media/5526636/ao2014133_final.pdf

BEA (2020). Near incursion of an aeroplane cleared to cross the runway during the take-off of another aeroplane. Rhône: BEA https://skybrary.aero/sites/default/files/bookshelf/5910.pdf

BEA (2022). Incursion of snow-clearance vehicles cleared to enter the runway, rejection of take-off run by an aeroplane. Rhône: BEA https://www.skybrary.aero/sites/default/files/bookshelf/33084.pdf

CIAIAC. (2015). Incident on 28 April 2015, involving an AIRBUS 321-212, registration F-GTAZ, operated by Air France, and a BOEING 737-400, registration OE-IAP, operated by TNT Airways, at the Barcelona-El Prat Airport (Spain). Barcelona: CIAIAC. https://www.transportes.gob.es/recursos_mfom/2015_013_in_eng_0.pdf

CIAIAC. (2016). Incident involving a Boeing 737-700, registration D-ABLB, operated by Germania Fluggesellschaft mbH, at runway 03R of the Gran Canaria airport (Canary Islands, Spain) on 7 January 2016. Canary Islands: CIAIAC https://www.icao.int/safety/airnavigation/AIG/Documents/Safety%20Recommendations%20to%20ICAO/Final%20Reports/IN-005_2016_final_report.en.pdf

CENIPA, (2018). Comando da aeronáutıca centro de ınvestıgação e prevenção de acıdentes aeronáutıcos, Serıous incıdent final report, CENIPA: Brasilia https://sistema.cenipa.fab.mil.br/cenipa/paginas/relatorios/rf/en/PRGTN_FAB2345_10ABR2018-IG.ING..pdf

CIAIAC. (2020). Incident involving a BOEING B737-800 aircraft operated by RYANAIR, registration EI-EFJ, and lighting vehicle 'Balizamiento 3' operated by AENA, on runway 24R at Palma de Mallorca Airport, on 19 July 2020. Mallorca: CIAIAC https://www.mitma.gob.es/recursos_mfom/comodin/recursos/in-031-2020_final_report.pdf

Cohen, L., Manion, L., & Morrison, K. (2002). Research methods in education. Oxfordshire, routledge.

DGCA (2022). Annual safety report 2022.Ankara, DGCA pubishing

DSB. (2018). Dutch safety board: shortened seiıous incident investigation. Amsterdam:DSB https://www.skybrary.aero/sites/default/files/bookshelf/5904.pdf

EASA (2019), Annual Safety Review 2019. Köln: EASA publishing

EASA (2023), Annual Safety Review 2019. Köln: EASA publishing

ECAA (2014). Aircraft Incident Investigation Report on Ethiopian Airlines Aircraft B767-300(ET-AMG) Runway Incursion Addis Ababa Bole International Airport. Addis Ababa: ECAA https://www.skybrary.aero/sites/default/files/bookshelf/4105.pdf

GPIA, (2021). Aircraft take-off with a Follow-Me vehicle on the runway. Porto: GPIA https://www.gpiaa.gov.pt/upload/membro.id/ficheiros/i007239.pdf

ICAO (2009). Annex 14: Aerodromes (Volume I Aerodrome Design and Operations). Montreal, Canada.

ICAO (2016). Annex 19: Safety Management. Montreal, Canada.

ICAO (2018). International Civil Aviation Organization Safety Management Manual (Doc 9859-AN/474). ICAO. Montreal, Canada.

ICAO (2021). ICAO Safety Report 2021.Montreal, Canada.

KNKT (2016). Aircraft Accident Investigation Report. Jakarta: KNKT https://www.baaa-acro.com/sites/default/files/2021-11/PK-TNJ.pdf

Moon W.C., Yoo K.E, Choi Y.C. (2011), Air Traffic Volume and Air Traffic Control Human Errors, Journal of Transportation Technologies, 2011, 1, 47-53 doi:10.4236/jtts.2011.13007, Korea

Nas, S. (2015). Emniyet ve Güvenlik Tanımları, Journal of ETA Maritime Science (JEMS), 3(2): 53-54

SACAA (2014). South African Civil Aviation Authority, Aırcraft Incıdent Report and Executıve Summary. Port Elizabeth: SACAA https://reports.aviation-safety.net/2014/20140710_A320_ZS-SZZ_CRJ2_ZS-NMF.pdf

Skybrary (2024). Accidents and Incidents. https://skybrary.aero/accidents-and-incidents?f%5B0%5D=when%3A%28min%3A1325376000%2Cmax%3A1640908800%29

TSB (2013). Runway incursion and risk of collision. Ottawa: TSB https://publications.gc.ca/collections/collection_2017/bst-tsb/TU3-5-13-0003-eng.pdf

TSB (2018). Runway incursion. Ottawa: TSB https://www.tsb.gc.ca/sites/default/files/rapports reports/aviation/A16W0170/eng/a16w0170.pdf

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